PROSPECTS FOR INCLUSIVE GREEN GROWTH

AND SUSTAINABILITY IN THE CAREC REGION

CAREC INSTITUTE

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ABBREVIATIONS

ADB	Asian Development Bank
AFD	Agence Drançaise de Développement
BECCS	Bioenergy with Carbon Capture and Storage
BGR	Brown Growth
BPD	Breusch-Gagan-Godfrey
BRI	Belt Road Initiative
BTH	Beijing-Tianjin-Hebei
CA	Central Asia
CAP	Capital Formation
CARs	Central Asian Republics
CAREC	Central Asian Regional Economic Cooperation
CCS	Carbon Capture and Storage
CE	Carbon Emissions
CEP	Circular Economy Practices
CS-ARDL	Cross-Section Autoregressive Distributed Lag
CSD	Cross-Section Dependency
CO2	Carbon Dioxide
CO2e	Carbon Dioxide Equivalent
COAL	Coal Prices
CO	Conference of the Parties
CPEC	China-Pakistan Economic Corridor
CPPA	Central Power Purchasing Agency
CPS	Country Partnership Strategy
CUSUM	Cumulative Sum
DEA	Data Envelopment Analysis
DIG	Digitalization
DISCO	Efficiency of Distribution Company
GENCO	Public Power Generation Company
EKC	Environmental Kuznets Curve
ENP	Energy Prices
EPD	Environmental Protection Department
ESG	Environmental, Social, and Governance
EU	European Union
EU CBAM	European Union Carbon Border Adjustment Mechanism
FIT	Feed-in Tariff
FRED	Federal Reserve Economic Data
FTA	Free Trade Agreement
GAS	Natural Gas Prices
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GSCM	Green Supply Chain Management

GSP	Generalized Scheme of Preferences
GW	Gigawatts
GG	Green Growth
GGR	Green growth
GNI	Gross National Income
GTFP	Green Total Factor Productivity
HC	Human Capital
HS	Harmonized System
ICT	Information Communication Technologies
IEA	International Energy Agency
IERU	Implementation and Economic Reforms Unit
IFC	International Finance Corporation
INDCs	Intended Nationally Determined Contributions
INS	Institutions
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
JICA	Japan International Cooperation Agency
KASE	Kazakhstan Stock Exchange
kg	Kilogram
kWh	Kilowatt Hour
LAB	Labor employed
LM	Lagrange Multiplier
MW	Megawatt
mmt	Million Metric Tons
Mtoe	Million Tons of Oil Equivalent
MDB	Multilateral Development Bank
MOE	Ministry of Environment
MOWP	Ministry of Water and Power
MPI	Malmquist Productivity Index
MRTD	Ministry of Road and Transport Development
MUB	Municipality of Ulaanbaatar
NARDL	Nonlinear Autoregressive Distributed Lag
NC	Natural Capital
NDC	Nationally Determined Contribution
NDCs	Nationally Determined Contributions
NR	Natural resources
NTDC	National Transmission & Dispatch Company
NZE	Net-Zero Emission
OLS	Ordinary Least Square
PM2.5	Particulate Matter
PBC	Pakistan Business Council
PBL	Policy-Based Loan
PCA	Principal Component Analysis
PCI	Productive Capacity Index
PJ	Petajoule
PRC	People's Republic of China
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PS	Private Sector
PTA	Preferential Trade Agreement
RBV	Resource-Based View
R&D	Research and Development
REE	Rare Earth Elements
REC	Renewable Energy Consumption
RESET	Regression Equation Specification Error Test
RET	Renewable Energy Transition
SC	Structural change
SD	Sustainable Development
SDG	Sustainable Development Goal
SOE	State-Owned Enterpris
SOP	Social Sciences Citation Index
SSCI	Sustainable Organizational Performance
toe	ton of oil equivalent
TDAP	Trade Development Authority Pakistan
TRP	Transport
TTFS	Transport and Trade Facilitation Strategy
TWh	Terawatt Hours
VIF	Variance Inflation Factor
WDI	World Development Indicators
WoS	Web of Science
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
UNDP	United Nations Development Program
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNFCC	United Nations Framework for Climate Change
UN SSE	United Nations Sustainable Stock Exchanges
US	United States
USA	United States of America
USAID	U.S. Agency for International Development
USD	United States Dollar
USSR	Union of Soviet Socialist Republics
VOC	Volatile Organic Compound
WTO	World Trade Organization

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INTRODUCTION

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The imperative for inclusive green growth and sustainability have never been more pronounced then in today's world. The regional geopolitical conflicts, climate vulnerability, food insecurity, supply chain disruptions, limited sustainable energy infrastructure investment, and trade restrictions emerged with unprecedented challenges to the CAREC region. The climate change impacts in terms of changing weather patterns, erratic precipitation, heat waves, flash floods and drought in the CAREC region are obvious. Also, improving the energy sector services and reducing carbon emissions are predominantly lagging in the CAREC region. However, the penetration of adaptation and mitigation measures are slow to overcome the profound green and sustainable growth challenges. Strengthening supply chain resilience and diversifying trade routes are indispensable responses to the risks of geoeconomic fragmentations. Therefore to enhance the effectiveness of inclusive green and sustainable policies, strategies and developmental programs, the CAREC region needs to adopt the underlying measures, national and international commitments to address inclusivity and sustainability challenges with integrated and cooperative approaches.

Over the past decades, global poly crises have demonstrated how the ripple effects of supply chains disruptions can swiftly permeate borders which emphasizing the crucial role of enhanced regional collaboration in navigating challenges and fortifying against future shocks. Amidst the ongoing trials faced by the CAREC region, it is indispensable not to overlook the promising prospects for inclusive green growth and sustainable development. Thus, the CAREC region presents both challenges and opportunities for policymakers to design calibrated policies toward green growth. The concept of inclusive green growth originates in response to extreme climate change adversities caused by economic growth. Therefore, it is essential to understand that green growth refers to fostering economic development without compromising environmental integrity. The 26th Conference of the Parties of the United Nations Framework on Climate Change (UNFCC) introduced the Glasgow Climate Pact, which enforces the reduction of carbon emissions and ensures climate resilience by keeping the global average temperature at 1.5 Celsius[1] . Subject to different conditions, all global economies are committed to climate change mitigation efforts as per the Nationally Determined Contributions (NDCs). Likewise, the CAREC countries have pledged to reduce carbon emissions from 15% to 60% by 2030, as per their NDCs.

Over the last two decades, the CAREC region witnessed robust economic growth, significantly narrowing the income gap with developed economies. In 2001, the CAREC region's average gross domestic product per capita (constant $ 2015) was $1808.99, which has been increased to $5289.31 in 2022; however, this rapid economic transformation has increased energy consumption per capita from 50.80 to 79.25 million btu per capita from 2001 to 2022[2] . Moreover, the growing population rate of the CAREC region demands more energy use, resulting in an exacerbated average carbon emissions from 3.06 to 4.44 metric tons per capita in the given time. These growing emissions pinpoint that climate change is an existential threat among pressing challenges confronting the region with far-reaching repercussions across economies and sectors. The CAREC region is characterized by high vulnerability to climate change, as witnessed by the severe 2022 flooding in Pakistan, devastating 2024 flooding in Kazakhstan, droughts in Afghanistan and China, and heat stress in the region.

The catastrophic effects of melting glaciers, less precipitation, and current devastating floods are posed in all Central Asian countries, including Kazakhstan, Kyrgyz Republic, Turkmenistan, Tajikistan, and Uzbekistan. The desiccation of the Aral Sea has caused drastic changes, which have reduced 80% of the surface area in the Aral Sea and increased threats of water scarcity[3] . These climate hazards confront the imperative to integrate climate considerations into decision-making processes. Aligning economic paradigms with climate imperatives has assumed global precedence to balance growth and development with climate conditions, underscores the need for strategic recalibration of economic strategies. In this aspect, each CAREC nation devises national-level green growth policies. A few examples are the National Strategy of the Republic

[1] UNFCCC. (2021). United Nations Framework Convention on Climate Change (UNFCCC).
https://ukcop26.org/uk-presidency/what-is-a-cop/

[2] https://www.eia.gov/international/data/world/other-statistics/energy-intensity-by-gdp-and-population;
https://databank.worldbank.org/source/world-development-indicators

of Tajikistan, Strategy on the Transition of the Republic of Uzbekistan to a Green Economy 2019-2030, the Concept of the Transition of the Republic of Kazakhstan to Green Economy, etc. Likewise, China is the most prominent player across the CAREC region, which integrates contemporary short and long-term economic dynamics with environmental sustainability through the execution of 13th and 14th five-year plans and has planned to cut down emissions to achieve carbon neutrality by 2060[4] .

Each CAREC country has its national plans, climate priorities, and international commitments, while the CAREC Climate Strategy 2030 is a milestone that focuses on regional climate actions and dialogues among the CAREC countries in pursuing energy efficiency, sustainable agriculture, renewable energy investments, efficient transport system, water use efficiency, sustainable cities, modernization of industrial structure, good health outcomes, and early warning systems to alert climate risks. The cutting-edge CAREC Climate Strategy highlights that robust regional cooperation, economic integration, and knowledge exchange are central to unlocking the region's potential for climate-resilient growth. While the journey towards inclusive green economic and sustainable development in the CAREC region will undoubtedly be challenging, it remains within reach through innovations and collaborations within and beyond the region's borders.

Leveraging advanced technology and capabilities to spur economic growth while safeguarding the environment is paramount to realizing this vision because technological advancements, digitalization, and enhanced connectivity present unprecedented opportunities for CAREC economies. However, realizing these opportunities necessitates economies of scale, which can be achieved through strengthened regional cooperation and coordination among CAREC countries. Thus, deepening regional integration in climate mitigation and adaptation initiatives opens new avenues for green sustainability. Moreover, productive capacity significantly contributes to driving higher economic outcomes with fewer emissions, among which energy transition is one of the attributes of green transformation.

[3] Baidya Roy, S., Smith, M., Morris, L., Orlovsky, N., & Khalilov, A. (2014).
Impact of the desiccation of the Aral Sea on summertime surface air temperatures. Journal of Arid Environments, 110, 79-85.

[4] Asian Development Bank (2023).
CAREC 2030: SUPPORTING REGIONAL ACTIONS TO ADDRESS CLIMATE CHANGE A SCOPING STUDY.

Energy transition entails the transformation of conventional energy sources into clean and green energy, accounting for 90% of carbon emissions mitigation and attaining net-zero emission targets.[5] The energy sector is the core area for climate change mitigation, as the CAREC region has considerable solar, wind, and hydropower energy potential. Facilitating energy transition requires vast financial and technological assistance because most CAREC countries rely heavily on hydrocarbons. Apart from this, wrecked energy infrastructure and subsidies on fossil fuels are other prominent obstacles to the energy transition. It sheds light on well-integrated technological advancements, i.e., electric vehicles, carbon-capture technology, photovoltaic solar panels, green buildings, and energy-efficient innovations, leveraging the consistency of energy accessibility and transition at lower costs to fulfill the growing energy demand in the region. Also, an innovative digital ecosystem reconciles all geographic barriers by enhancing cross-border connectivity and facilitating trade activities.

Due to the nature (landlocked) and structure (lack of diversity in trading partners and markets) of the CAREC economies, the CAREC region faces more vulnerabilities to enternal and external disruptions. Amplifying integration into global and regional value chains while bolstering self-reliance and resilience against external shocks requires diversification of products and services. The transition to novel production methods, digitalization, energy transformation, and innovative agricultural practices presents a wealth of opportunities for the region, albeit demanding forward-thinking policies for sustainable development. The CAREC region stands at a pivotal juncture, poised to address challenges and seize opportunities for inclusive and sustainable growth, and can chart a course toward a prosperous and resilient future by prioritizing regional collaboration, addressing energy-related bottlenecks, tackling climate change, and promoting innovation.

Keeping these considerations, the 3rd CAREC Annual Confernece book titled "Prospects for an Inclusive Green Growth and Sustainability in the CAREC Region" embarks

[5] IRENA. (2021). International Renewable Energy Agency.
https://www.irena.org/Publications/2022/Jul/Chinas-Route-to-Carbon-Neutrality

on a comprehensive journey through three distinct parts, each delving into critical dimensions shaping the region's trajectory towards a greener and more equitable future.

The first part, "Climate Change, Carbon Neutrality, and Productive Capacities in CAREC Region," demonstrates the mitigation and adaptation endeavors to the climate change between CAREC nations. It explores carbon neutrality's challenges, barriers, and policy implications while signifying the importance of productive capacities for green productivity in the region.

The second part, "Energy Transition, Green Growth, and Sustainability in the CAREC Region," highlights the navigating role of renewable energy transition towards green sustainability. The complex association between digitalization, renewable energy transition, green growth, bibliometric analysis of renewable energy trends, and geoeconomic green energy implications illuminate the economic paradigm of sustainable development.

The third part, "Green Supply Chain, ESG Markets, Trade, and Agricultural Sustainability in CAREC Region," discusses the sustainable practices within sectors. This section unravels the roadmap toward resilient prosperity by shedding light on environmental, social, and governance (ESG), supply chain management, agricultural sustainability, and trade dynamism.

These three sections create a coherent narrative highlighting the importance of sustainable, inclusive green growth to inspire transformative change and lead toward a thriving, inclusive, and sustainable future for the CAREC region and beyond by examining essential issues, proposing creative solutions, and promoting cooperation.

Chapter 1 "Climate Change Adaptation and Mitigation Strategies: Lessons from ADB and CAREC Cooperation" by Yinxin Yao and Shengchi Ma examines the Asian Development Bank's (ADB) collaborative strategies with CAREC countries to address climate change. This analysis leverages the latest data to explore how diverse economic, social, and political backgrounds shape each country's climate challenges, focusing on sustainable agriculture, water resource management, air pollution control, and energy transitions. It highlights the severe climate-related issues these countries face, such as water scarcity, increased natural disasters, and impacts on critical sectors like agriculture and energy, exacerbated by their dependence on agriculture and changing weather patterns. The chapter details ADB's support through financial aid, technical advice, and policy guidance aimed at fostering climate resilience and sustainable development. This includes funding for climate change mitigation projects like renewable energy and efficient infrastructure. Moreover, the CAREC Institute complements these efforts by enhancing research and capacity-building initiatives in vital areas like agriculture and water management. The insights and case studies presented offer practical recommendations for policymakers to enhance their climate resilience and sustainable development strategies.

Chapter 2 "Achieving Carbon Neutrality in the CAREC Region: Barriers, Challenges, and Policy Implications" by Falendra Kumar discusses the increasing greenhouse gas emissions in CAREC member economies and explores pathways to carbon neutrality, highlighting associated challenges and policy needs. Utilizing a multi-method approach, including theoretical frameworks and data analysis from 2010-2020 sources like the Asian Development Bank and International Energy Agency, the study reviews recent trends in energy demand and emissions growth. It notes significant efforts like China's 25% reduction in emissions from 2016 to 2020, with a goal for carbon neutrality by 2060. The chapter underscores the need for developing and adopting green technologies, reducing reliance on fossil fuels, and enhancing carbon management strategies such as sequestration and recycling. Effective carbon neutrality will require robust regional cooperation, substantial investments, and tailored country-specific policies to balance economic growth with environmental sustainability.

Chapter 3 "Productive Capacities and Green Growth: Implications for Climate Change in the CAREC Region" by Asif Razzaq analyzes the link between productive capacities and economic growth, focusing on green growth across CAREC member countries from 2001 to 2022. Using the Malmquist Productivity Index and Data Envelopment Analysis, the study observes a 29.13% increase in the productive capacities index (PCI), alongside a GDP per capita rise of 192.39%. Strong correlations are found between PCI and economic growth, particularly in China and Kazakhstan, with varying results across other nations. Despite disparities, higher PCI generally promotes higher GDP and enhances green productivity, indicating that effective PCI improvements could lead to more sustainable economic models. The study emphasizes the importance of developing productive capacity pillars like structural changes and natural capital for sustainable growth, suggesting that CAREC countries focus on policies that foster these elements to combat climate change effectively.

Chapter 4 "Bibliometric Analysis of Renewable Energy in the CAREC Region: Research Trends and Future Prospects" by Burulcha Sulaimanova uses bibliometric analysis to assess renewable energy research trends across 11 CAREC countries from 1991 to 2023, drawing on English-language scientific articles from the Web of Science database. The analysis differentiates between a "Total sample," including references to China, and a "Fragmented sample" that excludes them, to mitigate China's research dominance. Findings show China leading in renewable energy research, while Pakistan emerges as a significant contributor among other CAREC countries, particularly in sustainable energy solutions. The study indicates limited research activity in Central Asian countries, except for Kazakhstan, which focuses on natural resources and energy security.
This chapter provides valuable insights for policymakers and highlights a growing momentum in renewable energy research within the CAREC region.

Chapter 5 "The Role of Renewable Energy Transition and Digitalization in Promoting Green Growth in CAREC Countries" by Ilma Sharif examines the effects of renewable energy transition and digitalization on green growth within CAREC countries, using data from 2001 to 2022. Employing the cross-section autoregressive distributed lag method, the study identifies significant influences of these factors on green growth, highlighting a notable interaction between renewable energy and digitalization that markedly enhances green growth. The findings suggest targeted policy measures to further harness these drivers for sustainable development in the region.

Chapter 6 "Green Growth Triumphs Over Brown Growth Despite Energy Price Volatility: A Paradigm Shift in Sustainable Development" by Ummara Razi discusses how green growth has become a crucial policy solution for economic and environmental sustainability challenges in CAREC countries. The study uses the nonlinear autoregressive distributed lag model to analyze the impacts of brown growth and energy price volatility from 2000 to 2021. It finds that while brown growth initially supports green growth by building infrastructure and industry, it negatively impacts it in the short term due to high carbon emissions. Energy price fluctuations also affect green growth adversely both in the short and long term. The study recommends policies that minimize reliance on fossil fuels and promote energy diversification and efficient technologies to support sustainable development.

Chapter 7 "Geoeconomic Implications of Green Energy Transition in CAREC" by Dimitris Symeonidis explores the challenges and opportunities associated with transitioning to low-carbon energy sources in Central Asia. It highlights the need for renewable energy adoption to address climate change impacts in the region. The study examines how this transition affects supply security and economic dynamics, emphasizing the potential risks and benefits. By analyzing stakeholder behavior and regional policies, the study offers recommendations to mitigate risks and maximize benefits for CAREC states while ensuring global market stability.

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Chapter 8 "The Impact of GSCM and Circular Economy Practices on Organizational Performance in CAREC Economies" by Mohsin Shahzad examines how Green Supply Chain Management (GSCM) practices, integrated with circular economy practices (CEPs), affect sustainable organizational performance (SOP) in CAREC economies. As businesses face ecological challenges, adopting GSCM strategies—like cleaner production, eco-design, recycling, and sustainable sourcing—helps enhance environmental performance and economic benefits. This study focuses on the role of CEPs in strengthening SOP by promoting resource regeneration and waste minimization, particularly in the manufacturing sectors of China and Pakistan. The findings suggest that while GSCM practices contribute to SOP, CEPs are crucial in mediating these effects, indicating a need for companies to adopt both practices for better sustainability outcomes.

Chapter 9 "ESG Development in CAREC: Focus on China and Kazakhstan" by Fu Xin, Ran Sheng, and Changzhen Zhang discusses the role of Environmental, Social, and Governance (ESG) frameworks in supporting sustainable development within CAREC nations.

Highlighting the CAREC 2030 strategy's focus on sustainable economic cooperation, the study notes significant ESG progress in China and Kazakhstan. As of September 2022, many Chinese companies and funds have embraced ESG reporting and investment, aligning with China's carbon neutrality goals. Kazakhstan has also advanced, integrating global standards that promote market transparency and sustainable investments. This research emphasizes the importance of robust ESG practices in enhancing corporate sustainability and resilience against global challenges like climate change, contributing to CAREC's long-term development goals.

Chapter 10 "Sustainable Trade Bridges: Pakistan-Uzbekistan Prosperity in CAREC" by Adeel Kadri and Muhammad Musa explores how Uzbekistan, a double-landlocked country, aims to boost regional trade using existing routes and infrastructure owned by other nations, while Pakistan boasts three major ports along the Arabian Sea. Both countries stand to benefit from improved bilateral trade; Pakistan's ports are underutilized, and Uzbekistan seeks access to international waters. By granting Uzbekistan access to its ports, roads, and railways, Pakistan could see increased cargo traffic and financial gains, while Uzbekistan gains a sustainable trade route to the sea. This study examines the untapped trade potential between the two nations and advocates for a sustainable partnership to realize it.

Chapter 11 "Sustainable Cotton Industry Cooperation in China, Kazakhstan, and Uzbekistan" by Yu-Jia Deng et al. addresses challenges in the cotton industry exacerbated by the pandemic. Focusing on agricultural regional cooperation as a key to industrialization along the Silk Road Economic Belt, the paper examines China's role in modernizing Central Asian cotton production. It proposes models for bilateral cooperation, highlighting issues such as technology, infrastructure, and business environment. The study advocates for a multilateral sustainable cooperation model, emphasizing policy support, technological innovation, and financial services to enhance resilience and inclusivity in the cotton industry.

Collectively, these three parts and chapters form a cohesive narrative that underscores the imperative for inclusive green growth and sustainability in the CAREC region. By interrogating key challenges, exploring innovative solutions, and advocating for collaborative action, this book endeavors to inspire transformative change and pave the way towards a prosperous, equitable, and sustainable future for the CAREC region and beyond.

The first annual conference book, COVID-19 and Economic Recovery Potential in the CAREC Region, reveals the economic recovery and response policy measures to COVID-19 crises between the CAREC economies, while the second annual conference book, Resilience and Economic Growth in Times of High Uncertainty, showcases the debate on sustained resilience in post-COVID period and policies on food security, agriculture, regional connectivity to e-commerce developments and small-medium sized enterprises issues. Unlike these prior annual conference books, the third annual conference book contributes profoundly to the policy perspective and academic literature by providing comprehensive policies that support environmental preservation, sustainable supply chain practices, and renewable energy. These cohesive policies are presented in three sections based on green growth and sustainability under the framework of the CAREC Climate Strategy by independent research analysts, ADB and CAREC's policy experts, and academia.

Central to unlocking the region's potential is robust regional cooperation, economic integration, and knowledge exchange. Technological advancements, digitalization, and enhanced connectivity present unprecedented opportunities for CAREC economies. However, realizing these opportunities often necessitates economies of scale, which can be achieved through strengthened cooperation and coordination among CAREC economies.

While the journey towards inclusive green economic and sustainable development in the CAREC region will undoubtedly be challenging, it remains within reach through innovation and collaboration, both within and beyond the region's borders. Leveraging advanced technology and capabilities to spur economic growth while safeguarding the environment and fostering equitable participation is paramount to realizing this vision.

PART ONE

PART I CLIMATE CHANGE, CARBON NEUTRALITY, AND PRODUCTIVE CAPACITIES IN CAREC REGION”

PART ONE

CHAPTER 01

CLIMATE CHANGE ADAPTATION AND MITIGATION STRATEGIES

Lessons from the Cooperation Between ADB and three CAREC Countries

Yixin Yao and Shengchi Ma

1.1 INTRODUCTION*

The unique socio-economic and political characteristics of the member countries of the Central Asian Regional Economic Cooperation (CAREC) present a compelling landscape for examining diverse development paths. Situated at the crossroads of Europe and Asia, these nations hold significant strategic and economic potential, and a crucial place on the global stage geographically and economically. These nations together comprise a population of nearly 2.1 billion people, equivalent to about a quarter of the world's total population by 2022. Economically, these countries collectively account for a substantial portion of the world's natural resources as well. For instance, Kazakhstan is among the world's top producers of uranium, oil, and coal. Turkmenistan has the world's fourth-largest reserves of natural gas, and Mongolia is rich in copper, gold, and coal.

The region's richness, characterized by abundant natural resources and vibrant potential for economic growth, is contrasted by its diversity in terms of economic structures, political institutions, and social conditions. From nations grappling with post-conflict reconstruction to those seeking to transition from resource dependence, the region encompasses a broad spectrum of development contexts. This diversity in the CAREC region provides a fertile ground for understanding the various paths these countries take in their journey of growth and progress. Based on national development strategies, the CAREC countries can be classified into five intersecting categories:

(1) conflict- ridden economies seeking stability and reconstruction (Afghanistan),
(2) resource-rich economies seeking diversification and modernization (Azerbaijan, Kazakhstan, Turkmenistan, Kyrgyz Republic, Tajikistan, and Mongolia),
(3) transition economies seeking diversification and institutional reforms (Georgia and Uzbekistan),
(4) large economies seeking economic transition and sustainable development (People’s Republic of China (PRC)),
(5) agrarian economies seeking modernization and poverty reduction (Kyrgyz Republic, Tajikistan, Pakistan, Afghanistan, and Uzbekistan).

Note that the CAREC countries have started considering climate change in their national development strategies. The rationale is straightforward. Despite the successful adoption of the 2015 Paris Agreement, the most recent reports from the Intergovernmental Panel on Climate Change (IPCC) in the late 2020s project even more dire consequences for our warming planet than initially anticipated, with potential irreversible impacts. Facing a ticking clock, climate action has been catapulted to the

* Authors thank Miss Tianyi Tao from The Stony Brook School, New York, USA for her dedicated efforts in the collection of data, which greatly contributed to this research.

forefront of international discourse. Particularly for the CAREC region, an area known for its socio-economic and ecological diversity, the stakes have never been higher. The degree to which climate change is prioritized can vary significantly based on the country's circumstances, capabilities, and priorities. Countries especially vulnerable to the effects of climate change, such as those with large agricultural sectors or those facing water scarcity, may more strongly emphasize climate change mitigation and adaptation in their development strategies. Similarly, countries with substantial fossil fuel reserves might focus on balancing economic development derived from these resources with the global need to reduce carbon emissions.

The Asian Development Bank (ADB) has been a key partner in the CAREC program since its inception in 2001, providing technical assistance and financial resources to facilitate regional cooperation and integration. It also focuses on improving transportation and energy infrastructure, facilitating trade, and enhancing economic policy dialogue among member countries. Targeting issues related to climate change, the ADB's role has become increasingly important given the environmental vulnerabilities and challenges many CAREC countries face. It assists these countries in integrating climate change considerations into their development planning and investing in climate-resilient infrastructure.

Based on the above, this study explores the project database and other relevant documents of the ADB to unravel the motivations, design, and operational mechanics of its policy-based loans (PBLs) initiatives. A review and comparative analysis of these projects identify the elements that drive their successful design. This examination culminates in valuable insights and recommendations that can inform and enhance the planning of future PBL projects.

1.2 CHALLENGES IN CAREC COUNTRIES

Climate change brings severe challenges to the CAREC region, with water scarcity being a significant concern. In arid and semi-arid regions such as Kazakhstan and Turkmenistan, and the mountainous terrains of Tajikistan and Kyrgyz Republic, diminished water sources lead to agricultural vulnerabilities given that these economies have significant agricultural sectors.

However, the issue extends beyond agriculture, affecting urban and industrial water supplies as well. Countries like Azerbaijan and Georgia along the coasts of the Caspian and Black Sea grapple with rising sea levels and extreme weather events. These changes threaten coastal economies and unique ecosystems. For Mongolia, desertification is a critical concern, affecting traditional nomadic lifestyles and straining already scarce water resources. On the energy front, increasing temperatures lead to higher energy consumption for cooling. This energy demand often relies on outdated, inefficient systems such as over-subsidized electricity tariff systems and burning raw coal for heating, which wastes energy. In addition, a heavy reliance on fossil fuels for energy exacerbates air pollution and feeds the cycle of climate change. China, with its diverse regional climates, faces a complex combination of these challenges including water scarcity, agricultural vulnerability, increased energy demand, and pollution. These intertwined challenges emphasize the need for comprehensive, adaptable strategies to build climate resilience across the CAREC region.

To help the CAREC countries move toward sustainable development and build a society more resilient to climate change, ADB is striving to transition from a traditional Multilateral Development Bank (MDB) to a "climate bank." In his most recent speeches and interviews, the ADB President presented a strategic framework designed to address the ever-increasing threats of global warming. ADB's approach includes tailoring region-specific interventions, boosting investments in green initiatives by MDBs, and fostering an environment of knowledge sharing. The strategy extends to global cooperation, and proposes innovative, incentivizing policies such as carbon pricing and tax incentives to encourage sustainable behavior.

The Country Partnership Strategy (CPS) between ADB and the CAREC countries reflects these trends. Climate change mitigation was named as one of the development focuses in Azerbaijan, Pakistan, and Uzbekistan to reduce greenhouse emissions and diversify energy consumption.

Climate actions are integrated in the development strategies of all CAREC countries, such as policy reform, institutional capacity building, activating financing, human capital development, and gender mainstreaming. In the case of the PRC, the current CPS further plotted contexts in climate change mitigation and adaptation to facilitate sustainable transition through the country's economic development. With cooperation and assistance designed based on the regional development context, the partnership between ADB and the CAREC countries is expected to yield sustainable growth and progress climate change. A review of the CPSs between the ADB and CAREC countries identifies the following critical challenges to these nations' sustainable futures:

- Outdated policy frameworks and insufficient institutional capacity
In many CAREC countries, especially central Asian members, the energy and water usage systems are outdated and require an urgent reform for better efficiency and availability. The complexity of such issues is compounded because of their intersectoral nature, which hinders the progression and coordination of these policy reforms.

- Lack of financial resources
Unsustainable financing is a major issue in CAREC countries. On one hand, the private sector in many countries has not been fully activated to enrich the resource pool to accelerate growth. On the other, despite the limited scale of international assistance programs, the effects are not fully redeemed due to a lack of readiness.

- Low public awareness and gender equity
Waste and high-emission usage of resources is common in the CAREC countries. Thus, improving public awareness could be a useful mechanism for drawing individuals into climate action. Gender mainstreaming[1] can also encourage a large proportion of the population to be involved in the transition to sustainability.

1.3 ADB'S CLIMATE CHANGE ACTIONS IN THE CAREC COUNTRIES

ADB has for the past few decades created numerous innovative projects and activities to support the CAREC countries in the adaptation to and mitigation of climate change. A key ADB initiative has been promoting renewable energy and energy efficiency in the region.

For instance, ADB has provided funding and technical assistance for developing wind and solar power projects in Pakistan and Kazakhstan. It has also been instrumental in supporting climate change adaptation measures in the CAREC countries. This includes improving water resource management in response to glacial melt in mountainous countries like Tajikistan and Kyrgyz Republic, and enhancing the climate resilience of agricultural systems in countries like Mongolia and Afghanistan. ADB also provides

[1] Gender mainstreaming is the process of assessing the implications for women and men of any planned action, including legislation, policies, or programs, in all areas and at all levels. It is a strategic approach for making women's and men's concerns and experiences an integral dimension of the design, implementation, monitoring, and evaluation of policies and programs in all political, economic, and societal spheres. The ultimate goal of gender mainstreaming is to achieve gender equality by integrating gender equality in national public and private organizations, policies, and programs, and in the long run, transform discriminatory social institutions, laws, cultural norms, and community practices. To look up for more information, please check UN Women's official website. (https://www.unwomen.org/en/how-we-work/un-system-coordination/gender-mainstreaming)

assistance in capacity building, aiding countries in the region to enhance their ability to plan and implement effective climate change mitigation and adaptation strategies. This includes supporting policy dialogue, providing technical knowledge, and fostering regional cooperation on shared climate change challenges.

Among all the projects ADB launched in the CAREC countries, PBLs are a typical tool for ensuring the success of project objectives.

PBLs are financial instruments used by MDBs to provide direct support to borrowing countries. These are linked to the implementation of specific policy and institutional reforms. PBLs offer several advantages. First, they provide flexibility, as the funds are not tied to specific projects, allowing countries to use them where most needed. These loans can stimulate policy and institutional reforms and enhance a country's developmental trajectory. By offering direct support to a country's budget, PBLs can aid in managing fiscal pressures, particularly in times of economic hardship. The second advantage is predictability, since the disbursement is linked to policy results rather than project completion, ensuring consistent financing. Third, PBLs can fortify a country's systems and capacities, fostering national abilities for planning and monitoring the use of funds.

Finally, PBLs enable a strategic dialogue between the lending institution and recipient country, promoting a stronger development partnership.

Through PBLs, ADB has approved 43 projects related to climate change in the CAREC countries from 2015 to 2022 (ADB, 2022)[2] . The distribution in countries is relatively even, with the most (9) in the Kyrgyz Republic followed by 8 in Mongolia and Pakistan (Figure 1.1). There were no climate-related PBLs in Afghanistan, Kazakhstan, and Turkmenistan.

However, the loan/grant share of the projects in Pakistan was more than half the investment in the projects in all other CAREC countries (Figure 1.2). This is because

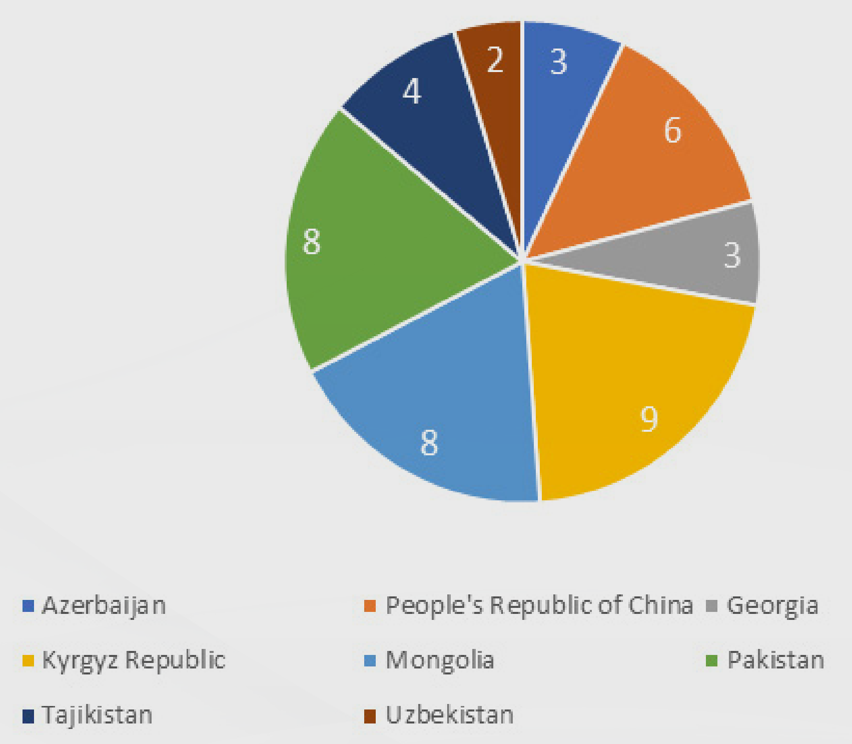
[2] ADB. (2022). 2022 climate finance SDCD database.

the approved projects are best suited to Pakistan, as they focus on the continuous improvement of the energy sector, fiscal system, and food security, among other areas.

For the other countries, the projects usually focus on one aspect. According to sector, Figure 1.3 shows that ADB's PBLs tend to be concentrated in the energy sector (13 projects). These projects focus on more efficient energy usage and public management to establish fundamental institutions and measures in the fiscal, energy, human capital, and food sectors to ensure a society more resilient to climate change.

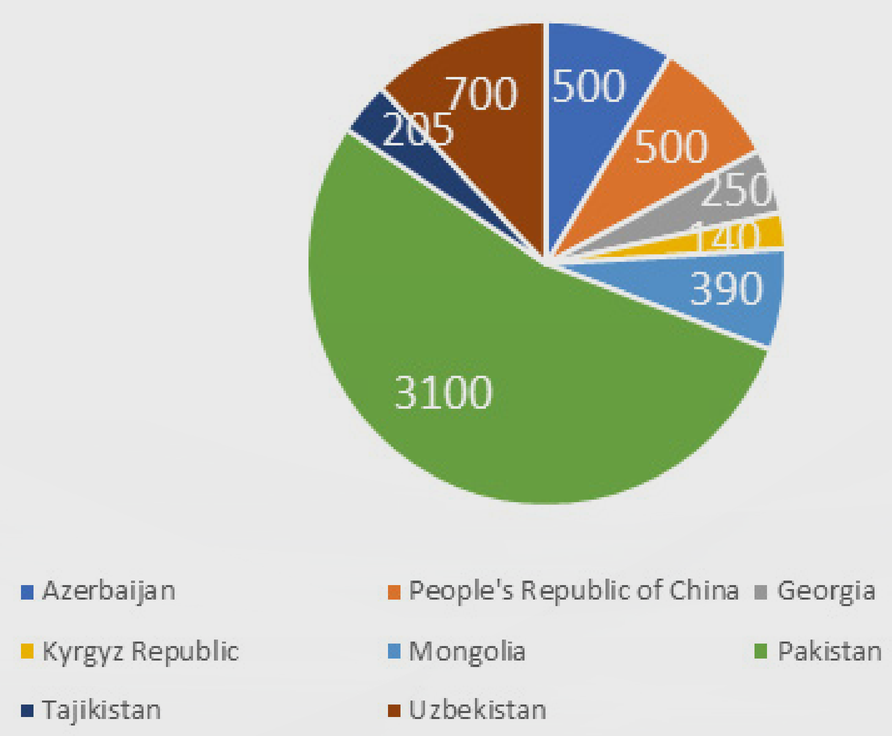
These also resonate with ADB's design and evaluation of the projects (Figure 1.4). Most are considered "low" in terms of climate change impact, since their major objective other than reducing adverse emissions is fundamental social reform, which may not seem related to climate change. However, this is not characteristic of the projects in the PRC and Mongolia. Regardless, the activities will potentially bring about more sufficient green finance, environmentally friendly energy usage and agriculture, and human capital that is skilled and aware of climate change. These aspects are vital in CAREC member countries in terms of climate change mitigation and adaptation.

Figure 1.1. Number of ADB PBL projects in CAREC member countries



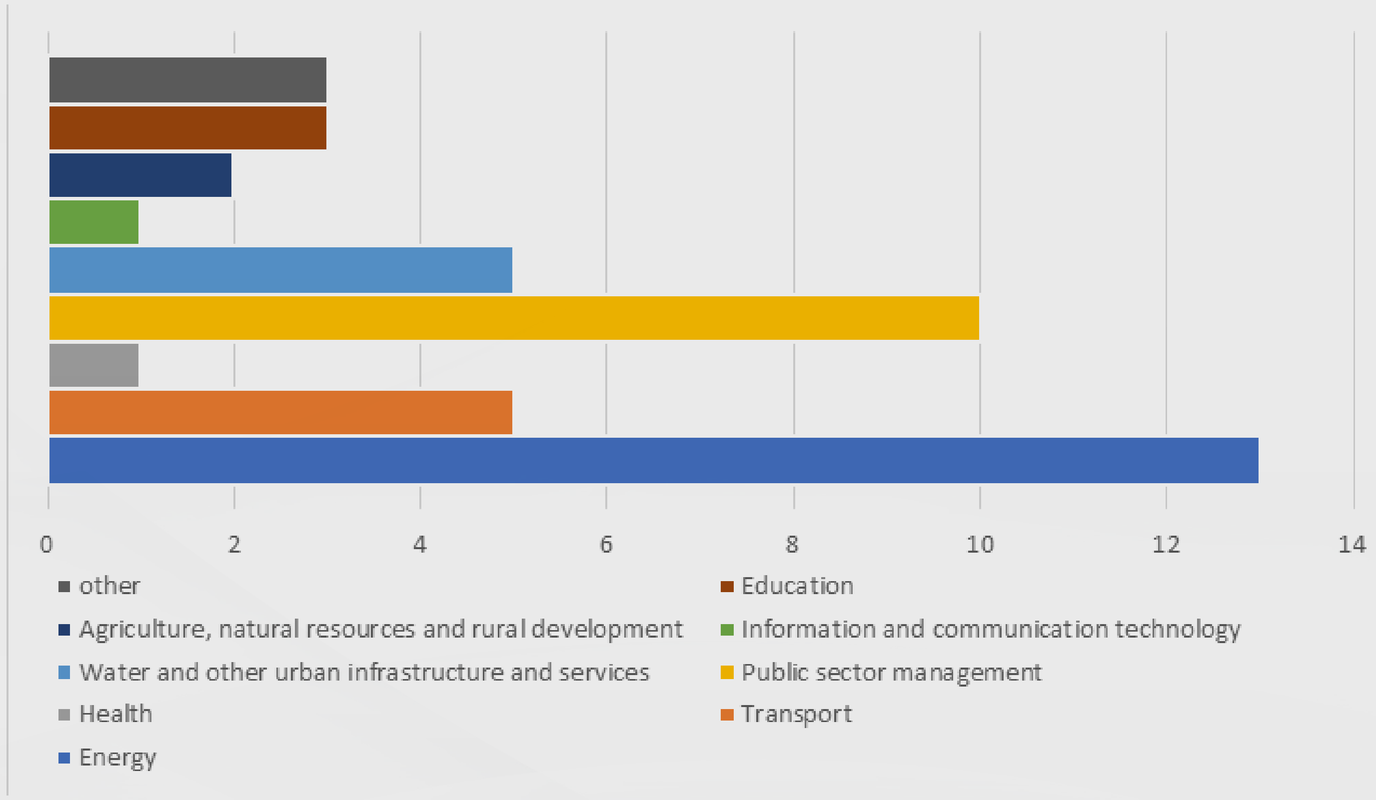
Source: By author

Figure 1.2. Loan/grant share of ADB PBL projects in CAREC countries (US$ million)



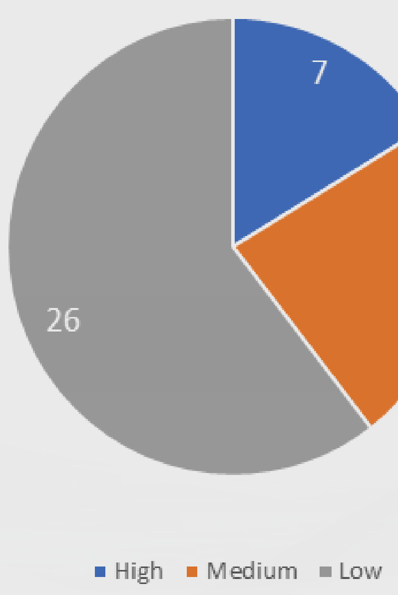
Source: By author

Figure 1.3. Number of PBL projects in different sectors



Source: By author

Figure 1.4. PBL project impact on climate change



Source: By author

1.4 COMPARATIVE CASE STUDIES OF THE ADB-CAREC COUNTRIES' COOPERATION INVESTMENT PROJECTS

Most of the aforementioned 43 programs are still active. By July 2023, only four had been completed. These are in Pakistan, the PRC, and Mongolia. This section examines three completed ADB projects related to climate change to elucidate their complex workings. This exploration clarifies the rationale, design, operation, and critical success factors of these initiatives.

1.4.1. Pakistan: Sustainable Energy Sector Reform Program - Subprogram 3[3] [4]

Project Summary

Modality and Funding: The program falls under the category of a PBL. The loan amount of US$300 million was supplied by the ADB from its ordinary capital resources.

Project Objectives and Outputs: This program is intended to assist the reform efforts of the government of Pakistan in the energy sector. Subprogram 3 has the following aims:

Output 1: Improved Management of Tariffs and Subsidies - This outcome centers on suggesting legislative modifications to resolve the financial sustainability issues plaguing the sector. Initiatives include refining the roles and responsibilities of the government and sector regulator, enhancing decision-making procedures and accountability, refining the definition and applicability of surcharges, and laying the groundwork for the sector regulator.

[3] ADB. (2017). Proposed Policy-Based Loan for Subprogram 3 Islamic Republic of Pakistan: Sustainable Energy Sector Reform Program: Report and Recommendation of the President to the Board of Directors. Asian Development Bank (ADB). https://www.adb.org/sites/default/files/project-documents/47015/47015-003-rrp-en.pdf

Output 2: Promotion of Energy Efficiency and Conservation - Subprogram 3 institutionalizes energy efficiency and conservation via the enactment of legislation promoting such practices. The government merged two boards and planned to enhance the efficiency of distribution companies (DISCO) through strategic sales. Energy efficiency was promoted through the National Energy Efficiency and Conservation Act. NEPRA established the Electricity Sector Market Operations Unit and introduced transmission tariff guidelines. In the gas subsector, the Ministry of Petroleum and Natural Resources adopted a restructuring plan.

Output 3: Accountability and transparency in the power subsector improved during FY2016 and part of FY2017. NEPRA published performance evaluation reports on public power generation companies (GENCOs), DISCOs, the Karachi Electric Supply Company, and the (The National Transmission & Despatch Company) NTDC's compliance with licenses. To address the media's misunderstanding of energy sector data, the Ministry of Water and Power (MOWP) conducted its first media training activity in May 2017. Similar training is expected to continue regularly.

Background and context

For years, Pakistan's energy sector has faced severe difficulties such as power shortages, elevated transmission and distribution losses, and concerns about financial sustainability. These issues have taken a substantial toll on the economy, stunting industrial growth and affecting citizens' quality of life.

The government of Pakistan has sought to counteract these challenges with various reform measures and initiatives. However, these efforts have encountered obstacles and their effectiveness has been curtailed. Sluggish legislative processes and pushback from vested interests have impeded the implementation of necessary legislative changes to resolve financial sustainability issues, such as tariff and subsidy management. Moreover, the energy sector's governance and institutional framework still need substantial

[4] ADB. (2021). Pakistan: Sustainable Energy Sector Reform Program (Subprograms 1, 2, and 3): Completion Report. Asian Development Bank (ADB). https://www.adb.org/sites/default/files/project-documents/47015/47015-001-47015-002-47015-003-pcr-en.pdf

enhancements, such as budget management fortification, financial accounting improvement, and reporting.

Further issues involve fiduciary risk and public financial management. The overall fiduciary risk at the federal level remains moderate to high, necessitating improvements in areas like internal control, auditing, and legislative oversight of budget formulation and execution. There is also a need to coordinate and complement initiatives financed by different development partners to ensure the efficient implementation of reforms.

Despite these obstacles, certain areas have shown signs of progress following the government's efforts. Since 2014, capacity building and training initiatives have been implemented at the federal and provincial levels. Steps have also been taken to combat corruption, including the monitoring and reporting work conducted by the public accounts committee of Parliament.

The Sustainable Energy Sector Reform Program, particularly Subprogram 3, is designed to tackle these challenges and advance Pakistan's energy sector. This program focuses on managing tariffs and subsidies, promoting energy efficiency and conservation, enhancing the efficiency of electricity enterprises, and reducing reliance on imported fuel. These reforms aim to establish a more reliable, sustainable, and secure energy sector that supports the country's economic growth and enhances its citizens' quality of life.

Introduction of the project

The Sustainable Energy Sector Reform Program in Pakistan is a comprehensive initiative that aims to address and overcome the enduring challenges in the country's energy sector. The program focuses on managing tariffs and subsidies, fostering energy efficiency and conservation, enhancing the operational efficiency of electricity enterprises, and significantly reducing Pakistan's dependence on imported fuel.
To augment the financial stability of the energy sector, the program proposes effective

legislative changes for managing tariffs and subsidies. Such changes encompass refining the roles and responsibilities of the government and the sector regulator, improving decision-making processes, and providing a clear definition and applicability of surcharges. Through these changes, the program aims to ensure a more efficient allocation of resources to enhance the financial viability of the energy sector.

Simultaneously, the program is making strides to increase energy efficiency and conservation. Legislation has been introduced to promote energy-efficient practices and reduce wastage. By advocating for efficient energy usage and diminishing transmission and distribution losses, the program strives to improve the overall efficiency of the energy system, contributing to a more sustainable and reliable energy sector.

The program also seeks to enhance the efficiency of electricity enterprises. This involves taking steps toward the public offering of minority interests in three DISCOs. This strategy aims to attract private investments to enhance the business environment and ultimately improve service delivery and decrease losses.

Furthermore, the program is cognizant of the need to curb the country's dependence on imported fuel. Therefore, it supports crucial reforms in the electricity and gas subsectors to disentangle the link between economic growth and fuel imports. The program backs the implementation of the Petroleum Exploration and Production Policy (2012), which introduces competitive gas pricing for existing and new gas concessions. These reforms aim to reduce imports and balance payment issues.

Last, efforts are underway to bolster public awareness and understanding of the energy sector, which is important in ensuring the success of the reform program. The MOWP holds joint media training sessions with Central Power Purchasing Agency (CPPA), NTDCs, DISCOs to familiarize the media with the sector data disclosed on websites.
In addition, a public education campaign has been rolled out to acquaint the media with the types of data available and teach them how to interpret it. These steps ensure

citizens stay informed about the challenges and reforms of the energy sector, fostering public support and participation.

1.4.2. PRC: Beijing-Tianjin-Hebei Air Quality Improvement[5] [6]

Project Summary

Modality and Funding: The total loan amount for the program is US$ 4,798.2 million, of which US$300 million is provided by the ADB. Co-financing partners are The World Bank, German Development Cooperation through KfW, PRC central, and location governments.

Project Objectives and Outputs: The project aims to reduce air pollution in the Beijing-Tianjin-Hebei (BTH) region and to enhance public health. The program plans to accomplish its objectives through three primary outputs:

Output 1: Policies and actions to reduce air pollution from key sectors must be issued and approved. This includes strategies like restructuring the energy matrix by reducing coal consumption and advocating for cleaner energy alternatives, advancing public transport in urban areas, and limiting seasonal biomass burning while promoting cleaner energy in rural areas.

Output 2: Strengthened environmental policy and institutional framework for implementation. This includes steps such as improving the monitoring and supervision of municipal coal reduction, allocating a budget for training on air quality surveillance and regulatory enforcement, and enhancing the capacity of the Environmental Protection Department (EPD).

Output 3: Enhanced employment support for inclusive industrial transformation. This targets the reemployment and repositioning of workers who underwent training in 2015–2016 to promote inclusive growth and ensure that the transition to cleaner industries benefits all stakeholders.

[5] ADB. (2016). Air Quality Improvement in the Greater Beijing-Tianjin-Hebei Region—China National Investment and Guaranty Corporation's Green Financing Platform Project: Report and Recommendation of the President. Asian Development Bank (ADB). https://www.adb.org/projects/documents/prc-air-quality-improvement-greater-beijing-tianjin-hebei-cnigc-green-financing-rrp

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These outputs collectively strive to meet the program's objectives of reducing air pollution and improving public health in the BTH region. The combined efforts of policy issuance and implementation, strengthening of the institutional framework, and employment support aim to address the underlying causes of air pollution and foster sustainable development in the region.

Background and context

The BTH region in the PRC plays a critical role in the country's socio-economic development, contributing 10% to the national GDP. However, the region's sustainable growth is under threat due to significant air quality challenges, presenting considerable public health risks. The levels of sulfur and nitrogen oxides, ozone, and inhalable particulate matter (PM 2.5) have escalated to a point where they could cause severe health issues.

In 2014, the BTH region reported an annual average PM 2.5 concentration several times higher than those in the cities of developed countries, totaling an alarming 93.0 micrograms per cubic meter. This level of air pollution urgently calls for effective measures to mitigate its detrimental impacts on public health and ensure the region's sustainable development.

The government of Hebei province has implemented policies and set environmental standards to control air pollution. However, the effectiveness of these measures has been stymied by inadequate data collection, a lack of analytical capability, and insufficient institutional capacity to enforce regulatory compliance.

The vast geographical expanse of the BTH region adds complexity to devising targeted policies and interventions to tackle key pollution sources.

[6] ADB. (2020). Air Quality Improvement in the Greater Beijing-Tianjin-Hebei Region Green Financing Scale up Project: Report and Recommendation of the President. Asian Development Bank (ADB). https://www.adb.org/projects/documents/prc-51033-001-rrp

Another factor is the economic and social implications of reducing the capacity of polluting industries. These industries not only contribute to the region's economy, but also provide employment opportunities to local communities. Therefore, air pollution control measures should be complemented by a comprehensive social protection system and employment opportunities to support affected workers during the transition.

Due to these challenges, current efforts to improve the air quality of the BTH region have not been sufficient. Consequently, a comprehensive program is needed that reduces emissions from major air pollution sources, strengthens the policy framework and institutional capacities for implementation, and addresses socio-economic aspects through enhanced employment support during industrial transformation.

In response to these needs, ADB has proposed a policy-based loan to the PRC for the Beijing-Tianjin-Hebei Air Quality Improvement-Hebei Policy Reforms Program. This program intends to mitigate air pollution in the BTH region through measures that include reducing coal consumption, promoting clean energy, and enhancing public awareness of environmental issues.

Introduction of the project

The Beijing-Tianjin-Hebei Air Quality Improvement-Hebei Policy Reforms Program, a collaborative project between the ADB and PRC, seeks to address the severe air pollution issues prevalent in the broader capital area known as the BTH region.

To reach its goal of diminishing emissions from major air pollution sources, the program executes various policy measures and investment initiatives. One fundamental action is the modification of the energy infrastructure through reducing coal use and an endorsement of clean energy. The program proposes the execution of a time-bound investment plan for expanding the natural gas network, thus speeding up the adoption of cleaner energy sources. It also encourages the retrieval of synthetic natural gas from coke oven flue gas for use in the natural gas distribution network, promoting waste gas utilization for energy production while reducing emissions. Another key initiative involves the swift decommissioning of decentralized heat-only boilers, which are to be replaced with centralized combined heat and power plants equipped with enhanced emission reduction capabilities. This measure aims to augment the efficiency of heating services while curtailing emissions from the residential sector. By adopting quantitative targets, all 11 municipalities in the region are set to reduce raw coal consumption and advocate for centralized, non-coal-fired heating services, providing a clear path toward a transition to cleaner heating sources.

The program also endeavors to bolster the environmental policy and institutional framework to ensure the effective execution and enforcement of measures to control air pollution. This includes revising the Hebei Air Pollution Prevention and Control Regulations to introduce clear, enforceable provisions regarding volatile organic compound (VOC) control, BTH air quality management coordination mechanisms, and accountability for environmental performance. Furthermore, the program aspires to establish provincial VOC emission standards for key industries, targeting 11 sectors to further reduce VOC emissions.

In addition to environmental initiatives, the program acknowledges the need to enhance employment support for inclusive industrial transformation. It proposes better employment assistance and social protection for workers affected by the phasing out of small coal-fired boilers and other industrial production capacity adjustments. This includes the issuance of a provincial government opinion on improved employment and entrepreneurship, which provides guidance and support for those affected.

1.4.3. Mongolia: Ulaanbaatar Air Quality Improvement Program[7] [8]

Project Summary

Modality and Funding: The total loan amount for the program is US$130 million, which is provided entirely by the ADB.

Project Objectives and Outputs: The Ulaanbaatar Air Quality Improvement Program aims to tackle the severe air pollution crisis plaguing Ulaanbaatar, Mongolia. The program focuses on three fundamental areas of reform:

Reform Area 1: Improved implementation action plan efficiency and air pollution control regulatory framework

- Approval of the National Program for Reducing Air and Environment Pollution 2017–2025 and its implementation action plan

- Amendments to laws on air, air pollution fees, and government special funds to enable the collection and use of fees for air quality improvement

- Development of energy efficiency standards for electric stoves and heaters and emission standards for lower-emitting fuel

Reform Area 2: Key measures on air pollution reduction and health protection

- Replacement of approximately 80,000 tons of raw coal used for heating and cooking in the most polluted areas with cleaner-burning processed coal or lower-emitting fuel
- Vaccination of children under the age of 5 years with the pneumococcal conjugate vaccine

[7] ADB. (2018). Proposed Policy-Based Loan Mongolia: Ulaanbaatar Air Quality Improvement Program: Report and Recommendation of the President to the Board of Directors. Asian Development Bank (ADB). https://www.adb.org/sites/default/files/project-documents/51199/51199-001-rrp-en.pdf

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- Installation of insulation and air filtration in kindergartens, schools, and hospitals to reduce exposure to indoor air pollution

Reform Area 3: Mechanisms for environmentally sound and integrated urban, energy, and transport systems

- Development of a roadmap for transitioning to low-sulfur transportation fuel

- Creation of new guarantee products to support investment by small and medium-sized enterprises in products or services to reduce air pollution

- Injection of sufficient capital to establish a credit guarantee fund for air pollution reduction projects

The Ulaanbaatar Air Quality Improvement Program is dedicated to improving air quality, mitigating health risks, and promoting sustainable development, while addressing the various challenges and risks tied to air pollution in Ulaanbaatar. The outcomes of the program include the execution of an enhanced regulatory framework; establishment of measures to reduce air pollution and protect health; and creation of mechanisms that enable the development of environmentally responsible urban, energy, and transport systems.

Background and context

Ulaanbaatar, Mongolia's capital city, is grappling with a severe air pollution issue, earning it the undesirable title of being one of the most polluted cities globally. The city's chilling winters, with temperatures often dropping below -20°C, result in a high demand for heating energy. The primary pollutant source in Ulaanbaatar is raw coal combustion

[8] ADB. (2021). Mongolia: Ulaanbaatar Air Quality Improvement Program and Ulaanbaatar Air Quality Improvement Program – Phase 2: Completion Report. Asian Development Bank (ADB). https://www.adb.org/sites/default/files/project-documents/51199/51199-001-53028-001-pcr-en.pdf

for heating and cooking, predominantly in ger areas—peri-urban settlements lacking basic public services.

The city's rapid urbanization, compounded by an influx of people seeking better opportunities, has led to haphazard and inadequate urban development, intensifying air pollution. The expansion of ger areas without the necessary infrastructure such as water, sanitation, heat supply, and public transport further aggravates issues pertaining to pollution. The reliance of the government and private buildings on highly polluting and inefficient coal-fired heat-only boilers also negatively impacts air quality.

Air pollution in Ulaanbaatar carries substantial repercussions. High levels of fine particulate matter in the air has severe health impacts such as increased medical expenses, lost productivity, chronic diseases, and reduced life expectancy, particularly among vulnerable populations like children. The economic and social welfare of the city's residents, especially those in low-income households, is detrimentally affected by pollution.

The Mongolian government, acknowledging the pressing need to address air pollution, has undertaken efforts to mitigate it. It has implemented the National Program for Reducing Air and Environment Pollution 2017-2025, a program aimed at combating air pollution and enhancing air quality. Despite these measures, the existing initiatives have failed to effectively tackle Ulaanbaatar's air pollution issue due to the scale thereof.

Several factors have presented challenges to the government's initiatives, including inadequate implementation of the national program, weak regulatory frameworks, and limited financial resources, all of which have impeded air quality improvement. Moreover, a lack of public awareness regarding the connection between fuel use, air pollution, and health impacts has hindered the adoption of cleaner technologies and practices.

Considering the severity of the air pollution problem and limitations of the government’s efforts, the ADB supports the Ulaanbaatar Air Quality Improvement Program through a loan of US$130 million. The program aims to provide additional resources and bolster efforts to improve Ulaanbaatar's air quality. Raising the public’s awareness of the links between fuel use, air pollution, and health impacts is a crucial part of the program, as understanding these connections is important in encouraging cleaner technologies and practices.

Introduction of the project

The Ulaanbaatar Air Quality Improvement Program, a comprehensive initiative targeting Ulaanbaatar's severe air pollution, one of the most polluted cities worldwide.

The program pursues three main reform areas: improving the national program's implementation for reducing air and environment pollution; adopting air pollution reduction measures and health protection strategies; and creating mechanisms for environmentally friendly and integrated urban, energy, and transport systems.

The program's initial goal is to enhance regulatory frameworks, increase coordination among relevant government agencies, and effectively monitor and enforce air quality standards. This includes approving the national program's implementation action plan, which authorizes policy actions to mitigate air pollution.

To reduce air pollution and protect health, the program focuses on replacing household coal-burning stoves with district heating systems. Financial aid for procuring lower-emitting fuel, such as semi-coke briquettes, will be provided, especially for impoverished and female-led households in ger areas. It also intends to retire inefficient and highly polluting coal-fired heat-only boilers, replacing them with district heating, electricity, or non-coal heating alternatives.

The program includes plans to extend the district heating infrastructure and vaccinate around 40,000 children with the pneumococcal conjugate vaccine to combat respiratory illnesses and improve overall health.

Furthermore, the program aims to develop an air quality and emission compliance monitoring upgrade strategy in collaboration with the Municipality of Ulaanbaatar (MUB) and Ministry of Road and Transport Development (MRTD). The plan is to finalize a study on climate change adaptation to identify strategies to address the impacts of climate change on the city's urban and energy systems.

Capacity building and awareness-raising activities are also essential aspects of the program. The Ministry of Environment (MOE) and MUB will launch an education and outreach program to raise awareness about air pollution and reduction measures among the public, schools, and community organizations.

Emphasizing gender equality and social inclusion, for the education and outreach programs, a target of at least 50% female participation has been set, focusing on female-led households. It also encourages establishing a multi-stakeholder coordination mechanism led by the MOE and MUB to oversee the program's implementation and to facilitate information sharing, joint decision-making, and effective coordination of efforts.

The program includes a comprehensive monitoring and evaluation framework to track policy actions, measure air pollution reduction, and assess health and environmental outcomes. Regular monitoring and evaluation will ensure the program remains on track to achieve its objectives.

In conclusion, the Ulaanbaatar Air Quality Improvement Program, through a combination of improved implementation of the national program, air pollution reduction measures, and

establishment of environmentally friendly systems, seeks to improve Ulaanbaatar's air quality and protect public health. By fostering awareness, gender equality, and stakeholder coordination, the program aims to create a sustainable and healthy future for Ulaanbaatar.

1.5 INTEGRATION AND COMPARISON

While all three projects—in Pakistan, the PRC, and Mongolia—are designed to mitigate the impact of climate change by reducing emissions, they differ in focus (see Table 1.1). Pakistan's project primarily targets energy sector reforms to address power shortages and fiscal issues related to energy production. The main challenge was dealing with the chronic power shortage and circular debt issue. Hence, strong actions were taken on tariff management, sector performance, and corporate governance. In contrast, the PRC's project focuses on air quality improvement, especially PM2.5 reduction, by decreasing production in polluting industries and adjusting the energy structure.

For that country, balancing environmental goals with social protection and industrial transformation was a significant challenge. The project combines policy measures, capacity reduction in polluting industries, and social protection considerations, indicating a more comprehensive approach. The Mongolian project also focuses on air quality; however, the policy actions do not stop at mitigating climate change. They also focus on urban adaptation including transportation system reform, replacing heating fuels, and green financing.

Noteworthy is that the Mongolian project included practical measures such as disseminating fewer polluting briquettes as a replacement for raw coal and implementing a vaccination program to reduce the health risks from COVID-19.

All three programs implemented policy actions to reduce emissions and were considered successful based on the evaluations in completion reports. However, many issues occurred and some lessons were learned during the process.

The varying levels of success in each of these cases can be attributed to different degrees of political commitment, institutional capacity, the effectiveness of international development partners, and flexibility of program design and execution in response to national contexts. For example, Pakistan's initiative faced persistent issues of circular debt in the energy sector stemming from complex factors such as tariff-cost mismatches, special tariff arrangements driven by social and political considerations, and rising energy generation costs.

Despite international interventions, key issues remained unresolved, highlighting the crucial lesson that resolving such deep-rooted problems requires robust political support and leadership. Notably, instances of significant progress in Pakistan were associated with active leadership driving reforms, which emphasizes the role of committed leadership in enabling transformative change. In contrast, the PRC’s air quality improvement program had more successful outcomes, which were underpinned by the ADB's profound involvement in policy design and the government’s strong commitment. The PRC case reinforces the fact that sustained engagement by international organizations, in conjunction with active participation from local governmental bodies in policy discussions and design, can result in effective programs.

The significance of coordinated efforts between international development partners to bolster policy effectiveness is evident in the financing collaboration involving the ADB, World Bank, and KfW. The program in Mongolia, which focuses on cross-sector issues like air quality, highlights the role of governmental coordination and continued political commitment in successful implementation. Notably, the program's intervention during the COVID-19 pandemic showcased the essential role of policy flexibility and adaptability in crisis situations. The Mongolia case underscores the necessity for comprehensive policy frameworks complemented by well-coordinated actions and capacity building to ensure long-term program success.

Various methods to augment financial resources for the programs were evident. For the energy sector reform program in Pakistan, to reduce the sector’s fiscal pressure and activate private capital, the initial focus was on the strategic sales of DISCOs to private entities. However, this was hindered by political issues, and the government later pivoted toward partially listing shares of high-performing DISCOs in the stock market to improve performance. Despite challenges in privatization, the reform program aimed to enhance the performance of the sector overall, decreasing circular debt and increasing accountability and transparency. The ADB’s role and guidance were crucial throughout this process, as it provided critical financial and advisory support to ensure the smooth transition and execution of these reforms.

As part of the Mongolia program, the country’s green financing mechanism supported projects focusing on climate resilience, green construction, and energy efficiency. It prioritized funding for projects that gave preferential access to women. This mechanism, managed by the National Committee on Reducing Environmental Pollution and the Ministry of Environment and Tourism, subsidized loans to eligible low-income households and entities. It supported the use of green solutions such as electric heaters and clean heating to reduce air pollution, particularly in ger areas. Commercial banks like Khaan Bank, Khas Bank, and State Bank provided green loans and interest subsidies, benefiting more than a hundred borrowers, almost half of whom were women.

Here, ADB contributed US$290 million in two phases to subsidize these loans. In addition to this financial support, ADB provided technical assistance in the form of environmental education programs, air quality monitoring, and the introduction of green technology. It also actively engaged with the Mongolian government and stakeholders in policy discussions to ensure the program's success. In addition to these efforts, ADB kept exploring the potential of co-financing to ensure the success of the programs. Unlike the PRC program, the other two programs were initially designed to be financed solely by ADB. However, until the projects were completed, an additional US$100 million for Pakistan and US$60 million for Mongolia was co-financed by the Agence Française de Développement (AFD) and Export-Import Bank of Korea.

ADB has also been instrumental in providing technical assistance to the Pakistan and Mongolia programs, although not for the PRC program. This assistance addresses challenges and areas of development unique to each country. In Pakistan, the focus of ADB's assistance was on enhancing the capacity and efficacy of the energy sector. Collaborating with other development partners like the World Bank, JICA (Japan International Cooperation Agency), and (U.S. Agency for International Development) USAID, ADB directed its resources toward strengthening the regulatory structure of the CPPA, managing circular debt, and refining energy sector legislation, among other aims. This support was expressed in the form of a parallel knowledge technical assistance; the provision of legal, financial, and regulatory consultants; and preparation of an additional technical assistance loan—which was cancelled without disbursements—to augment the functions of the reform monitoring unit in the Implementation and Economic Reforms Unit (IERU).

In contrast, in Mongolia, the technical assistance had a more environmental focus, employing US$1.2 million across different phases to design and implement key elements of the country's environmental reform program. Specifically, the technical assistance aimed to deliver environmental education and outreach programs, monitor air quality, control pollution, and introduce green technologies and financing mechanisms. It then expanded to include climate adaptation strategies, urban resilience efforts, the development of a clean heat supply plan for ger areas, and conducted studies on longer-term electric heating tariff structures. While some activities remain under implementation, this technical assistance has enhanced Mongolia's approach to environmental sustainability and climate resilience. Despite the contrasting areas

of focus, the purpose of ADB's technical assistance in Pakistan and Mongolia was to provide expertise, promote dialogue, and foster development tailored to each country's needs and circumstances.Note that the Mongolia program was the only one of the three that incorporated gender mainstreaming. The gender equity actions in the Mongolia program, divided into phases 1 and 2, aimed to ensure significant female involvement and benefits.

In phase 1, gender actions included ensuring a 50% participation rate of women in education and outreach programs, prioritizing low-income households headed by women in the distribution of lower-emitting fuel, and integrating gender analysis in the study on innovative heating technologies.

In phase 2, gender-targeted actions involved guaranteeing a participation rate of at least 40% of women in the community engagement program, achieving a 25% vaccination coverage for pregnant women nationwide with flu shots, and operationalizing the green finance mechanism with preferential access for women.

These actions were successfully implemented and exceeded their targets. For instance, the Community Engagement Program garnered a 56% participation rate from women. Similarly, vaccination coverage surpassed the target, with 60% of pregnant women and children receiving flu shots by October 2020. Finally, the operationalization of the green financing mechanism benefited women substantially, who represented 56% of beneficiaries in the community engagement program and 40% of green loan borrowers. The program effectively mainstreamed gender equity into its actions, ensuring substantial female involvement and benefits.

Table 1.1. Comparative overview of the three selected PBL projects in Pakistan, the PRC, and Mongolia

Criteria/Project	Pakistan Project	PRC Project	Mongolia Project
Project Name	Pakistan: Sustainable Energy Sector Reform Program - Subprogram 3	Beijing-Tianjin-Hebei Air Quality Improvement	Mongolia: Ulaanbaatar Air Quality Improvement Program
Objective	To address power shortages and fiscal issues	To improve air quality	To improve air quality through urban adaptation
Methods	Strong policy actions were implemented on tariff management, sector performance, and corporate governance.	Structural policy actions were implemented to reduce production in polluting industries and adjust the energy structure.	Policy actions were implemented in reforming the transportation system, replacing heating fuels, and green financing with practical measures such as replacing sources of fuel and a vaccination program.
Evaluation	Successful	Successful	Successful
Lessons learned	Lack of robust political support and leadership could stagnate policy reforms.	Strong government commitments and seamless cooperation with ADB could present swift and smooth policy reform actions.	Comprehensive policy frameworks, complemented by well-coordinated actions and capacity building, could ensure long-term program success.
Co-financing	Financed only by ADB initially and co-financed by AFD at a later stage	Co-financed by The World Bank, German Development Cooperation through KfW, PRC central, and location governments	Financed only by ADB initially and co-financed by the Export-Import Bank of Korea later and through mobilizing private capital
Technical Assistance	To enhance the capacity and efficacy of the energy sector	None	Several programs in cleaner fuels, vaccination, green technology and finance, and monitoring air quality, etc.
Gender mainstreaming	None	None	To ensure vaccination coverage and promoting green finance

Source: By author

1.6 RECOMMENDATIONS

1.6.1. Strong national leadership and long-term engagement

The programs in Pakistan, the PRC, and Mongolia underscored the critical role of strong national leadership in driving and implementing significant reforms to improve air quality. In Pakistan, despite the successes achieved, implementing policy reforms presented unique challenges that required consistent political ownership and commitment from key government agencies. This was especially true when addressing cross-sector issues such as air quality was complex and necessitated robust coordination between ministries and agencies.

On the other hand, long-term engagement, as seen in the cases of the PRC and Mongolia, was also pivotal in advancing reforms and sustaining their impacts. In the PRC, the ADB's continued engagement with the Hebei Provincial Government through follow-on loans, policy dialogue, and strategic technical assistance amplified the impact of policy reforms. In Mongolia, ongoing engagement with the government, supported by ADB and other development partners, helped sustain momentum toward improving air quality in Ulaanbaatar and other satellite cities, demonstrating the transformative potential of long-term commitment. Strong government commitment and solid progress will also encourage more development agencies to participate in development projects, boosting the progress of climate change adaptation and mitigation.

1.6.2. Tailor-made structural reforms and innovations to address climate change adaptation and mitigation

The three case programs emphasize the critical role of structural reforms in tackling multi-faceted climate change challenges. In Pakistan, energy sector reforms focused on addressing tariff rationalization and subsidy reduction, driving a sustainable energy transition while ensuring social equity. The program in the PRC aimed at industrial transformation and human capital enhancement to foster a green economy and low-carbon urban development. Mongolia's comprehensive approach encompassed coal-free solutions and gender-responsive strategies, reflecting the interconnection of environmental, social, and economic factors in climate actions.

Furthermore, tools such as privatization, co-financing, and establishing a green financing mechanism were used in some programs to increase fiscal resources for better implementation. Through these focused reforms, each program demonstrates how tailor-made reforms and innovations can effectively confront the complexity of climate change issues. The experiences could be applied in future projects for a thorough research of the status quo and tailor-made project designs. Important game-changers such as capacity building, comprehensive industrial transformation and co-financing are ought to be considered along with the main objective for overall succession.

1.6.3. Full usage of ADB's knowledge bank to provide technical assistances for a greener transition

Technical assistance played a pivotal role in both the Pakistan and Mongolia case programs. In Pakistan, technical assistance facilitated inter-agency coordination and policy execution for complex issues such as air quality, while promoting capacity building. In Mongolia, the ongoing technical assistance in phase 2 of the project was instrumental in sustaining policy actions, developing clean energy measures, and ensuring data collection for air quality improvement.

Essentially, technical assistance served as a bridge, ensuring efficient coordination, knowledge transfer, and the sustainability of reforms in both programs. The Mongolia program highlighted the critical role of gender actions (embedded in technical assistance) in tailoring equitable solutions to air pollution and related health issues.

This inclusive approach, accounting for the specific vulnerabilities of women and girls, resulted in more effective outcomes and ensured the shared benefits of improved air quality and health across all segments of society.

As it was shown in the results, capacity building, which usually cost minimal compared with the scale of the entire loan project, is worth of playing an increasing important role in upcoming climate mitigation and adaptation projects for addressing urgent needs and long-term development issues.

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CHAPTER 02

ACHIEVING CARBON NEUTRALITY IN THE CAREC REGION:

Barriers, Challenges, and Policy

Falendra Kumar

2.1 INTRODUCTION

Climate change, as a consequence of unrelenting CO_2 emissions, has immensely impacted the environment (Clémençon, 2023). Indeed, the surge in global temperature induced by greenhouse gases (GHGs) has affected human well-being (Shivanna, 2022). Thus, CO_2 emissions must be reduced by 45% in 2030 from 2010 levels and net-zero emissions (NZEs) must be achieved by 2050 (Liu & Raftery, 2021). Limiting global warming and mitigating climate change also entail restricting the global temperature rise at 1.5 °C (Warren et al., 2022). Therefore, retiring fossil-based energy and promoting clean energy technologies are imperative (Lv, 2023).

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World leaders have arrived at an agreement to achieve carbon neutrality, defined as the achievement of NZEs by matching carbon emissions with its elimination to halt its surge, for mitigating climate change and addressing energy crises. The development of clean and renewable technologies can improve energy efficiency to achieve carbon neutrality. Carbon neutrality requires decarbonization, low carbon development, and low carbon transition via switching to clean energy resources. Decarbonization refers to the method of lowering the carbon intensity of primary energy resources (Donthi, 2020). Low carbon development implies the decline in fossils energy intensity in both the productive and consumptive activities (Bai et al., 2023). Low carbon transition refers to a procedure for reducing CO_2 emissions (Slameršak et al., 2022).

The pathways to achieving the 2 °C goal of the 2015 Paris Agreement and tracking the likelihood of meeting the 1.5 °C goal by 2050 include the integration of NZEs in policy planning and decision-making (Brecha et al., 2022). Accordingly, national governments have announced voluntary pledges to reach climate targets through Intended Nationally Determined Contributions (INDCs), which have evolved into the first Nationally Determined Contributions (NDCs) that help countries execute their climate change agenda after 2020. The NDCs offer new financial tools to help developing economies lower their CO_2 emissions. Achieving carbon neutrality will be the chief pathway to a sustainable Central Asia Regional Economic Cooperation (CAREC) region. Against this backdrop, this study analyzed the trends and drivers of GHGs emissions in CAREC member countries, as well as carbon neutrality in the region, including the barriers and challenges, pathways, and policy implications.

2.2 LITERATURE REVIEW

In recent decades, global warming has increased the climate risks across different regions (Yamori & Goltz, 2021), severely impacting societies worldwide (Griffiths & Sovacool, 2020) and considerably harming ecosystems (Kong & Sun, 2021). Increasing climate risks have significantly impacted water and food sources, human health, and the environment (Monjardino et al., 2021). The unprecedented rise in temperature has produced disastrous effects on animal habitats and marine resources, sped up glacier melting (Abbasi, 2021), and impeded future development (Kawashima et al., 2021) and social growth (Amo & Ganu, 2020). Achieving carbon neutrality can save the global community from the harms of global warming and severe climate crises (Chi et al., 2021).

Carbon neutrality requires the decarbonization of the energy sector, which can be achieved by the rapid reduction in renewable energy costs (He et al., 2020), sequestration of thermal power (Wang et al., 2021a), and application of bioenergy with carbon capture and storage (BECCS) techniques (Yang et al., 2021). Technological and policy inducements can aid in reaching NZEs by 2070 (Rissman et al., 2020). For example, the cement and steel industries are considering decarbonization policies (Ren et al., 2021). The building sector has also planned to achieve decarbonization (Xing et al., 2021). Notably, the transportation sector, particularly the air, sea, and cargo components, faces substantial challenges to achieving carbon neutrality (Chiaramonti & Maniatis, 2020). Meanwhile, passenger transport can reach NZEs by 2050 (Bu et al., 2021). Van Soest et al. (2021) thoroughly analyzed the effect of energy transition on energy system and found that Brazil and the United States (US) are likely to achieve NZEs a decade prior to the global average compared to late phase-out year in India and Indonesia due to differences in carbon storage, transport emissions, and non-CO2 emissions.

Despite all efforts to reduce emissions globally, considerable gaps remain between reduction targets and achievements to reach the goals of the Paris Agreement (Bonoli et al., 2021). Carbon neutrality can lower carbon emissions steadily (Shi et al., 2021) via multiple pathways (Broadstock et al., 2021), such as building green corridors (Attahiru et al., 2019), addressing cultural barriers (Sovacool & Griffiths, 2020), promoting clean technologies (Ren et al., 2021), and encouraging low-carbon behaviors (Wang et al., 2021b). However, most studies have focused on the 2°C or 1.5°C goals and paid cursory attention to the carbon neutrality targets (Duan et al., 2021). Studies on carbon neutrality have also paid scant attention to the context of the CAREC regional economies, except the People's Republic of China (PRC). Therefore, the present study is a modest attempt to fill this knowledge gap.

2.3 OBJECTIVES AND METHODOLOGY

This study probed the following research questions focusing on CAREC member countries. What are the trends and drivers of GHGs emissions in CAREC economies? What are the barriers and challenges with respect to achieving carbon neutrality in the CAREC region? How do governments of CAREC countries develop the pathways to achieving carbon neutrality? What policy actions should be prioritized to achieve carbon neutrality? This qualitative study used a multi-method approach, implementing theoretical and data triangulations and desk research.

The multi-method design combines qualitative and quantitative approaches (Fetters & Molina-Azorín, 2017) to produce comprehensive insights regarding complex phenomena (Tashakkori & Teddlie, 2020). The multi-method approach surmounts the weakness of a single technique (Fetters, 2020) and enhances the authenticity and consistency of research results (Tashakkori & Teddlie, 2020). This approach can be applied in the triangulation of research corroborations using qualitative or quantitative techniques (Onwuegbuzie & Johnson, 2019).

The present study referred to varied data sources and theoretical reports for analysis using triangulation to validate the data and theoretical understanding of the problem under investigation. Triangulation refers to the authentication of data and theoretical perspectives by cross-examination of different sources related to a phenomenon (Denzin, 2012). It also entails the application of diverse theoretical angles to elucidate identical data from different stakeholder perspectives. This study conducted both data and theoretical triangulation to validate the research inferences. Data triangulation involves triangulating varied data sources to evaluate and authenticate their uniformity, whereas theoretical triangulation refers to the application of theoretical analysis to identify different aspects of the phenomenon under study. Data triangulation can enhance trust in data sources and improve the analysis of the problem under investigation (Stavros & Westberg, 2009). Theoretical triangulation can lower alternative descriptions of a phenomenon and offer profound research analysis (Banik, 1993). Therefore, this research integrated data and theoretical triangulations to enhance the reliability of research results, mitigate biases, and offer diverse perspectives.

The study also used a descriptive method for content analysis to triangulate the data and information from multiple sources. The secondary data were collected from various national and international publications. The study used the Key Indicators Database of the Asian Development Bank (ADB), International Energy Agency (IEA), and country reports of the governments of the CAREC member countries to elicit pertinent data and information on the phenomenon under study. The study then applied deductive content analysis on the collected data. Qualitative research and descriptive approach were implemented to analyze the scenarios in their present state, specifically when extant information was scant. Therefore, this study used qualitative methods to analyze the trends and drivers of carbon neutrality and to ascertain the barriers, challenges, and pathways to achieving carbon neutrality in CAREC countries, as well as to draw

theoretical contributions and practical implications. Notably, data were not available for all CAREC member countries for different aspects of carbon neutrality, which represented the major limitation of this study.

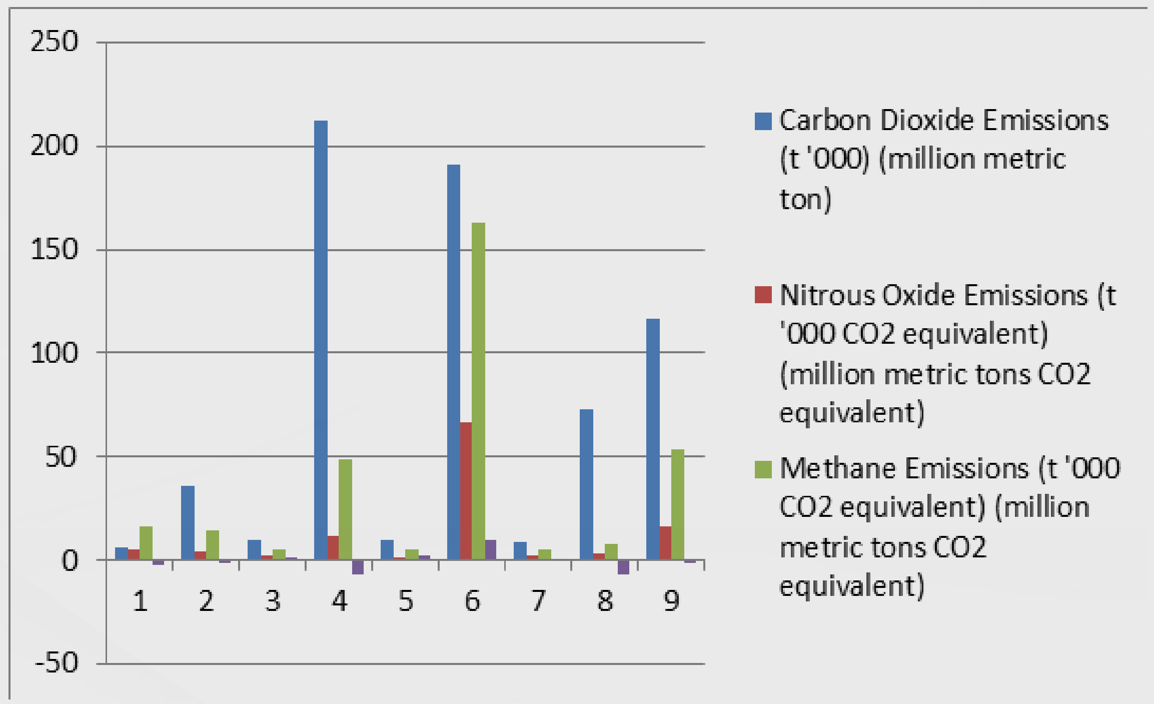
2.4 TRENDS AND DRIVERS OF GREENHOUSE GASES EMISSIONS IN THE CAREC REGION

The CAREC member countries are Afghanistan, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Mongolia, Pakistan, Tajikistan, the PRC, Turkmenistan, and Uzbekistan. Most of the regional economies are landlocked. The region is highly susceptible to climate change impacts, and reliance on fossil fuels for productive and consumptive activities is significant.

2.4.1 Trends of Greenhouse Gases Emissions

Figure 2.1 shows that CAREC economies emit considerable carbon emissions, mostly from industry, agriculture, and energy generation and use. In the region, carbon emissions were substantial in the PRC, at 10,707 million metric tons (mmt) in 2019, owing to the sheer size of the economy. In the PRC, the nitrous oxide and methane emissions were estimated at 555 and 1,176 million metric tons carbon dioxide equivalent (mmtCO2e), respectively, in 2019, whereas other GHGs showed a decline of 364.71 mmtCO2e. The PRC’s carbon emissions stood at 29.4% of global emissions in 2019, making the PRC the biggest emitter of carbon globally. It announced its target of reaching carbon peak and carbon neutrality by 2030 and 2060, respectively, to usher in a climate economy. Other CAREC countries also emitted considerable carbon, nitrous oxide, and methane emissions. In 2019, GHGs emissions declined in most CAREC countries but not in Pakistan, the Kyrgyz Republic, Georgia, and Turkmenistan. Pakistan recorded emissions of 10.23 mmtCO2e in the same year.

Figure 2.1. Emissions in CAREC countries excluding the PRC, 2019



Source: Author's creation based on the ADB's Key Indicators database.

The Paris Agreement entails maintaining the average global temperature rise to below 2°C and to restrict it to 1.5 °C to avert the harmful effects of climate change. NDCs are expected to reduce half of the emissions to reach the 2°C target. All CAREC member countries have endorsed the Paris Agreement and set their INDCs targets and updated their NDCs based on their COP26 pledges (Table 2.1). CAREC member countries' NDCs targets reflect vigorous pledges to lower GHGs emissions and achieve carbon neutrality. However, several CAREC countries may not reach the targets envisaged in their NDCs without new policies. Therefore, additional efforts are needed.

Table 2.1. CAREC Member Countries' Targets for Intended Nationally Determined Contributions (INDCs) and Updated Nationally Determined Contributions (NDCs)

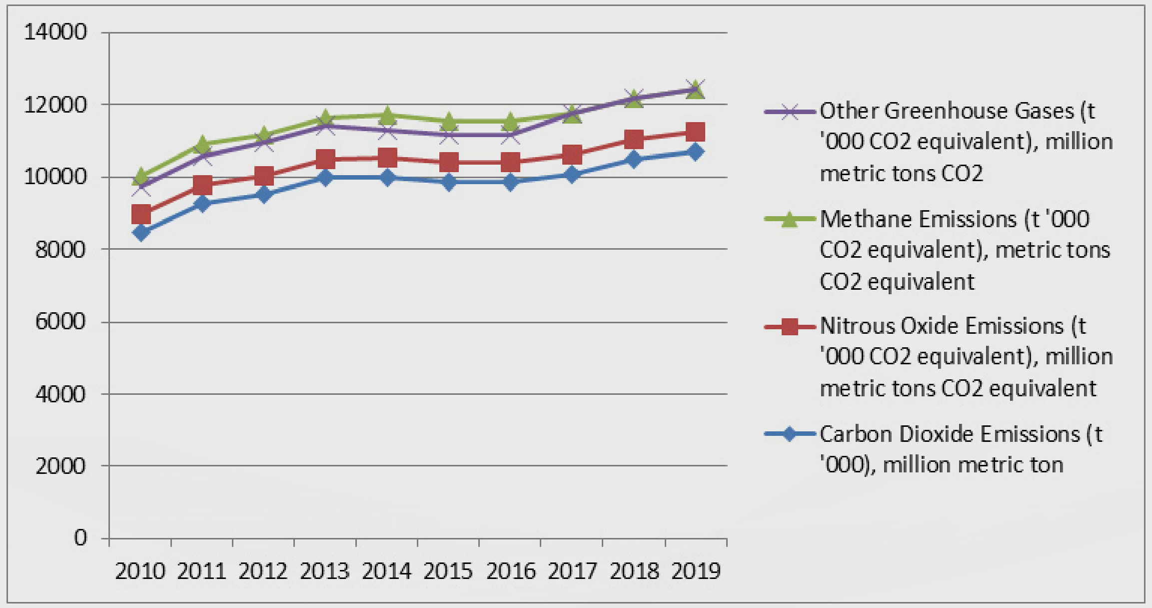
Country	First INDCs Targets for GHGs Emissions Reduction	Updated NDCs Targets for GHGs Emissions Reduction
Azerbaijan	35% by 2030 from 1990 level	No new target submitted
Georgia	15% by 2030 below BAU scenario for 2030 Equal to reduction in emission intensity per unit of GDP by 34% from 2013 to 2030	35% by 2030 from 1990 level 50%–57% by 2030 from 1990 level, subject to international assistance
Kazakhstan	15% by 2030 from 1990 level 25% by 2030 from 1990 level, subject to international assistance	No new target submitted
Kyrgyz	11.49%–13.75% by 2030 from 2010 level	15.97% under BAU scenario by 2030 from 2017 level
Republic	29%–31% by 2030 from 2010 level, subject to international assistance	43.62% by 2030 from 2010 level, subject to international assistance
Mongolia	14% by 2030 under BAU scenario	22.7% by 2030 under BAU scenario 27.2% by 2030, subject to mitigation measures
Pakistan	20% by 2030 from 2015 level subject to international assistance	50% by 2030 from 2015 level 15% from domestic resources 35% subject to international assistance
PRC	60%–65% by 2030 from 2005 level	65% to achieve carbon peaking by 2030 and carbon neutrality by 2060
Tajikistan	23%–35% by 2030 from 1990 level	50%–60% by 2030 from 1990 level
Turkmenistan	GHGs emissions in tune with GDP growth by 2030	No new target submitted
Uzbekistan	10% by 2030 from 2010 level	35% by 2030 from 2010 level

Note. BAU, business as usual. Source: Author's compilation based on country reports.

Figure 2.2 shows the carbon emissions in the PRC. The country's carbon dioxide, nitrous oxide, and methane emissions increased from 2010 to 2019 and revealed a fluctuating trend. Its emissions of other GHGs showed a declining but fluctuating trend from 2010 to 2016. For the period 2010–2019, the PRC's growth in energy consumption stood at 4% despite equal reduction in energy intensity, reflecting its economic structure. The PRC recorded 2% surge in total per capita CO2 emissions in recent years. In 2020, the PRC added 32% to the global carbon emissions. In 2021, the PRC integrated its goals of carbon peaking and carbon neutrality in its 14th five-year plan (2021–2025). This indicated the significance of carbon neutrality in the PRC's development policy. The PRC had already shown notable performance in tackling climate change under its 13th five-year plan (2016-2020), which reflected a considerable reduction in GHGs emissions intensity by 18.2% in 2020 from 2015 levels. The PRC has also achieved steady progress in energy conservation. It has steered low-carbon cities toward carbon neutrality targets.

Apart from carbon peaking and carbon neutrality plans for cities during the 14th five-year plan, the PRC has also initiated policies covering energy, industry, transport, construction, finance, and technology. Carbon-neutral targets are envisaged via clean energy, waste recycling, and a circular economy. The PRC's state-owned companies and private firms have also developed carbon-neutral plans.

Figure 2.1. Emissions in CAREC countries excluding the PRC, 2019

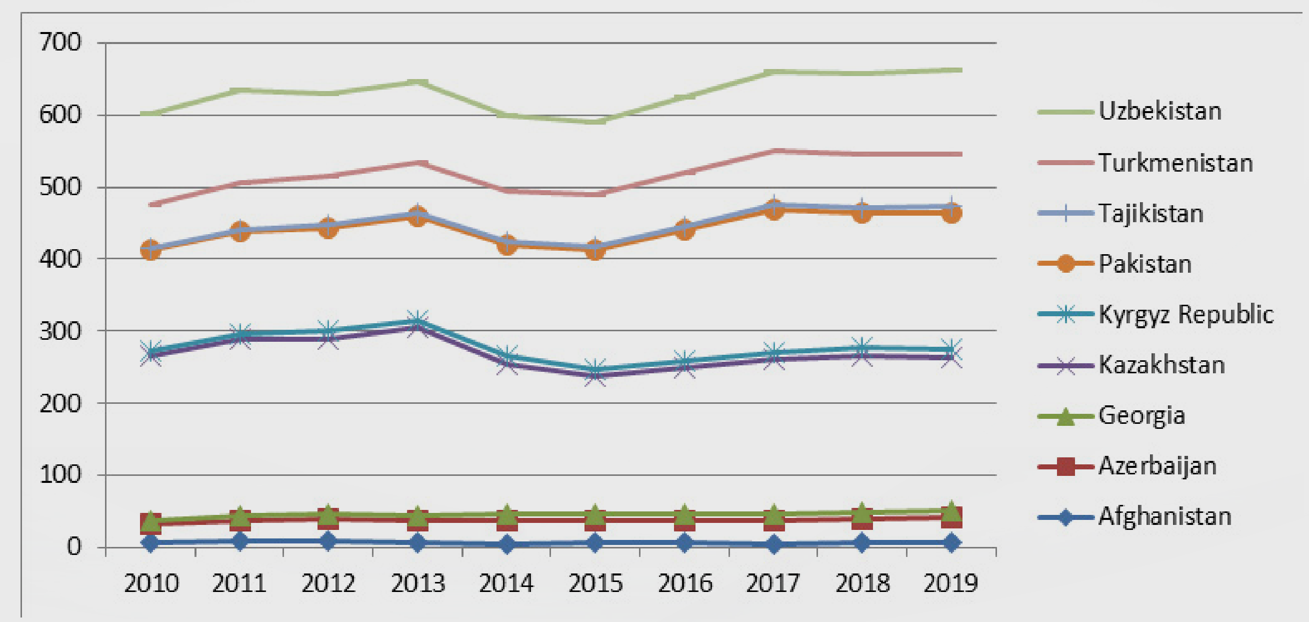


Source: Author's creation based on the ADB's Key Indicators database.

Figures 2.3a-2.3d depict the emissions trends in CAREC member countries excluding the PRC during 2010–2019. Figure 2.3a reveals the considerable carbon dioxide emissions of Kazakhstan, Pakistan, Uzbekistan, and Turkmenistan, at 212.11, 190.57, 116.7, and 72.87 mmt, respectively, in 2019, up from 229.69, 140.61, 126.23, and 59.18 mmt from 2010, respectively. Only three CAREC member countries, namely, Afghanistan, Kazakhstan, and Uzbekistan, reduced carbon dioxide emissions from 2010 to 2019. Turkmenistan had a steady surge, whereas other CAREC member countries had a fluctuating trend over the period. Figure 2.3b portrays the trend in nitrous oxide emissions. Pakistan remained the largest contributor of nitrous oxide emissions at 66.67 mmt in 2019, up from 53.51 mmt in 2010. Uzbekistan recorded a steady surge in nitrous oxide emissions from 2010 to 2019, whereas all other CAREC member countries had increased nitrous oxide emissions and displayed a fluctuating trend over the period.

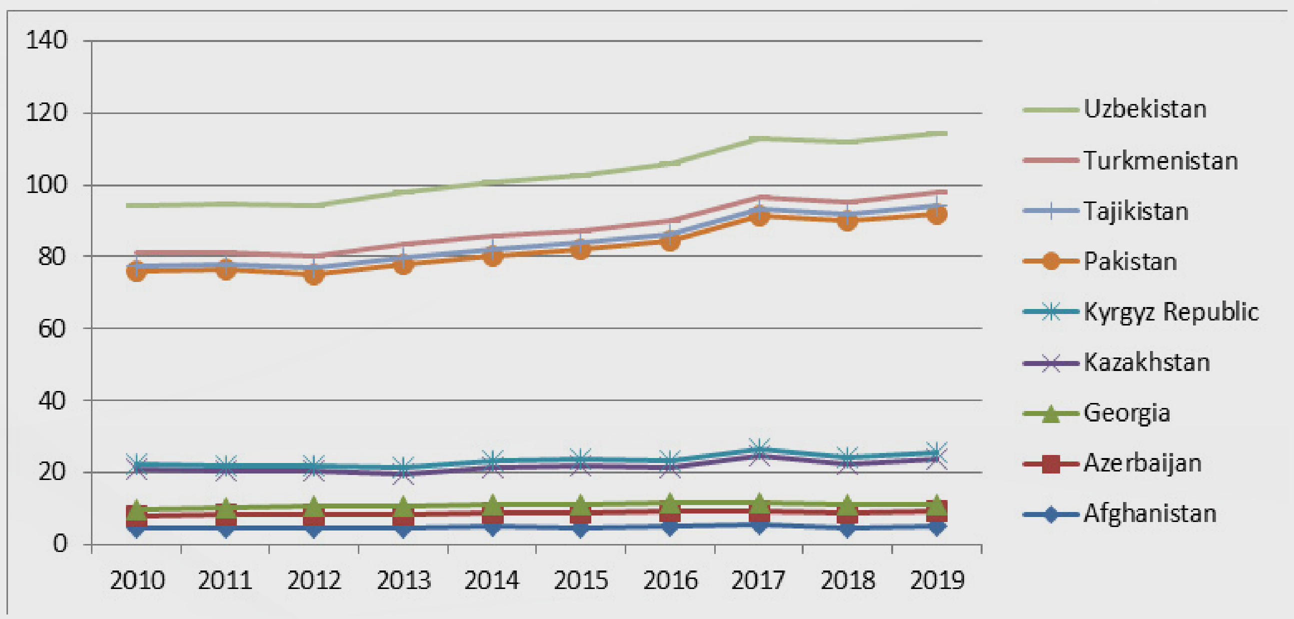
Figure 2.3c shows the trend in methane emissions from2010 to 2019. Pakistan, Turkmenistan, and Kazakhstan contributed significant amounts of methane emissions in 2019 at 162.79, 80.48, and 48.88 mmt, respectively, up from the 2010 amounts of 125.45, 53.74, and 48.59 mmt, respectively. The Kyrgyz Republic and Tajikistan recorded a steady increase in methane emissions, albeit at a low level. Pakistan experienced a significant increase, whereas other CAREC countries showed fluctuating trends. Figure 2.3d reveals that Pakistan has significantly increased emissions of other GHGs, from 3.53 mmt in 2014 to 10.23 mmt in 2016 despite considerable declines from 2010 to 2013. Despite the NDCs targets to lower emissions, the Kyrgyz Republic and Georgia recorded positive contributions of other GHGs emissions from 2010 to 2016 and 2012 to 2016, respectively. Turkmenistan experienced a decline in other GHGs emissions from 2010 to 2016 and recorded the highest decline of 6.86 mmt in 2016 in the CAREC region excluding the PRC, which displayed immense decline of 364.71 mmt in 2016.

Figure 2.3a. Carbon dioxide emissions(t '000) (million metric tons)



Source: Author's creation based on the ADB's Key Indicators database.

Figure 2.3b. Nitrous oxide emissions (t '000 CO^2 equivalent), million metric tons CO^2 equivalent



Source: Author's creation based on the ADB's Key Indicators database.

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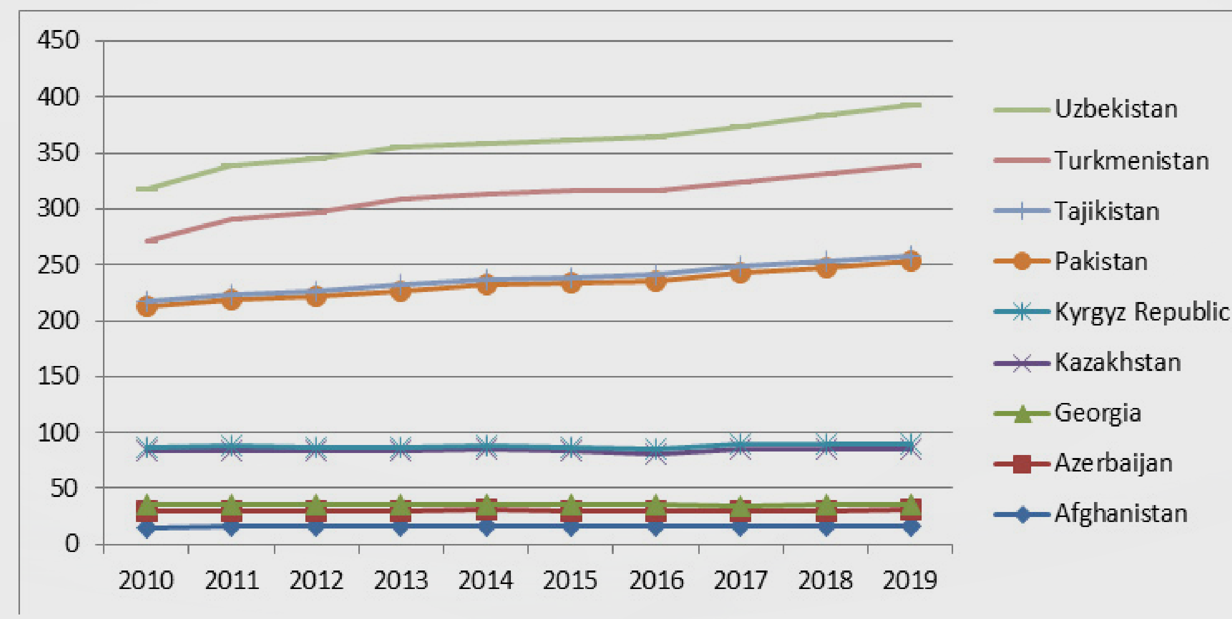
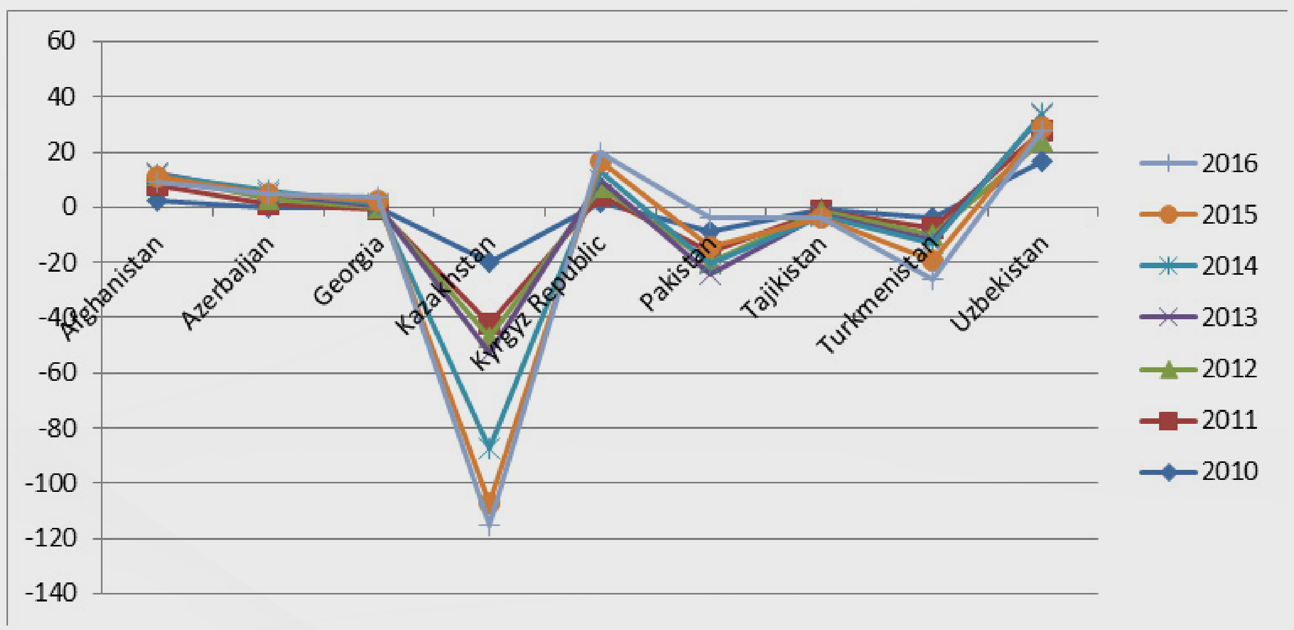
Figure 2.3c. Methane emissions (t '000 CO^2 equivalent), metric tons CO^2 equivalent



Source: Author's creation based on the ADB's Key Indicators database.

Figure 3d. Other Greenhouse gases (t '000 CO_2 equivalent), million metric tons CO2 equivalent



Source: Author's creation based on the ADB's Key Indicators database.

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Thus, CAREC member counties have lowered GHG emissions considerably compared to with global average. In 2010-2019, global GHGs emissions surged by 50%. Meanwhile, most of the CAREC member countries emitted lower than 1990 levels during this period, attributed to their lower application of fossils-based energy, economic reforms, and enhanced energy efficiency. CAREC member countries lowered their GHGs emissions alongside advancing development, managing to maintain the surge in GHGs emissions considerably lower than the output growth. Thus, the CAREC region displayed robust evidence in separating output performance from GHGs growth compared with other regions. Moreover, CAREC member countries formed considerable prospects to foster lower GHGs emissions vis-à-vis economic growth by leveraging their immense potential to enhance energy saving and efficiency using green energy generation.

Substantial hydro generation potential remained unexploited in Georgia, Kazakhstan, the Kyrgyz Republic, and Tajikistan. Some CAREC member countries have considerable potential to develop wind and solar energy production. In this context, strong regional cooperation would be imperative to tap the potential of green energy resources, develop clean energy technologies, and achieve carbon neutrality targets in the CAREC region. Robust regional cooperation can foster stronger energy trade via collaborative investments in energy trade infrastructure. Therefore, the CAREC Energy Strategy 2030 can be leveraged for cross-border energy trade cooperation to boost energy security and attract much-needed investments in the development of energy networks.

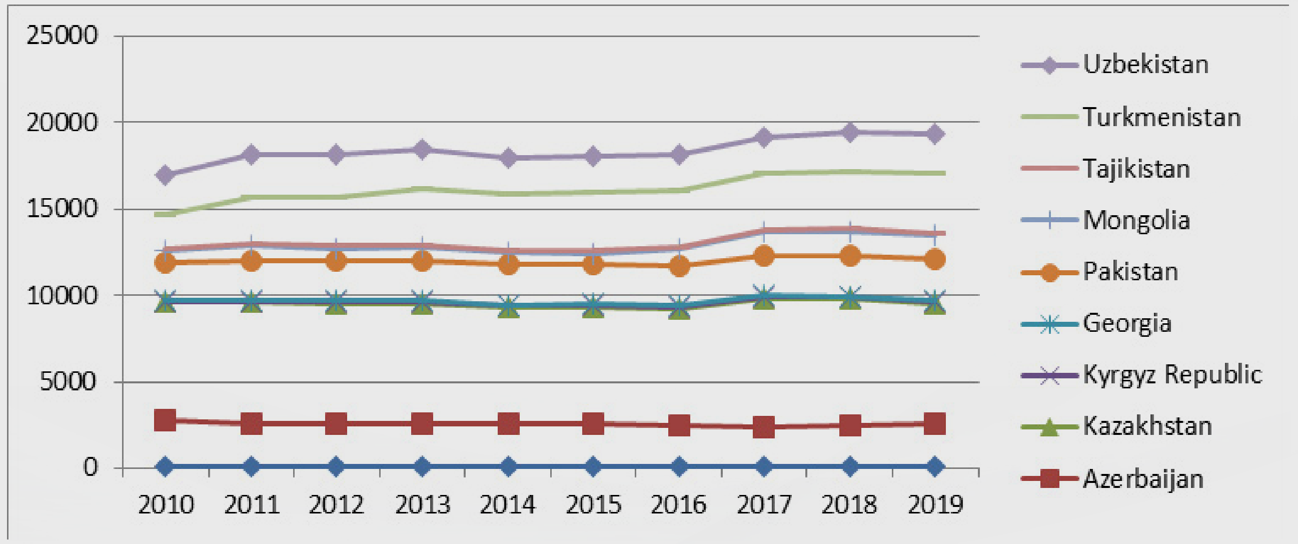
2.4.2 Drivers of Greenhouse Gases Emissions

Climate change mitigation necessitates lowering CO2 emissions through human contribution to decrease the supply of GHGs. The drivers of CO2 emissions include the conversion of fossils to produce energy and land use change attributed to deforestation and agriculture development. Broadly, energy and non-energy sectors are major contributors of CO2 emissions. CO2 emissions reduction requires transforming the drivers of CO2 generators through better energy efficiency, greater use of renewable energy, and fostering carbon capture and storage (CCS) technology.

The study identified the drivers of GHGs emissions in CAREC countries, as follows. In the PRC, energy production in petajoules (PJ) surged considerably from 88,642.02 PJ in 2010 to 109744.5 PJ in 2019, to meet energy demand in various sectors, whereas energy use has surged rapidly from 101,618.2 PJ in 2010 to 136,602.4 PJ in 2019. Gross Domestic Product (GDP) per unit use of energy (PPP per PJ) surged significantly from USD116.95 million in 2010 to USD164.65 million in 2019. The gap between energy production and energy use was met from energy import, which increased from 12.76% of energy use in 2010 to 19.66% in 2019.

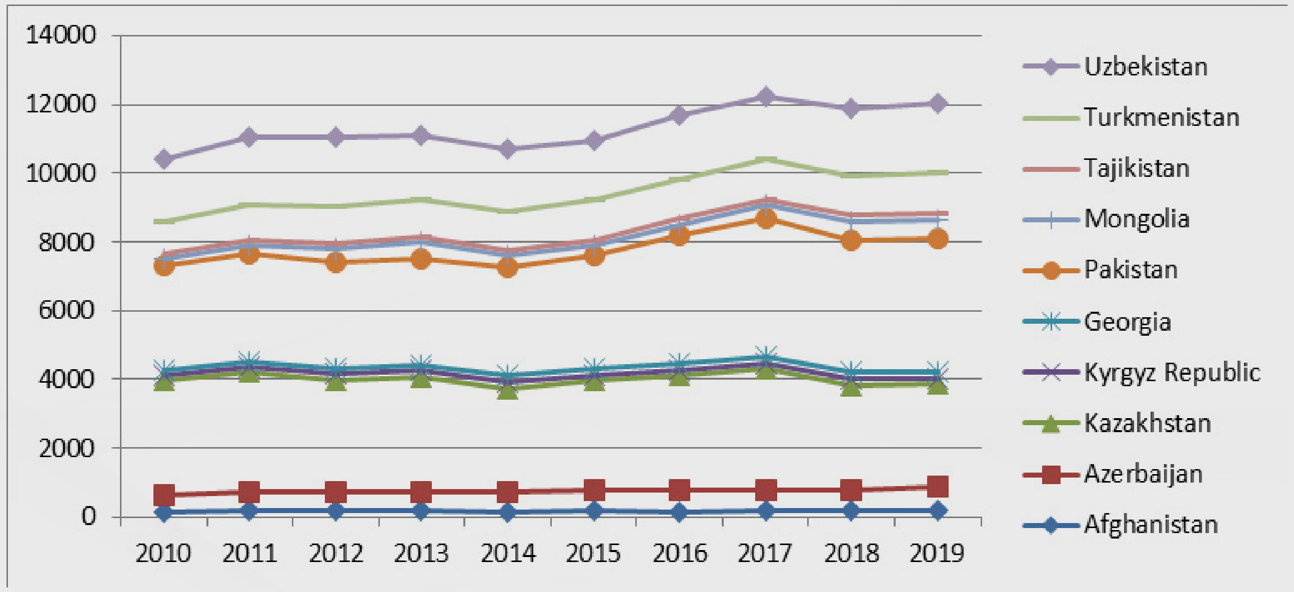
Figures 2.4a-2.4d depict the energy production, energy use, GDP per unit use of energy, and energy imports in CAREC member countries excluding the PRC. Figure 2.4a shows the energy production (PJ) in CAREC countries. In 2019, Kazakhstan recorded substantial energy production (6,983.51 PJ) followed by Turkmenistan (3,399.08 PJ), Pakistan (2,366.07 PJ), and Azerbaijan (2,474.803 PJ), whereas Georgia and Afghanistan produced comparatively less energy in the CAREC region. Figure 2.4b reveals that energy use (PJ) remained substantial in Pakistan (3,849 PJ) followed by Kazakhstan (3,002.8 PJ), Uzbekistan (1,998.84 PJ), Turkmenistan (1,191.324 PJ), and Azerbaijan (663.65 PJ), whereas the Kyrgyz Republic (158.58 PJ), Tajikistan (207.68 PJ), and Georgia (214.98 PJ) remained the least energy users in the region. Figure 2.4c portrays energy use GDP per unit in the region. It remained highest in Afghanistan (USD415.63 million), followed by Pakistan (USD299.20 million), Georgia (USD259.37 million), and Azerbaijan (USD218.14 million). Mongolia (USD74.38 million) and Turkmenistan (USD77.5 million) remained the least energy users in terms of GDP per unit. Figure 2.4d depicts the import proportion of the energy requirement. Georgia recorded the highest imports (78.74%), followed by Afghanistan (56.42%), Pakistan (38.52%), the Kyrgyz Republic (36.9%), the PRC (19.66%), and Tajikistan (18.19%). Azerbaijan, Turkmenistan, Mongolia, Kazakhstan, and Uzbekistan reduced energy imports considerably by 272.90%, 185.32%, 160.34%, 132.56% and 14.35%, respectively, in 2019.

Figure 2.4a. Energy production in petajoules (PJ)



Source: Author's creation based on the ADB's Key Indicators database.

Figure 2.4b. Energy use in petajoules (PJ)



Source: Author's creation based on the ADB's Key Indicators database.

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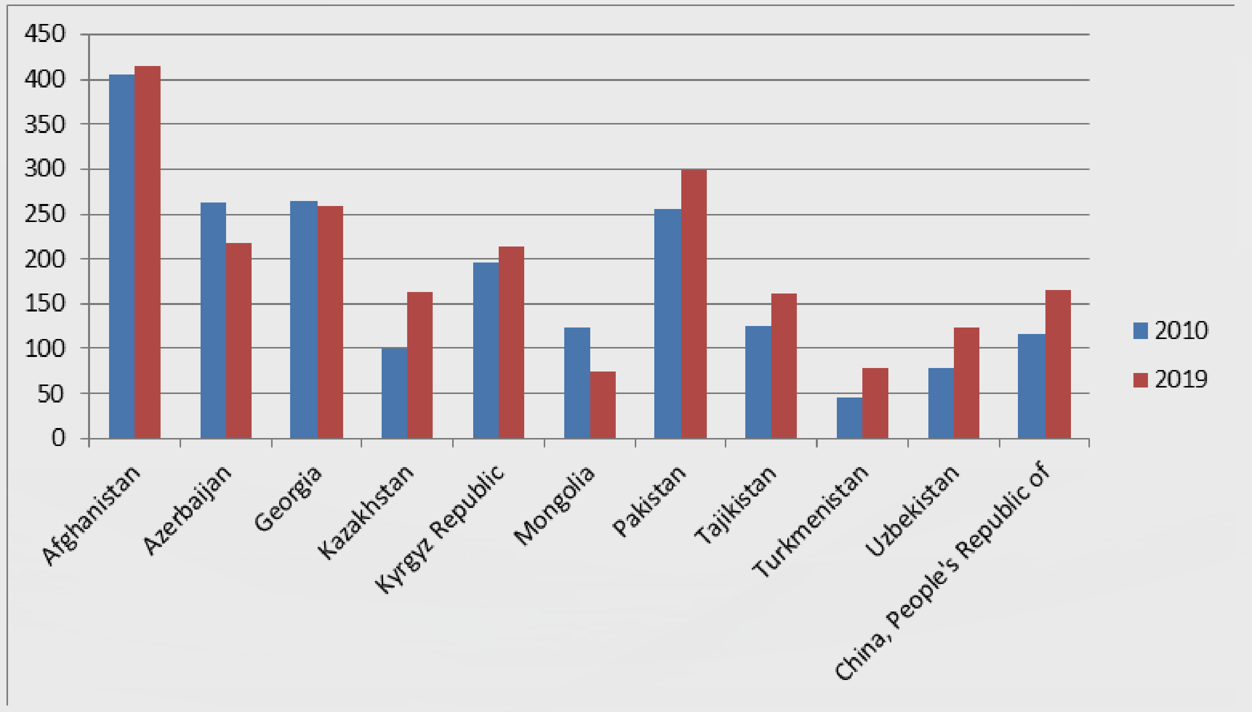
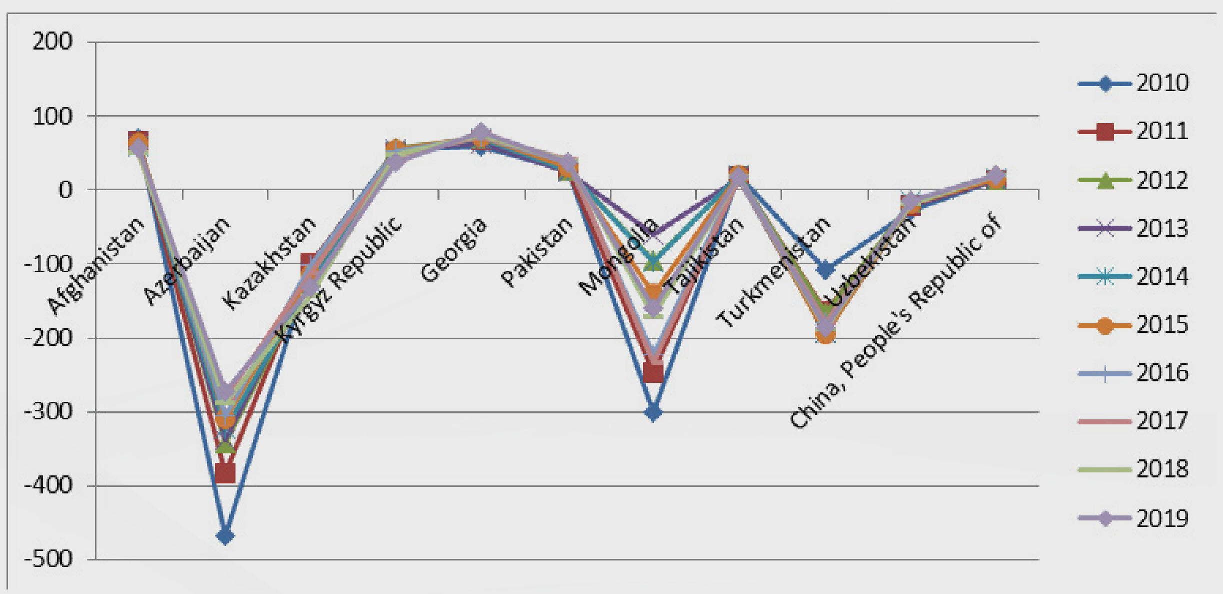
Figure 2.4c. GDP per unit use of energy (constant 2017 USD million PPP per PJ)



Source: Author's creation based on the ADB's Key Indicators database.

Figure 2.4d. Energy imports, net (% of total energy use)

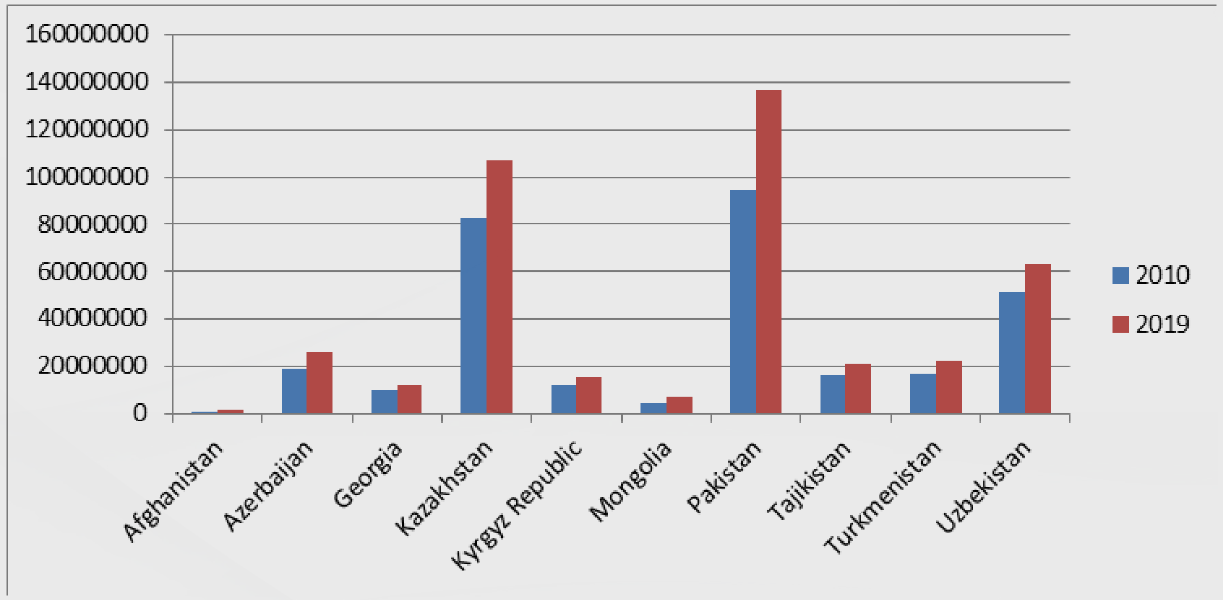


Source: Author's creation based on the ADB's Key Indicators database.

In the PRC, the total electricity production and electricity use surged by less than twice, whereas coal production surged from 3,428 mmt in 2010 to 4,125.83 mmt in 2021, and coal export declined significantly from 19.1 million tons in 2010 to 3 million tons in 2020. Crude petroleum production declined modestly from 203.014 mmt in 2010 to 194.76 mmt in 2020. Natural gas production increased more than twice from 96,000 million cubic meters in 2010 to 192,500 million cubic meters in 2020, whereas natural gas consumption surged multifold and its exports surged modestly from 2010 to 2020. The PRC's coal-based energy use was above 50% in 2019, whereas its total energy use was estimated at 7.08 billion tons of oil equivalent (toe), with coal and oil shares of 58% and 19%, respectively.

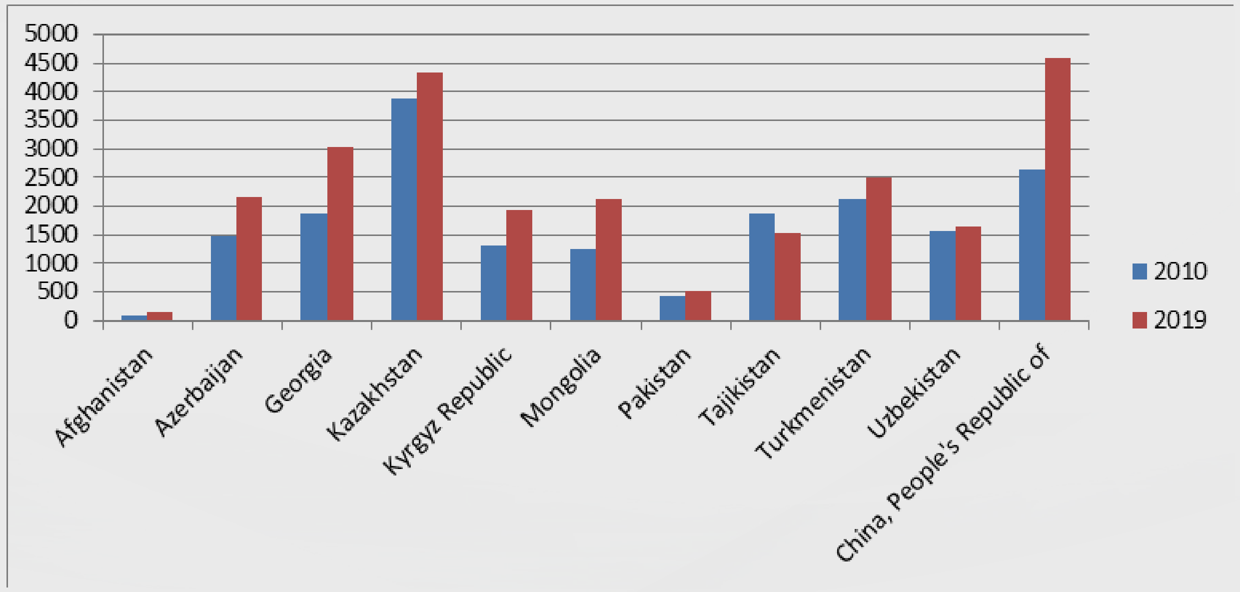
Figures 2.5a-2.5b depict the electricity production and consumption in the CAREC member countries. Figures 2.5a and 2.5b reveal that electricity production and consumption increased significantly from 2010 to 2019. Figure 2.6a shows the coal production in the region, excluding the PRC. Kazakhstan's coal production stood at 107.977 mmt in 2021, up from 103.646 mmt in 2010, followed by Mongolia at 33.6919 mmt in 2021, up from 25.16 mmt in 2010, and Pakistan at 9.23 mmt in 2021, up from 3.536 mmt in 2010. Other CAREC member countries produced considerably lower amounts of coal. Georgia's share in coal production was very small. Figure 2.6b shows the export of coal. Kazakhstan and Mongolia exported substantial amounts of coal at 25.52 and 25.12 million tons, respectively, in 2020. However, Kazakhstan's coal exports declined from 29.37 million tons in 2010, whereas Mongolia's surged from 16.72 million tons in 2010. Other coal-exporting countries in the CAREC region included the PRC, the Kyrgyz Republic, Afghanistan, and Azerbaijan.

Figure 2.5a. Total electricity production (MWh billion)



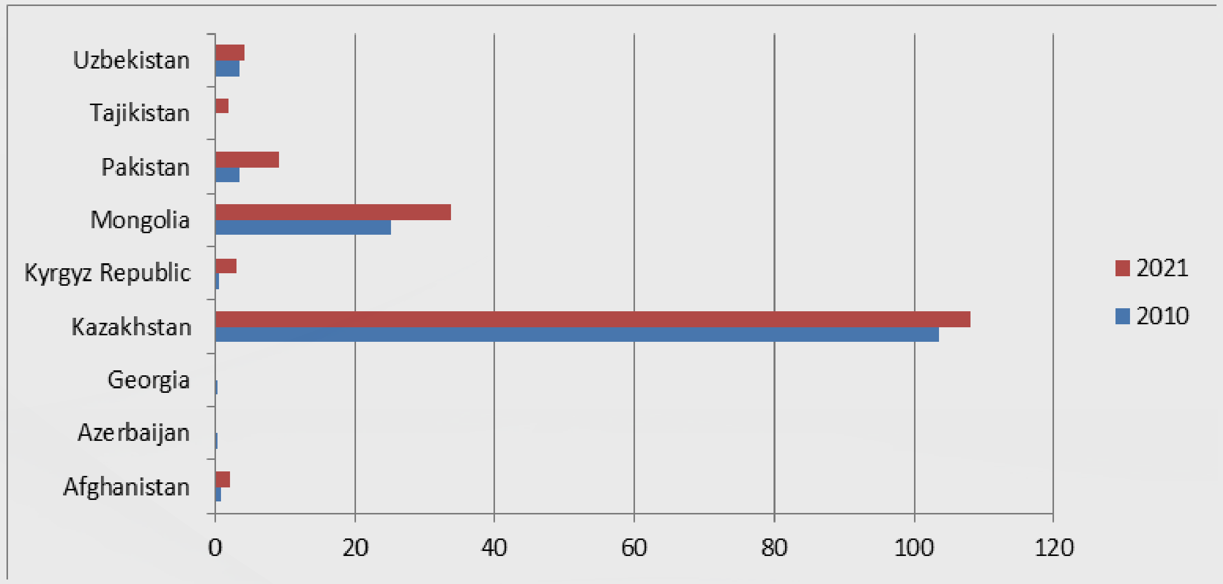
Source: Author's creation based on the ADB's Key Indicators database.

Figure 2.5b. Electric power consumption (kWh per capita)



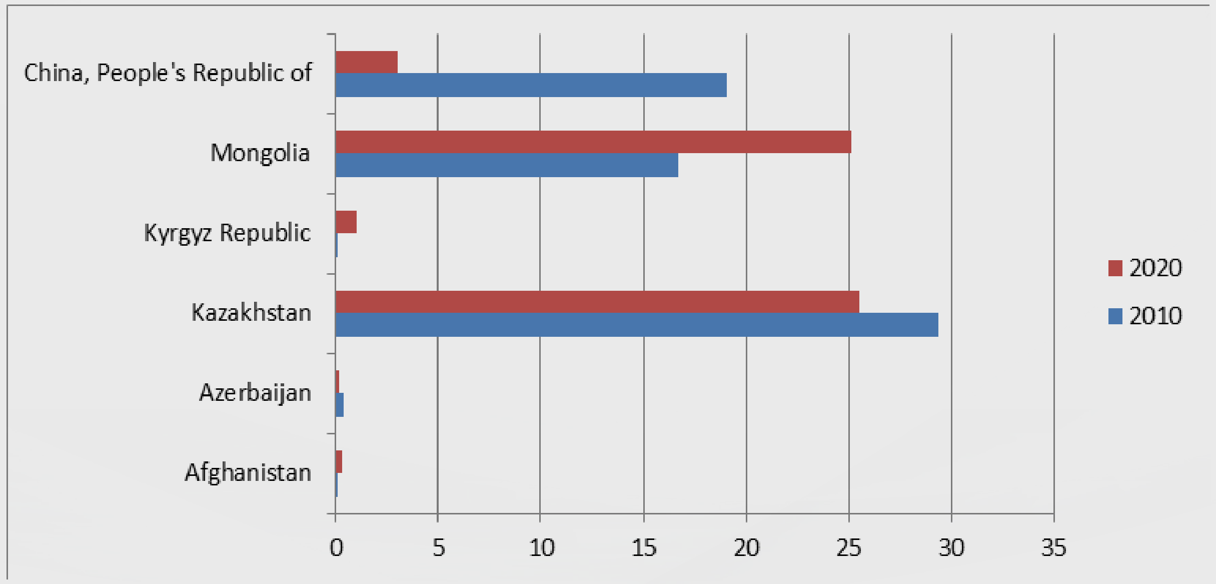
Source: Author's creation based on the ADB's Key Indicators database.

Figure 2.6a. Coal production (million metric ton)



Source: Author's creation based on the ADB's Key Indicators database.
Note: Data for Afghanistan, Azerbaijan, and Georgia are in tons.

Figure 2.6b. Coal exports (million tons)

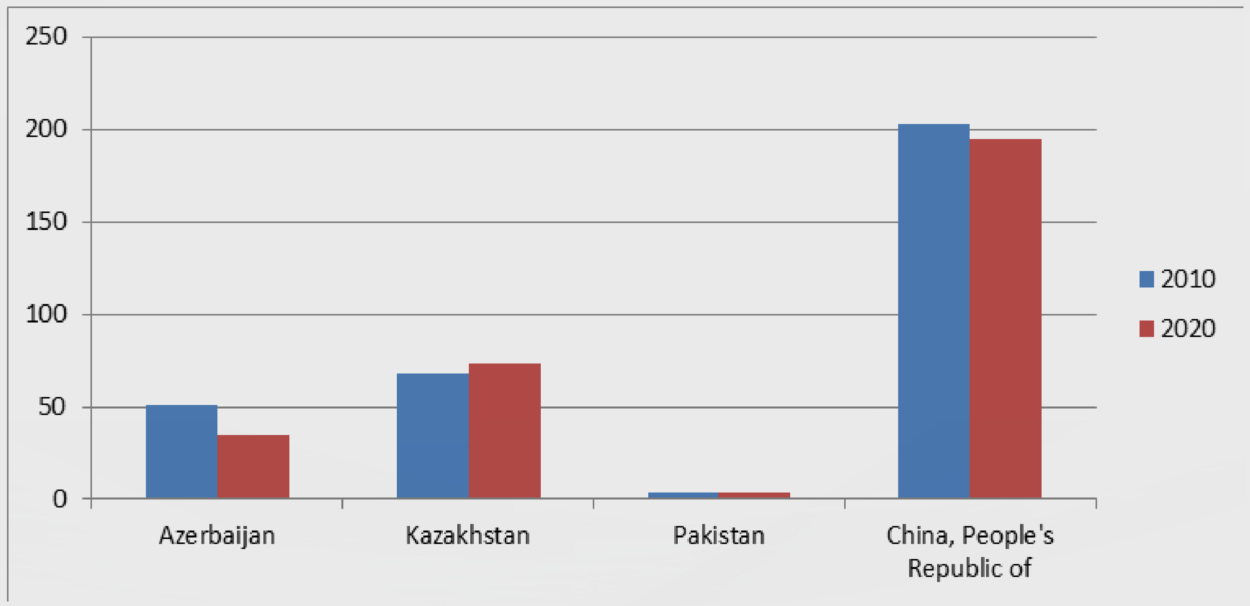


Source: Author's creation based on the ADB's Key Indicators database.

Figures 2.7a-2.7d present the production of crude petroleum and natural gas and the use and export of natural gas in selected CAREC member countries. Excluding the PRC, the production of crude petroleum surged in Kazakhstan to 73 mmt in 2020 from 68.08 mmt in 2010, whereas Azerbaijan experienced a decline from 50.8 mmt in 2010 to 34.53 mmt in 2020 (Figure 2.7a). Pakistan also experienced an increase in crude petroleum production from 3.23 mmt in 2010 to 3.76 mmt in 2020. Tajikistan, Georgia, and the Kyrgyz Republic recorded very low levels of crude petroleum production.

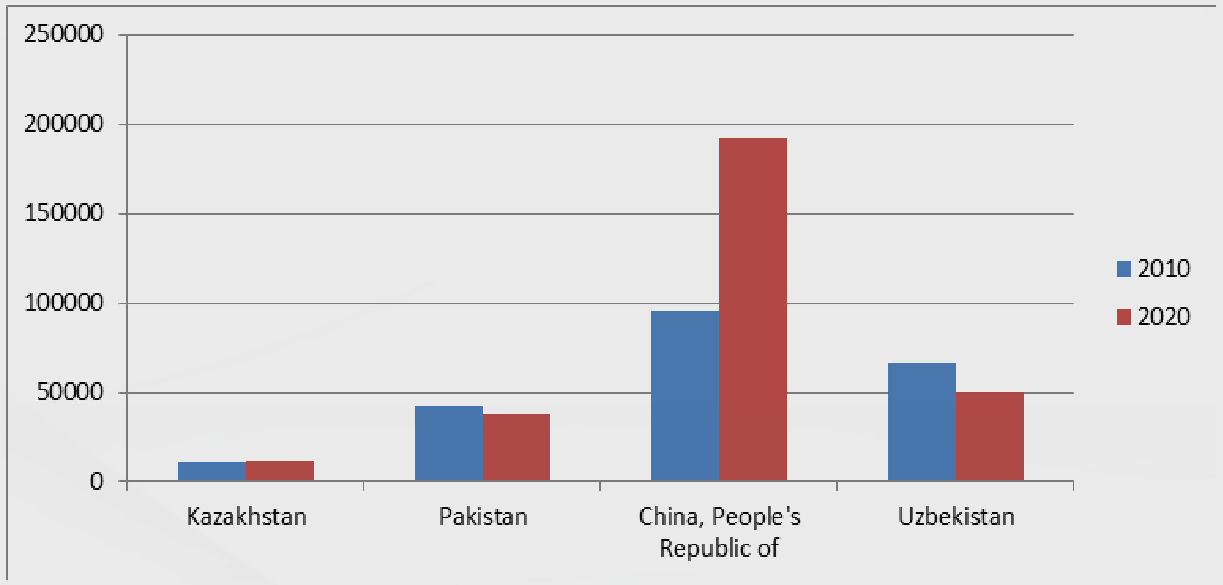
As for natural gas production (Figure 2.7b), it declined considerably in Uzbekistan (from 65,958.5 million cubic meters (mcm) in 2010 to 49,768.2 mcm in 2020) and Pakistan (from 41,995 mcm in 2010 to 37,288 mcm in 2020). Kazakhstan improved its production of natural gas from 10,607.318 mcm in 2010 to 11438.1 mcm in 2020. The Kyrgyz Republic and Georgia produced small amounts of natural gas. The use of natural gas remained considerable in the PRC, followed by Uzbekistan, Pakistan, and Azerbaijan from 2010 to 2020 (Figure 2.7c). In 2010–2020, the PRC increased its natural gas use by more than threefold, as did Pakistan and Azerbaijan, albeit at lower levels. Uzbekistan and Kazakhstan experienced a considerable decline in natural gas use. As for natural gas exports, they remained substantial in Kazakhstan and Azerbaijan in 2010–2020 (Figure 2.7d).

Figure 2.7a. Crude petroleum production (million metric ton)



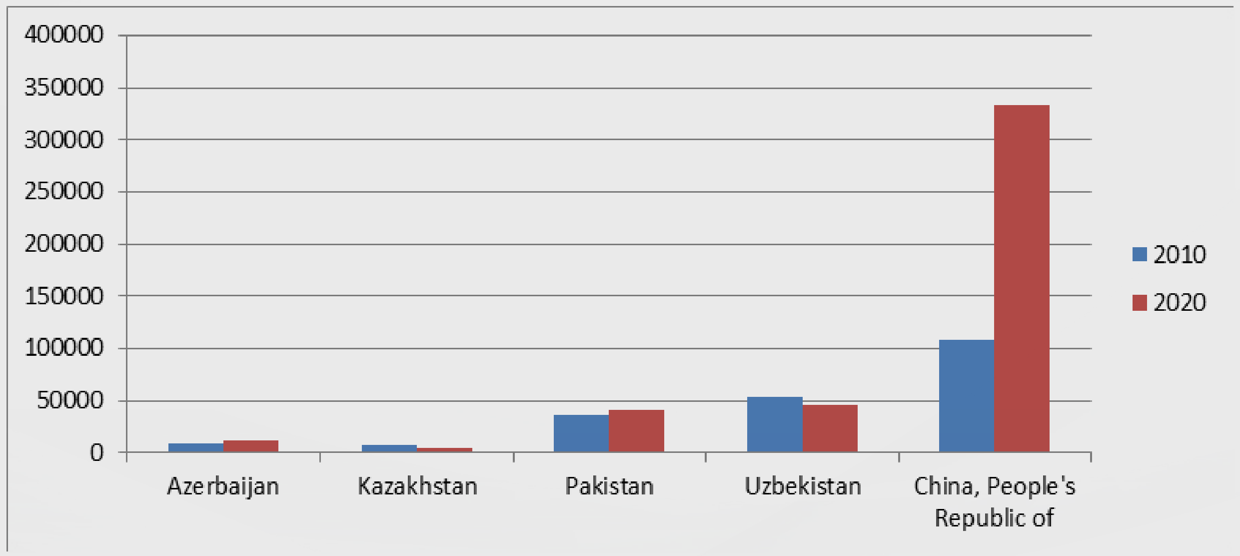
Source: Author's creation based on the ADB's Key Indicators database.

Figure 2.7b. Natural gas production (million cubic meter)



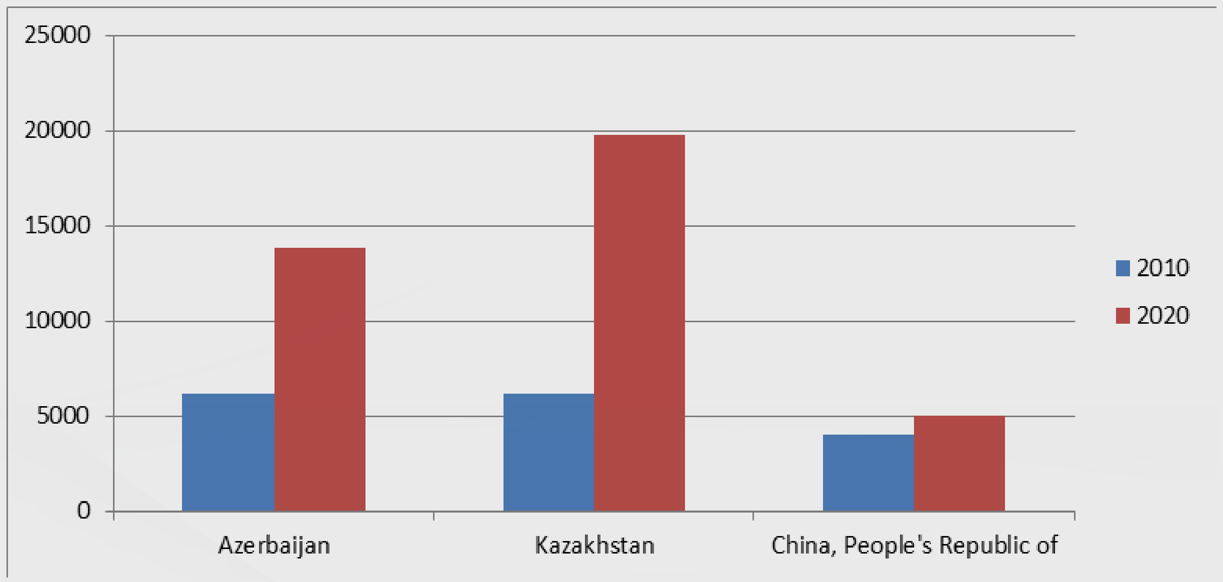
Source: Author's creation based on the ADB's Key Indicators database.

Figure 2.7c. Natural gas consumption (million cubic meter)



Source: Author's creation based on the ADB's Key Indicators database.

Figure 2.7d. Natural gas exports (million cubic meter)

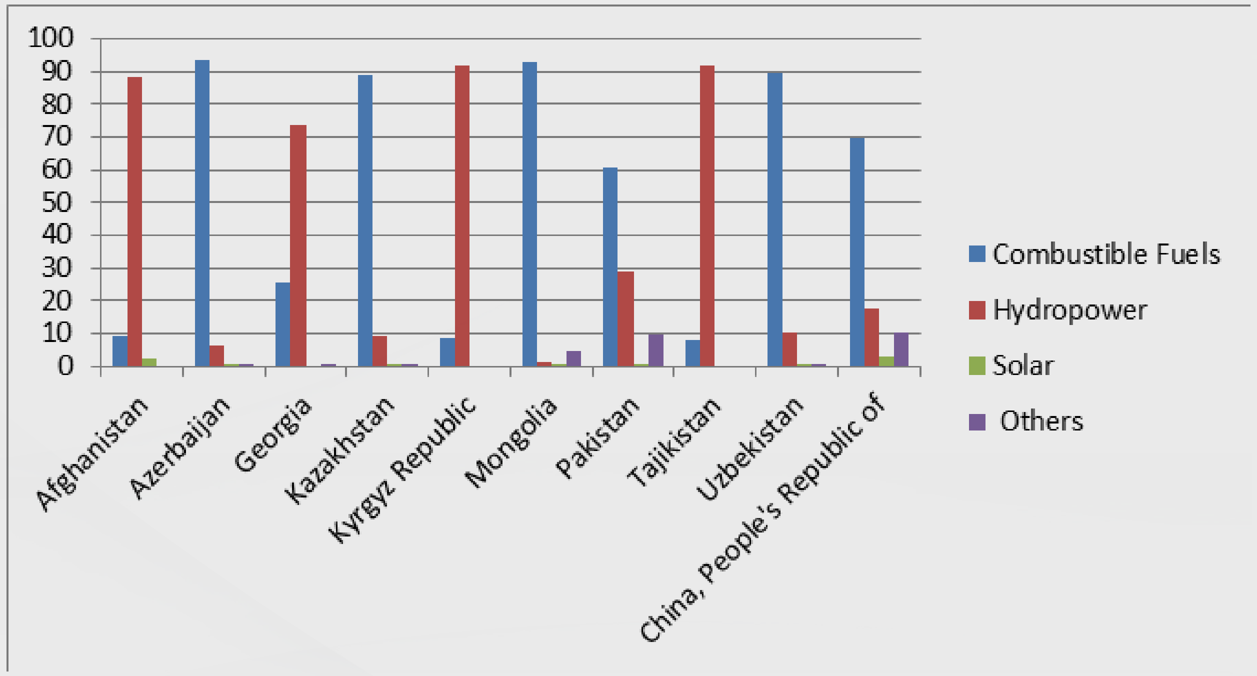


Source: Author's creation based on the ADB's Key Indicators database.

The CAREC regional economies have considerable prospects to generate renewable energy using hydropower, solar, and wind resources. Figure 2.8 shows the sources of electricity (% of total) in 2021. Combustible fuels contributed immensely to total electricity generation in Azerbaijan (93.29%), followed by Mongolia (93.15%), Uzbekistan (89.72%), Kazakhstan (89.21%), the PRC (69.57%), and Pakistan (60.8%). Hydropower contributed substantially to electricity production in Tajikistan (91.79%), followed by the Kyrgyz Republic (91.68%), Afghanistan (88.31%), and Georgia (73.91%).

Pakistan, the PRC, Uzbekistan, Kazakhstan, and Azerbaijan produced lower proportions of electricity from hydropower; while Mongolia had the lowest share. Except for Georgia, the Kyrgyz Republic, and Tajikistan, CAREC countries generated electricity using solar energy, albeit at a very small scale. The contribution of other renewable resources in electricity generation remained virtually absent in Afghanistan, the Kyrgyz Republic, and Tajikistan, compared with the PRC (10.05%), Pakistan (9.89%) and Mongolia (4.81%), which outpaced Georgia, Kazakhstan, Azerbaijan, and Uzbekistan.

Figure 2.8. Sources of electricity (% of total), 2021



Source: Author's creation based on the ADB's Key Indicators database.

Uzbekistan exploited about 40% of its hydro-energy potential, much higher compared with its neighbors the Kyrgyz Republic (15%), Kazakhstan (13%), and Tajikistan (5%). Turkmenistan recorded even less attention toward hydropower development.

Renewable energy generation integration and strong regional cooperation can facilitate the efficient and sound development of renewable energy in CAREC countries. Cross-border renewable energy trade can address peak scarcity and reduce seasonal water leakage. Regional economies can tap their renewable energy potential and export surplus energy. Doing so can enhance energy efficiency and foster lower carbon emissions, in line with carbon-neutral goals.

2.4.3 Carbon Intensity

The carbon emissions of a country are determined by its population and economic structure. Changes in the size of the population and economic pursuits, along with energy application, reveal the carbon and energy intensity of a country. This study defined carbon intensity as CO2 emissions per GDP and expressed as kg CO2/USD at 2015 PPP.

Figure 2.9 shows the carbon intensity in selected CAREC countries. In 2019, carbon intensity was lower than the world average (0.26 kg CO2/USD) in Azerbaijan (0.24 kg CO2/USD), Georgia (0.25 kg CO2/USD), and Tajikistan (0.21 kg CO2/USD), attributed to their low dependence on coal for electricity production and modernization of electricity projects. In Azerbaijan, carbon intensity was influenced more by natural gas-based electricity production and consumption than GDP growth. Georgia's carbon intensity reflected the significant contribution of fossils-based energy to electricity production and its application in heat and industry sectors. The substantial use of hydropower for power production accounted for the comparatively lower carbon intensity in Georgia. In the PRC, carbon intensity was significantly higher (0.46 kg CO2/USD) owing to the sheer size of economic activities. In Uzbekistan, carbon intensity stood at 0.42 kg CO2/USD in 2019. Despite a decline in carbon intensity by about 75% during 2000–2020, Uzbekistan's carbon intensity remained 77% higher than the world average owing to the country's greater reliance on fossils-based energy. Nonetheless, its carbon intensity is expected to fall further with increasing emphasis on renewable energy generation.

In 2019, Kazakhstan's carbon intensity stood at 0.44 kg CO2/USD, higher than the world average (IEA, 2021a), owing to greater industrial activities and high dependence on fossils-based energy. Kazakhstan would need improvement in the efficiency of its coal-based power generation and a transition to gas energy and renewable energy sources. Kazakhstan experienced an 82% surge in CO2 emissions from fossils-based energy generation and consumption in 2000–2020; meanwhile, income per capita increased by 247% during the same period (IEA, 2022). Figure 2.10 shows the carbon intensity of electricity production. In 2000–2019, it declined significantly in the PRC (from 810 g CO2/kWh in 2000 to 582 g CO2/kWh in 2019) and in Organisation for Economic Co-operation and Development (OECD) countries (from 479 g CO2/kWh in 2000 to 335 in 2019) but remained higher than the OECD and world average in 2000 (497 g CO2/kWh) and 2019 (451 g CO2/kWh). Notably, it increased in Kazakhstan by 2% from 507 g CO2/kWh in 2000 to 516 g CO2/kWh in 2019 owing to greater reliance on fossils-based power generation (IEA, 2022a).

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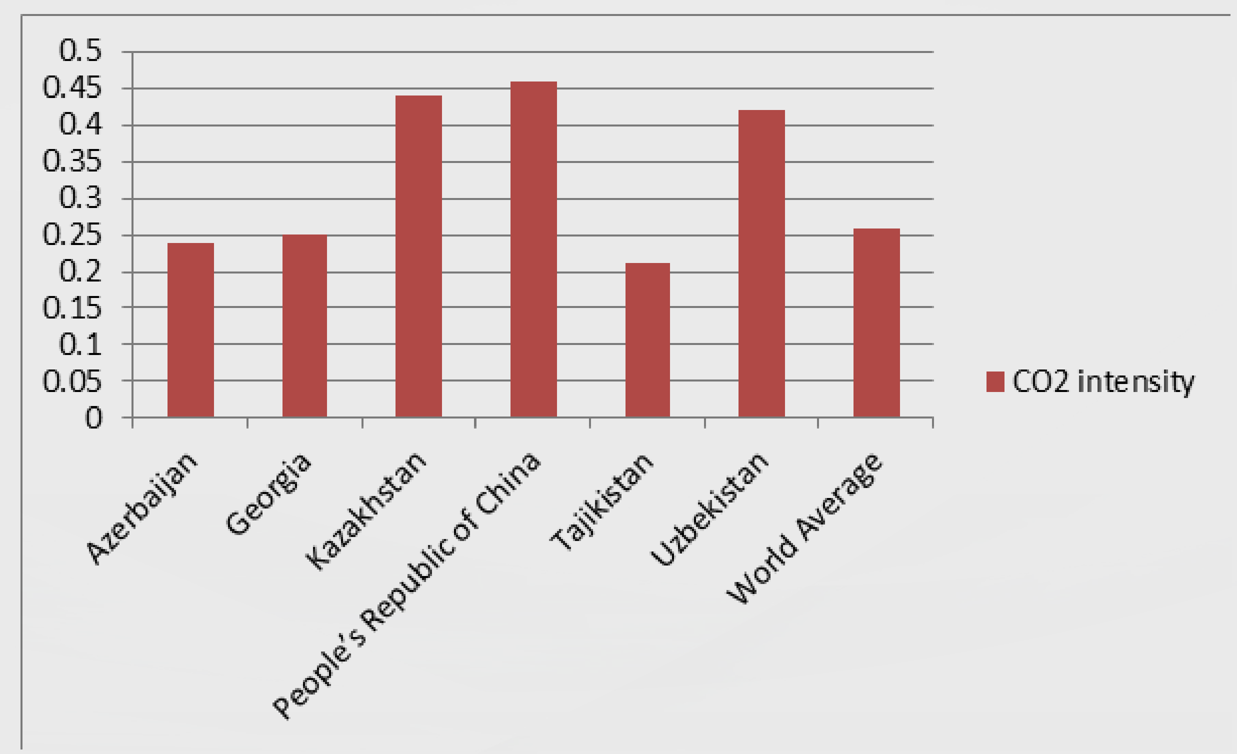
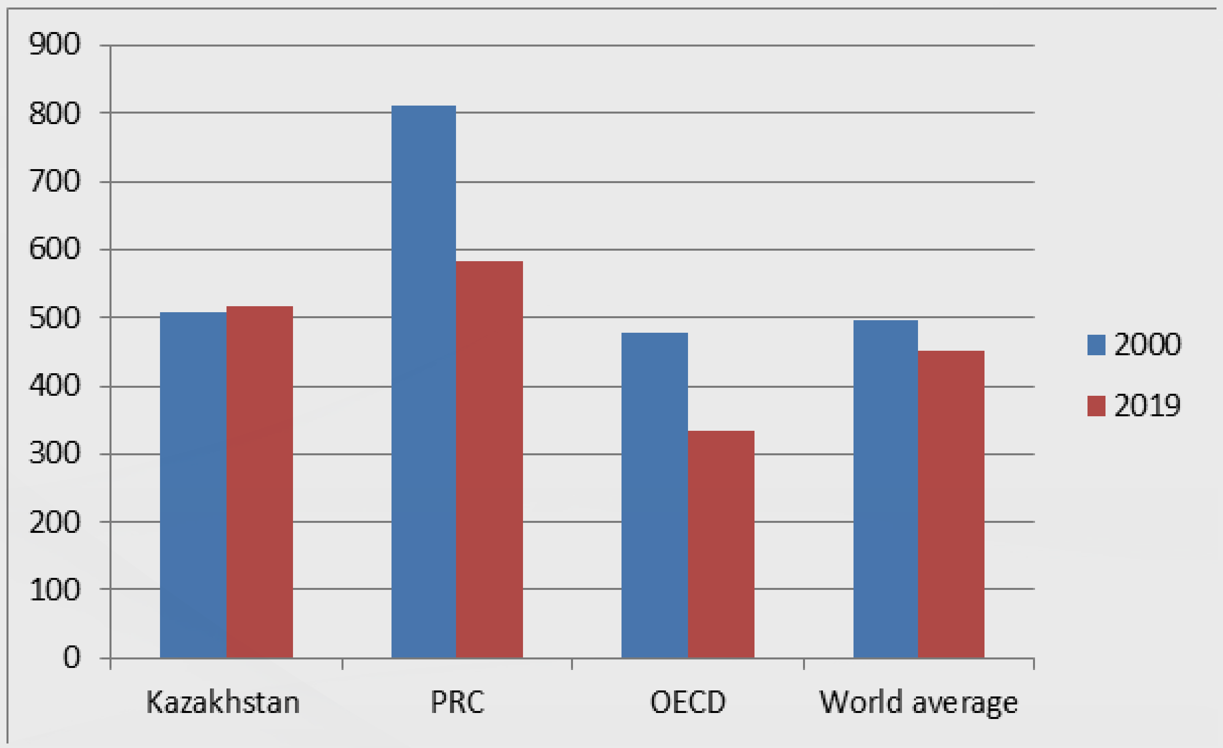
Figure 2.9. CO2 intensity in selected CAREC countries in 2019 (kgCO2/USD, 2015 PPP)



Source: Author's creation based on data from IEA (2021a).

Figure 2.10. Carbon intensity of electricity production in Kazakhstan, the PRC, and OECD (g CO2/kWh)



Source: Author's creation based on data from IEA (2022a).

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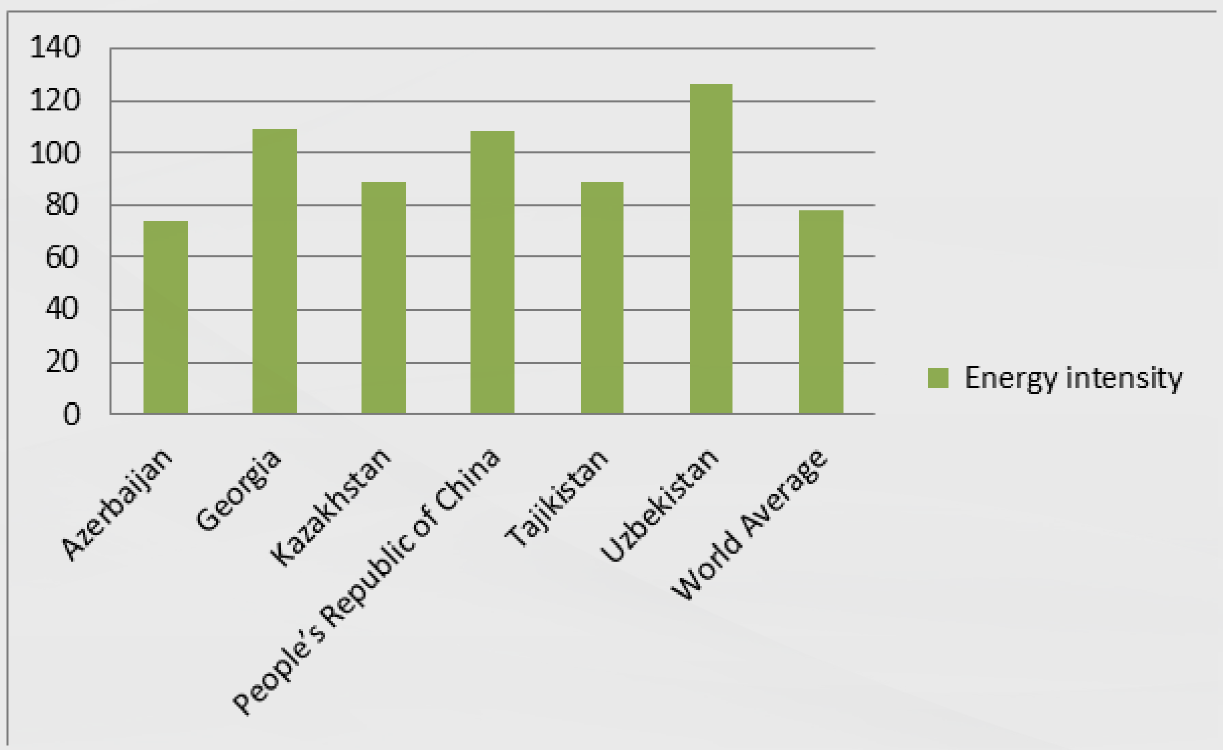
Reducing the carbon intensity in CAREC countries would require carbon taxation and cost-efficient technologies. Proposed NDCs should be vigorously implemented to reduce carbon intensity and switch to a green economy. Long-run low carbon emissions can be effectively realized by switching from fossils-based energy to renewable energy through substantial investment in renewable energy infrastructure and energy efficient technologies, phasing out of subsidies, carbon pricing, green hydrogen transition, greater public awareness, and public-private collaboration. CAREC governments should establish clean energy certification, subsidies, and financial incentives to boost renewable energy investment, deployment, and application.

2.4.4 Energy Intensity

Energy intensity refers to the total final energy consumption per GDP and expressed as toe per million USD at 2015 PPP. Figure 2.11 shows the energy intensity in selected CAREC member countries. Except for Azerbaijan (74 toe per million USD), the energy intensity of all the selected CAREC member countries significantly exceeded the world average (78 toe per million USD): Uzbekistan (126 toe per million USD), the PRC (108 toe per million USD), Georgia (109 toe per million USD), and Kazakhstan and Tajikistan (89 toe per million USD each). In 2000–2019, exports of oil and gas contributed to the fourfold surge in GDP growth in Azerbaijan despite the increase in population and energy use by about 25% and 65%, respectively (IEA, 2021b). Greater improvement in energy-efficient technologies worldwide failed to improve energy efficiency in the transport and housing sectors of Azerbaijan owing to its high population growth. Georgia's energy intensity was also considerably higher than the world average. In 2000–2020, Kazakhstan experienced a 20% decline in energy intensity owing to more than the threefold surge in GDP compared with about the twofold increase in energy use (IEA, 2022a). Kazakhstan also witnessed a reduction in energy intensity owing to improvements in energy efficiency and lowered carbon emissions vis-à-vis the rise in its economic pursuits. This scenario indicates the necessity of further expansion in energy efficiency and emission reduction. In Tajikistan, energy intensity declined considerably by 59% in 2000–2020, attributed to the rapid surge in GDP compared with energy use; the country's energy intensity remained lower than the world average (IEA, 2022b). Uzbekistan's energy intensity was considerably higher among the selected CAREC member countries and 50% larger than the world average, and confined to the residential, transport, and industrial sectors (UNECE, 2020).

Figure 2.11. Energy intensity in selected CAREC countries, 2019 (tons of oil equivalent (toe)/2015 USD million PPP)



Sources: Author's creation based on data from IEA (2022a).For the PRC, the data are taken from https://www.oecd-ilibrary.org/co2-intensity-and-energy-intensity-of-g20-economies-in-2014-and-the-path-to-2050_9789264273528

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Achieving carbon neutrality in the selected CAREC member countries requires reducing carbon and energy intensity by fostering energy efficiency in renewable energy production and consumption and improving energy efficiency in all economic sectors.

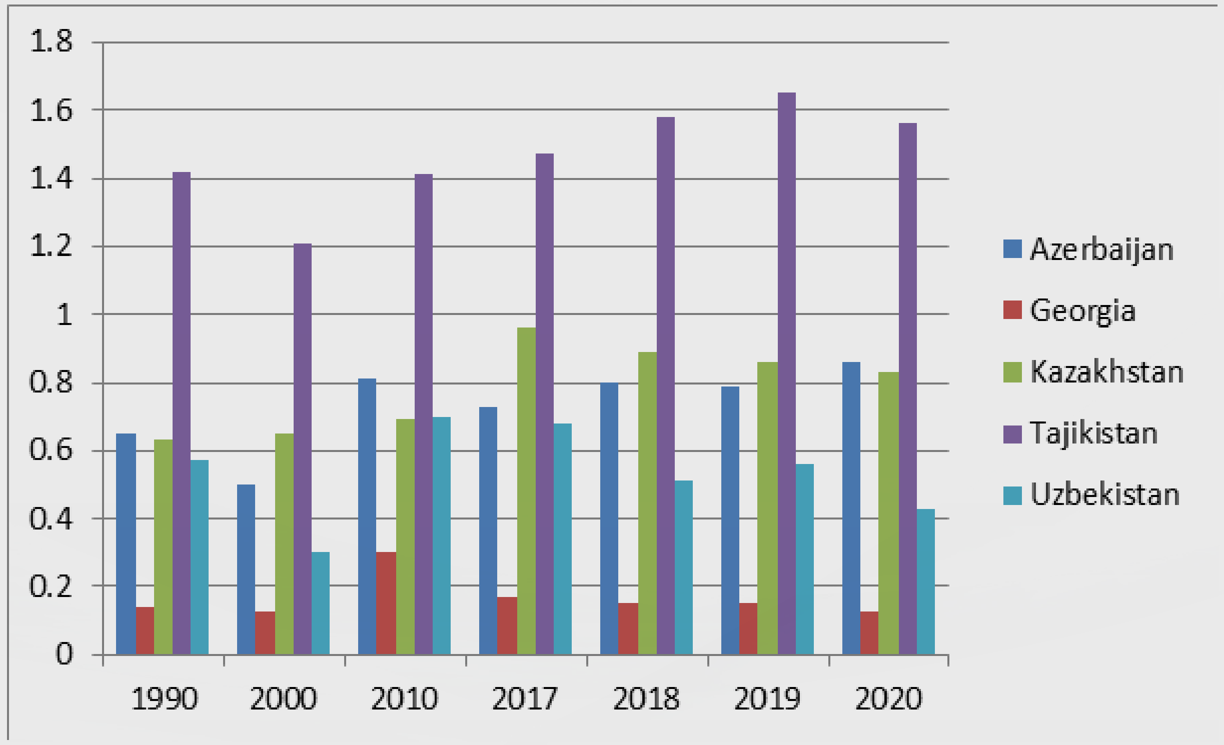
All the selected CAREC member countries should develop their own domestic policy and novel laws to foster energy efficiency, execute and implement compatible action plans, analyze and appraise data to review performance, and modify their plans accordingly to achieve their goals. Strong energy efficiency indicators need to be developed to monitor and evaluate the performance of policies targeting energy-intensive sectors. The knowledge and skills and political will regarding the advantages of improved energy efficiency should be bolstered.

2.4.5 Renewable Energy Resources

CAREC member countries possess immense prospects for renewable energy deployment. Azerbaijan's technical potential for solar and wind energy are estimated at 23 and 3 Gigawatt (GW), respectively, whereas its cumulative potential for bioenergy, geothermal, and small hydropower energy stands at 1 GW (IEA, 2020a). However, the use of oil and gas for energy generation remains substantial in Azerbaijan, and the government has drafted law to foster renewable energy deployment. The contribution of renewable energy to the total energy supply stood at 2% in 2018, much lower than the world average. In 2008–2019, the contribution of renewable energy fluctuated from 7% to 18% owing to wide differences in Azerbaijan's hydrological situations (IEA, 2021b).

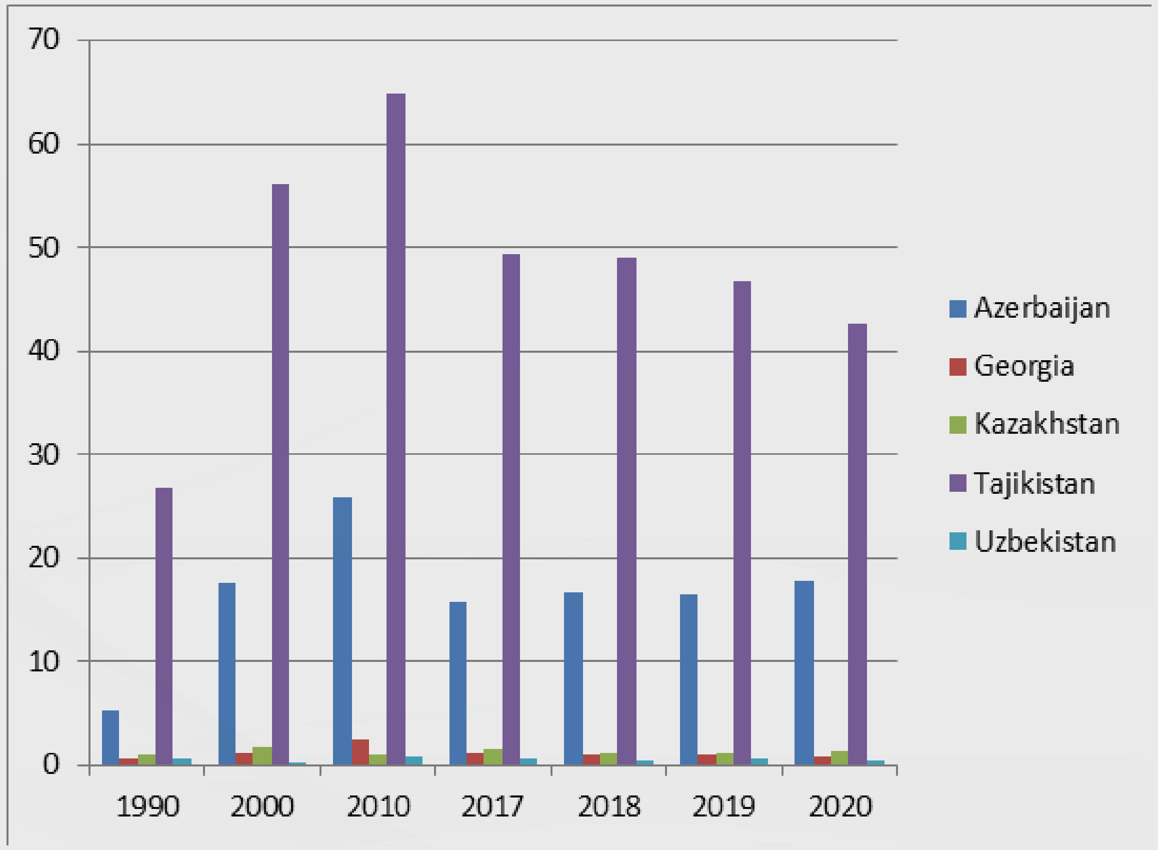
Figures 2.12a-2.12d show the total production/supply of hydropower, share of hydropower in the total supply, share of hydropower in electricity generation, and growth rate of hydropower in the total energy supply, respectively. These figures paint a picture of significant volatility and variation across selected CAREC member countries in 1990–2020. In 2019, Azerbaijan's share of hydropower in the total renewable energy supply stood at 59%, and the rest added from bioenergy, renewable municipal wastes, and solar and wind energy (IEA, 2021b). In Georgia, the untapped hydro and wind power potential are estimated at 15,000 Megawatt (MW) and 1,500 MW, respectively, and its solar energy potential is also considerable; in 2018, hydropower contributed 74% to the country's renewable energy generation (IEA, 2020b).

Figure 2.12a. Total production/supply of hydropower (Mtoe)



Source: Author's creation based on data from the IEA (2022).

Figure 2.12b. Share of hydropower in total supply (%)



Source: Author's creation based on data from the IEA (2022).

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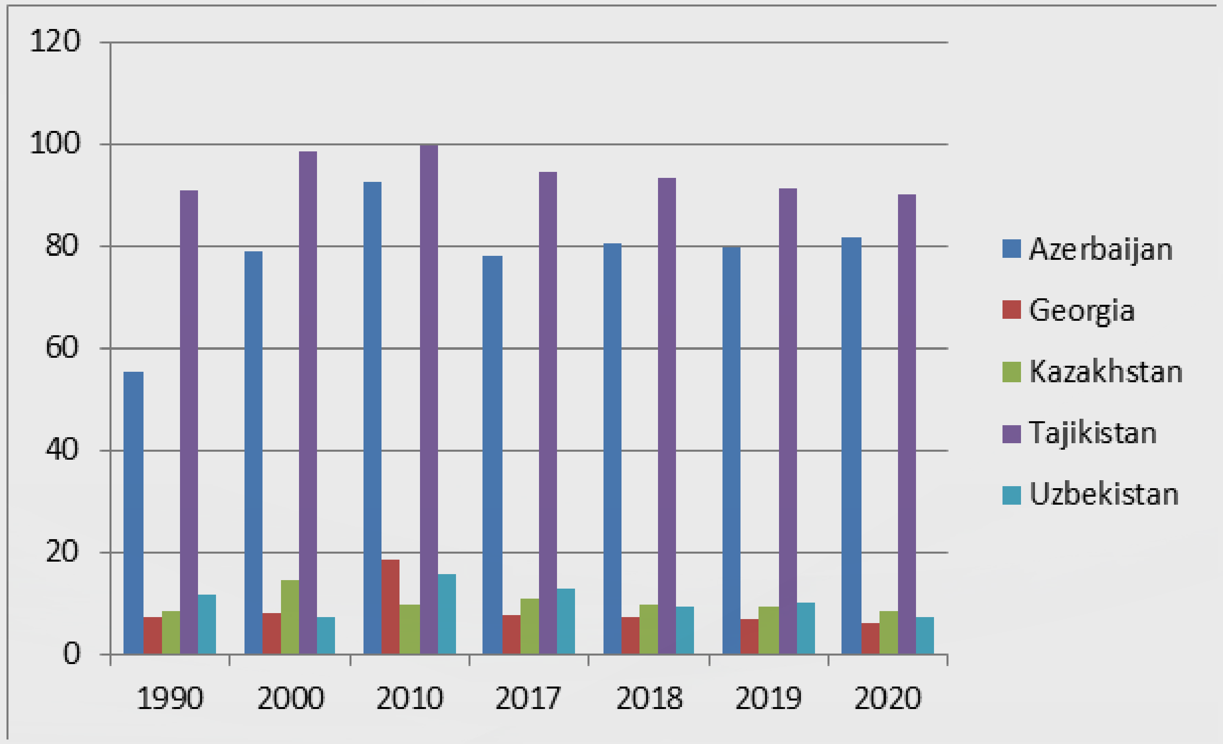
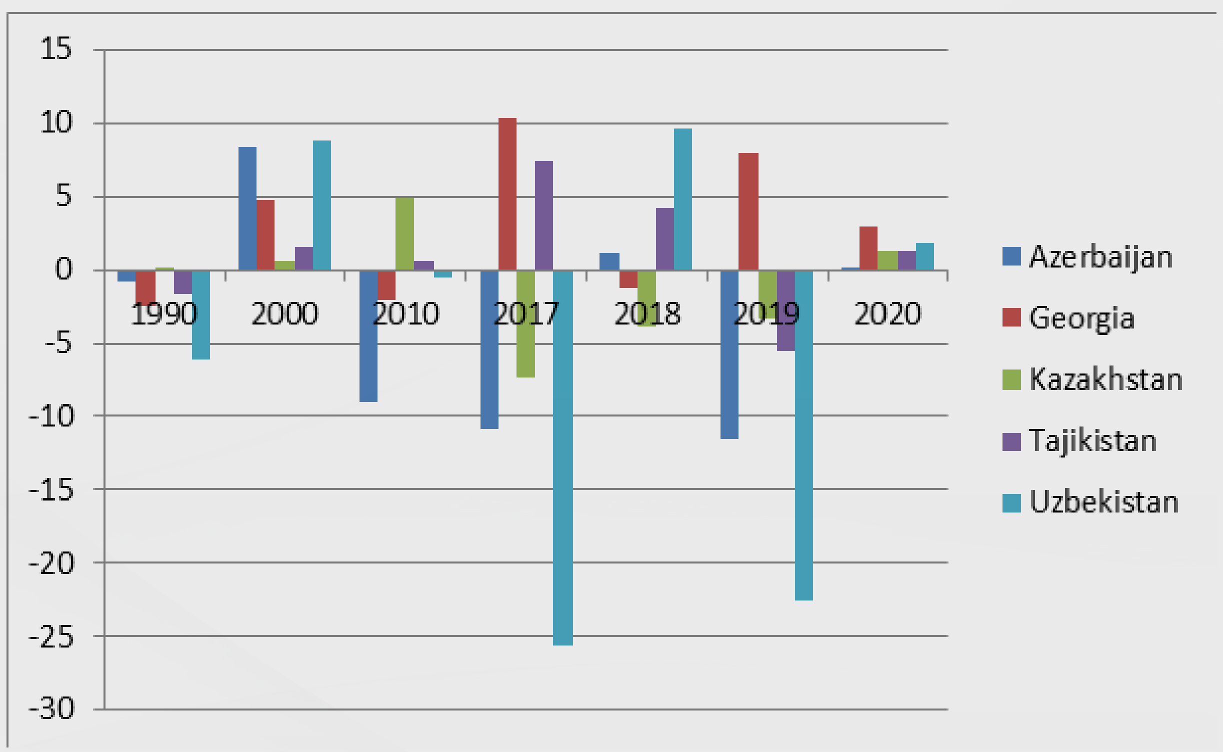
Figure 2.12c. Share of hydropower in electricity generation (%)



Source: Author's creation based on data from the IEA (2022).

Figure 2.12d. Growth rate of hydropower in total energy supply (%)

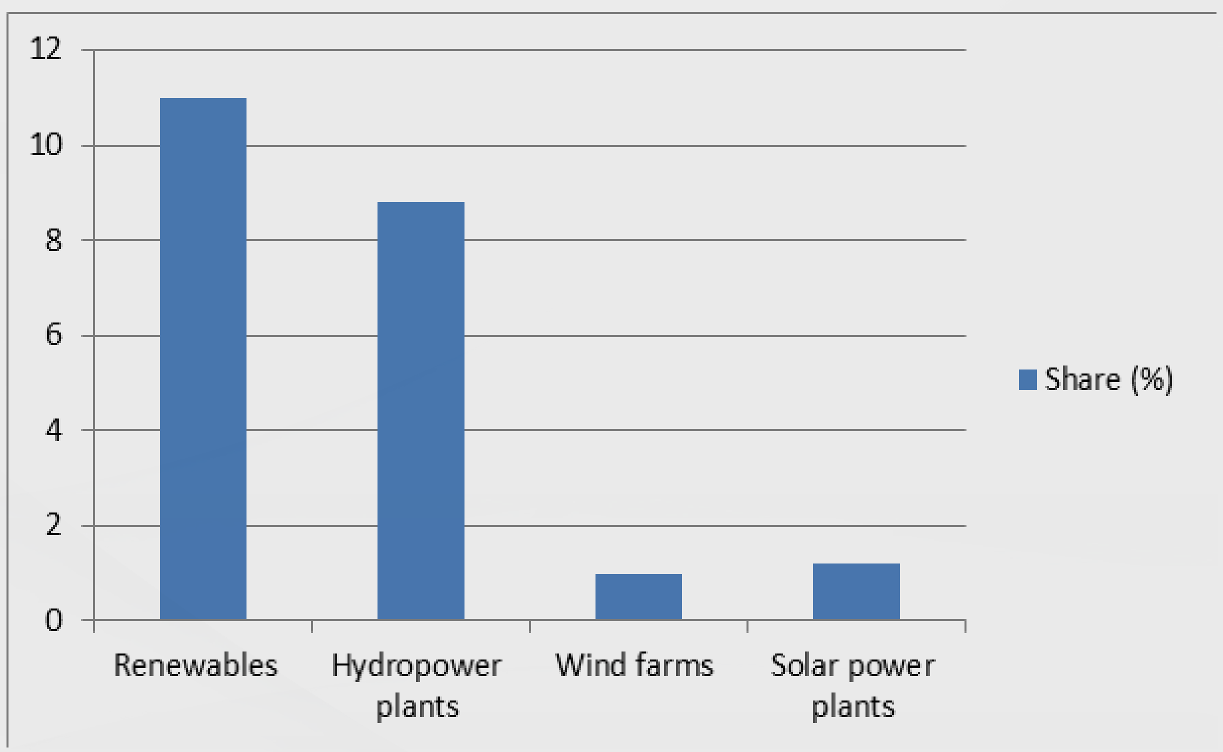


Source: Author's creation based on data from the IEA (2022).

Kazakhstan's share of renewable energy in power generation stood at 11% in 2020, mostly contributed by major hydro-energy projects, whereas wind and solar energy added only 1% to power production (Kazinform, 2021). Kazakhstan's hydropower, solar energy, and wind energy potentials, in billion kWh per annum, are assessed at 170, 920, and 2.5, respectively, whereas geothermal energy is estimated at 97 billion toe—almost equivalent to its oil and gas reserves (USAID, 2021a). Biomass energy stood at 1.5 tons of carbon per hectare per year, about half of the global average (IRENA, 2021).

Despite the significant potential of renewable energy in Kazakhstan, its share in the total energy supply and power production ranged between 1% and 10% (USAID, 2021b). Figure 2.13 displays Kazakhstan's installed share of renewable energy sources generation by power plant type in 2020. The share of hydropower plants, wind farms, and solar power plants in the total renewable sources stood at 8.8%, 1.0%, and 1.2%, respectively, whereas biomass energy contribution was virtually negligible in 2020.

Figure 2.13. Share of renewable energy generation by plant type in Kazakhstan, 2020



Source: Author's creation based on data from KEGOC (2021).

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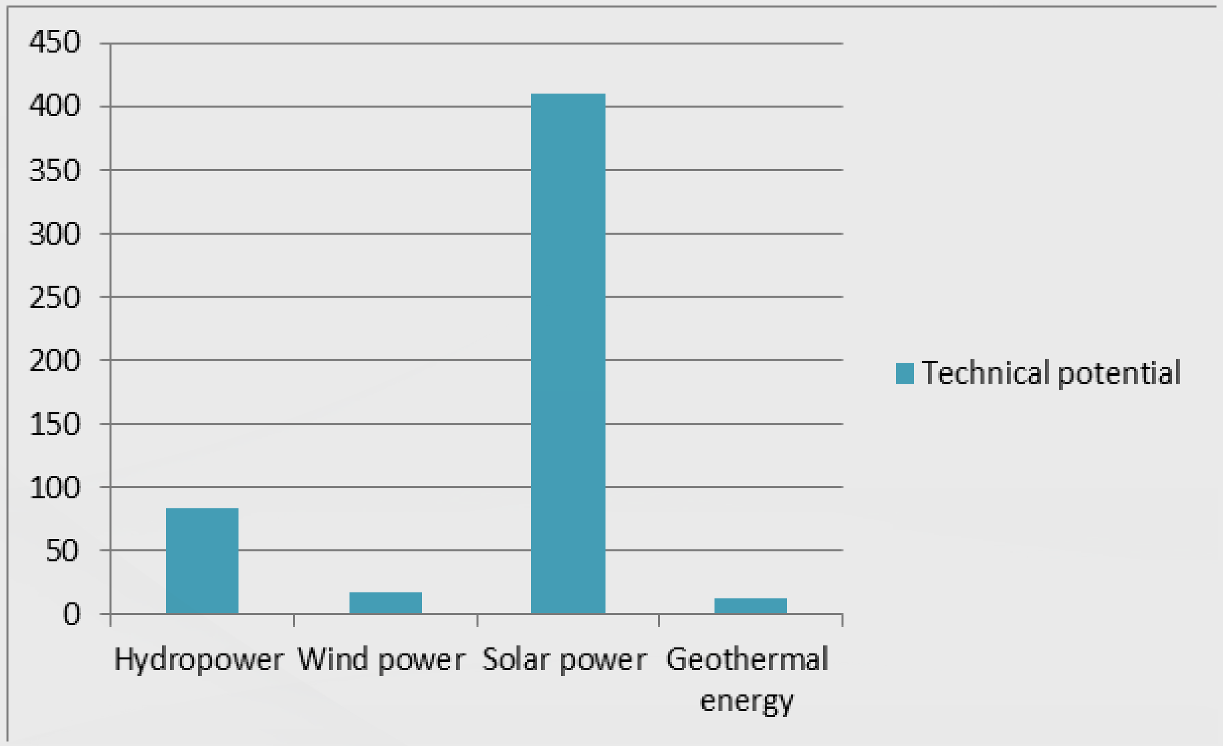
In the Kyrgyz Republic, renewable energy sources added 27% to total energy supply in 2018, with substantial contribution from hydropower (90%). Notably, data on biomass energy proved very deficient. The total energy production stood at 2.3 million tons of oil equivalent (Mtoe), and hydro energy contributed 53%. Coal's share stood at 37%, and the rest came from oil and natural gas. Dependence on energy imports remained considerable to meet the domestic energy consumption requirement of 4.2 Mtoe (IEA, 2021c). In Tajikistan, hydropower contributed 39.1% to the total energy supply in 2019. The development of other renewable energy sources, such as solar and wind energy, will add significantly to the country's energy security and transition to a green economy. In 2020, Tajikistan's renewable energy (all hydro) accounted for 90% [18.1 Terawatt hours (TWh)] of its electricity generation (IEA, 2022a).

Figure 2.14 displays the technical potential of renewable energy in Uzbekistan in 2019. The share of hydro energy to the country's total renewables stood at 1.2%, which added 10.2% to the total energy production and is expected to reach 20% by 2025. Meanwhile, the contribution of bio, solar, and wind energy was insignificant, and renewable energy contributed 8% to the total power production in 2020. The contribution of renewable energy sources to the total energy supply varied from 8% to 19% in 2000–2019 owing to fluctuations in hydrological situations; it was at 10.2% in 2019 (IEA, 2022a). Bioenergy from solid biofuels and biogas remained poorly accounted owing to data scarcity (IEA, 2020c). Uzbekistan plans to generate 12 GW of solar and wind energy and 1.5 GW of hydro energy by 2030. The effective exploitation of the potential of renewable energy will help Uzbekistan achieve the target of 25% total energy production from renewable energy sources by 2030 (IEA, 2022a).

Figure 2.14. Technical potential of renewable energy sources in Uzbekistan (PJ), 2019



Source: Author's creation based on data from the IEA (2020c).

CAREC member countries have immense untapped potential in renewable energy sources, which should be effectively utilized to achieve the goals of carbon neutrality. The transition to renewable energy sources requires financial incentives for deploying energy-efficient renewable energy and attracting greater private participation.

Energy market reforms, including tariff reforms, should be vigorously implemented to develop technical and institutional capabilities for increasing knowledge and skills and enhancing the financial viability of firms engaged in developing renewable energy sources. Small firms engaged in renewable energy generation and supply should be provided considerable support to leverage compatible technologies. Electricity market reforms should foster energy efficiency and aid switching to a carbon-neutral economy. Tariff reforms should integrate efficiency costs, including environmental costs, in the electricity pricing.

2.5 BARRIERS AND CHALLENGES TO ACHIEVING CARBON NEUTRALITY

Achieving the goals of the 2015 Paris Agreement entails the non-use of considerable proportions of identified oil, gas, and coal stocks in CAREC member countries. Carbon neutrality requires severing production from scant resources and transitioning to clean technologies, which involves the immediate departure from fossils-based energy technologies. However, CAREC member countries face various barriers linked to low-carbon technological transformation and innovation financing. The transition to clean energy technologies also faces institutional, political, economic, and financial barriers.

Technological Barriers. The main technological barriers for green transformation can be high-tech lock-in owing to inadequate technological development in contrast to fossils-based energy technologies and prospects of uncertain economic feasibility and meager investments in clean research and development (R&D). These barriers need a long-run technology policy that can boost the technological mix through public-private collaborations.

Institutional Barriers. Institutional barriers consist of transformation in behavioral and social norms and values that support fossils-based energy technologies. Robust regulations are needed to tackle institutional barriers. Old infrastructure should be freed and diminished. Institutional investors should be encouraged to build grid-based technologies.

Economic Barriers. Economic barriers include the limited financial proceeds from clean technologies and investments in trapped fossils-based energy technologies. High-carbon infrastructure generates economic barriers when strong market regulations are instituted. Clean energy technologies can generate externalities, given that cost of fossils-based energy technologies ignores harmful environmental impacts. Therefore, the CAREC member countries should internalize externalities via emissions trading. Moreover, incentives for unclean innovation must be abolished to foster divestment from carbon-intensive infrastructure. Reducing R&D incentives for fossils-based energy technologies can facilitate sustainable clean energy transition in the CAREC region. Steady tax benefits for clean technologies can also persuade sustainable transition away from dirty technologies.

Financial Barriers. Financial barriers include the information asymmetry that impedes the assessment of the costs and benefits of investments in dirty and clean technologies. Financial barriers occur in all stages of clean technologies owing to market imperfections in the CAREC member countries. Public and private investment in compatible infrastructure can remove these barriers. Financial markets must be regulated for greater investments in clean technologies.

Political Barriers. Political barriers include organizational failures to transition to clean technologies. An example is inadequate policy cooperation at different levels, which may induce departure from clean investments. This can be addressed by stronger regulations that can attract more investment in clean infrastructure. The region also lacks common targets in terms of investment in low-carbon activities. Political barriers can be addressed through robust planning for clean innovation and faultless switching from dirty technologies.

Transition Barriers. Transition barriers to clean technologies in the CAREC member countries hinder investment in low-carbon innovations, given that traditional technologies offer steady returns. Clean technologies involve larger risks and extended return periods to impel sustainable transition. Free competition can foster the development of clean technologies and attract greater private investment.

Inadequate technical knowledge and scientific skills act as significant barriers to the transition to a carbon-neutral economy in many CAREC member countries, excluding the PRC, Kazakhstan, and Turkmenistan. The heavy reliance on traditional energy resources has contributed substantially to carbon emissions. Moreover, the application of novel technologies for the development of renewable energy sources has been weak in many CAREC member countries. The institutional framework to achieve carbon neutrality varies by country, reflecting the disparity in execution of regulatory capacities. Low-carbon policies are espoused based on each country requirement. For instance, Kazakhstan targets to lower carbon emissions by 2050 and Tajikistan's GHGs emissions policy explicitly focuses on efficient resource use. However, CAREC member countries lack regulatory and regional cooperation in the execution of carbon neutrality in priority sectors. Greater reliance on fossils-based energy poses a substantial barrier to all CAREC member countries to lower carbon emissions and reach carbon neutrality. Except for the PRC, Turkmenistan, and Kazakhstan, CAREC member countries face the barrier of having to amplify the application of gas to lower their dependence on coal. Significant efforts have been made to tap the potential of hydropower as a renewable energy resource and substitute to fossils-based energy in many CAREC member countries.

However, the considerable wastage of hydropower potential in Tajikistan and the Kyrgyz Republic serves as potent barriers to switching to renewable energy and reaching carbon neutrality targets, requiring political commitments. Uzbekistan faces significant technological and financial barriers to exploiting its significant extant potential for solar energy deployment. Despite novel initiatives to attract green financing, the progress toward carbon neutrality remains limited and seemingly half-hearted. All CAREC member countries have embraced sustainable practices in production and consumption activities but recorded varied achievement levels owing to inadequate green investment pledges that are in turn attributed to social and economic reasons and political commitments. Kazakhstan, Tajikistan, and Turkmenistan face capability barriers in co-financing green projects and leveraging international financing to reach carbon neutrality targets.

CAREC countries face specific barriers to carbon neutrality. Azerbaijan confronts various barriers to fostering energy efficiency and achieving carbon neutrality, including lacking legal structure and political readiness, inadequate incentives and planned goals, inefficient energy tariffs, deficient skilled and trained personnel, and scarce information and understanding regarding numerous advantages of improved energy efficiency. Therefore, tackling these barriers is essential to boosting energy efficiency, lowering carbon emissions, and generating employment. In Georgia, the main barriers to developing renewable energy sources and reaching carbon neutrality include complicated official practices, inadequate pricing support, ambiguity in the electricity market, impeded grid connectivity, and inadequate hydrology data. The development of solar power in Uzbekistan needs to address the barriers of information asymmetry and

lack of skilled personnel, inadequate regulations, lack of investment, and insufficient integration in the energy system.

Energy subsidies act as a major barrier because they maintain the energy infrastructure and limit investments in energy-efficient technologies, which in turn increase transmission and distribution losses and cause frequent electricity cuts in Uzbekistan.

Understanding the connection between barriers and policy options becomes critical to transitioning from carbon-intensive to carbon-neutral investments. Existing regulations that support fossils-based energy technologies also restrict private financing of clean technologies owing to market uncertainty and constrain funds transfer to clean technologies. Therefore, CAREC leaders need to understand the financing costs and benefits of clean vis-à-vis dirty technologies. Novel financing instruments must also be developed to foster clean technologies in the CAREC member countries. Regional cooperation and public–private collaboration in skills development, clean R&D, and seizing the benefits of investment in dirty technologies and low-carbon projects should all be ensured. Carbon neutrality faces various challenges in the CAREC region.

Policy-Level Challenges. Achieving carbon neutrality entails international cooperation. However, the US and Russia have not pledged their carbon neutrality goals. Some countries have signed the Paris Agreement but not passed legislation to this effect. Many CAREC member countries intend to achieve carbon neutrality but fail to institute relevant policies and plans to foster clean technologies that help achieve carbon neutrality goals.

Resource-Level Challenges. Switching from fossils-based energy to clean energy is the primary yardstick to realizing carbon neutrality. The availability and development of clean energy resources vary across the CAREC member countries. This variability hampers the exploitation of renewable energy resources via the development of clean energy technologies that enable the achievement of carbon-neutral goals.

Technology-Level Challenges. The development of clean energy technologies influences the achievement of carbon neutrality targets. The cost of clean energy technologies is substantially higher compared with brown energy technologies, owing to which the production of hydro, solar, wind, and other renewable-based energy is limited in many CAREC countries. Cost-efficient green technologies require substantial R&D investment. Green hydrogen energy is highly carbon-neutral but costly compared with gray hydrogen. The development and application of CCS technology that is needed to generate green hydrogen remains limited in many CAREC member countries.

Market-Level Challenges. The development and use of clean energy technologies requires cost-efficiency compared with fossils-based energy technologies. The cost-effectiveness of fossils-based energy adversely influences the clean energy transition in the CAREC region. The green hydrogen supply chain faces substantial infrastructural constraints, such as inadequate refueling stations in all CAREC member countries, including the PRC.

Energy-Level Challenges. Achieving carbon neutrality requires switching from carbon-intensive energy consumption to green energy use. However, the existing energy structure in the CAREC region is controlled by fossils-based energy, which hinders the achievement of carbon-neutral targets.

All CAREC member countries have displayed immense reliance on fossils-based energy sources. Non-renewable resources, such as gas and coal, generate about 99% of energy in Uzbekistan and Kazakhstan, and about half of the energy use in Tajikistan. The PRC, Kazakhstan, and Turkmenistan have faced the challenge of high

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levels of CO2 emissions compared with the Kyrgyz Republic and Tajikistan. Tajikistan has demonstrated high use of renewable energy resources, whereas Kazakhstan, Turkmenistan, and Uzbekistan face the considerable challenge of efficient switching to clean energy and carbon neutrality.

Significant improvement in the efficiency of waste management can leverage the green economy and help reach carbon neutrality targets. Inadequate scientific and environment-friendly waste management practices pose a considerable challenge to CAREC member countries, except for the PRC, Turkmenistan, and Kazakhstan. Illicit landfills, which imperil groundwater supply, comprise a common challenge in the PRC, Tajikistan, the Kyrgyz Republic, and Kazakhstan. The PRC, Uzbekistan, and Kazakhstan have developed national waste management policies, whereas other CAREC member countries have embraced external assistance to properly manage waste. Inefficient waste management at construction sites creates immense challenges in the Kyrgyz Republic and Kazakhstan. Turkmenistan and Tajikistan face the challenge of managing industrial waste emanating from oil and mercury production.

To transition to green energy, CAREC member countries must address the challenge of investment needs and trained personnel, which are scarce, except in the PRC. Moreover, data on carbon emissions remain lacking in many CAREC member countries, thereby impeding proper and detailed carbon-neutral policy analysis. Extant regulatory and institutional frameworks focus on green economy and not attuned to carbon-neutral targets. Meanwhile, the COVID-19 pandemic crisis and Russia–Ukraine war have emerged as additional challenges to all CAREC member countries, jeopardizing the transition to carbon-neutral economies owing to the lack of investment and regional cooperation.

In Kazakhstan, a notable challenge is the low price of resources, such as water, for industrial applications; this has led to exploitative extraction. Kazakhstan's reliance on traditional fossils-based energy resources to steer economic development also diverts large financial resources away from investment in novel technologies for renewable energy deployment. The regulatory and institutional challenges to transitioning to a carbon-neutral economy are likewise considerable in Turkmenistan, where lapses in public policies impair private investment. In Turkmenistan, inadequate knowledge and skills, lack of infrastructure, and deficient data obstruct the achievement of carbon neutrality targets. Meanwhile, Tajikistan confronts the challenge of inadequate domestic investment in green projects, which impedes carbon-neutral transition pathways and fosters greater reliance on international investment. The inadequate capacity of private and government agencies to implement large-scale infrastructure development hampers the sustainable and judicious use of domestic financing in carbon-neutral manufacturing. In the Kyrgyz Republic, the lack of sustainable management of manufacturing and construction activities leads to the generation of significant levels of air pollution and therefore obstructs the pathways to a carbon-neutral economy. Great dependence on water-intensive cotton generation in Uzbekistan entails the exploitative application of water resources, increasing the risk of water scarcity in the river basins of regional countries. Uzbekistan also faces the substantial challenge of lacking skilled workers in the domestic economy owing to considerable migration of trained personnel to bordering economies that provide higher wages.

Realizing the cost efficiency of renewable energy generation through off-grid technologies remains a main challenge in Azerbaijan. The institutions and policies for developing plans toward improving energy efficiency are lacking in Azerbaijan, despite initiatives to draft legislation in 2018. Azerbaijan lacks robust regulatory frameworks to lower its CO2 emissions. Legal institutions to improve energy efficiency and develop renewable energy are also deficient in Azerbaijan. Moreover, Azerbaijan lacks carbon pricing and climate strategies despite initiatives for a domestic strategy to realize the NDCs and a low-carbon economy. In the case of Georgia, it has achieved a significant decline in energy intensity, but the reasons for the same are difficult to ascertain owing to the challenges of insufficient monitoring and evaluation.

Georgia lacks the legal structure to track energy efficiency in buildings. It also lacks coherence among the multiple agencies involved in instituting its energy efficiency policy. For Kazakhstan, the challenges are its great dependence on fossils-based power generation, substantial subsidies, low energy tariffs, inadequate regulatory framework, and lack of cooperation among relevant ministries. In Tajikistan, energy security is influenced by volatility in hydro conditions, outdated infrastructure, and lack of regional cooperation. Meanwhile, Uzbekistan provides low-price electricity to its population compared with most CAREC member countries and gives substantial subsidies to the residential sector. It plans to offer large subsidies during the phase-out period until 2030. Energy subsidies have generated a considerable challenge to improving energy efficiency, developing energy infrastructure, and reducing transmission and distribution losses and electricity cuts. Uzbekistan's energy efficiency governance also faces the challenges of inadequate public awareness and lack of cooperation among the relevant ministries. Uzbekistan lacks financial incentives, regulatory systems, and energy-efficient technologies to boost renewable energy. Local firms' participation in renewable energy deployment and maintenance is virtually absent.

In sum, the CAREC region has recorded substantial CO2 emissions and its carbon intensity has constantly surged. Despite efforts, achieving carbon intensity targets are hindered by the significant application of fossils-based technologies and limited application of clean technologies and novel skills. Achieving carbon neutrality goals is impeded by the irregular and spatial variability of renewable energy resources. In many CAREC member countries, clean hydrogen development faces technical and storage constraints and remains costly for larger application. However, achieving carbon neutrality can facilitate a smoother green energy transition in the CAREC region.

2.6 PATHWAYS TO CARBON NEUTRALITY

The PRC has revealed its plan to reach carbon peak and carbon neutrality by 2030 and 2060, respectively. At the same time, the PRC is the biggest energy user and CO2 emitter globally, owing to which the PRC's roadmap to carbon neutrality has attracted global interest. The PRC's pathways to clean energy transition include instituting industrial reforms, ensuring greater energy savings, enhancing energy generation and use efficiency, deploying green energy, and embracing a circular economy. The PRC has strongly pledged to realize carbon neutrality via compatible policies. It has set carbon reduction goals and prerequisites to achieve carbon neutrality targets. At Copenhagen in 2009, the PRC envisioned lowering its carbon emissions by about 45% per unit of GDP in 2020 from 2005 levels and the share of non-fossils-based energy in primary energy consumption at 15%, while increasing forest stock by 1.3 billion cubic meters (Kong, 2020). At Paris in 2015, the PRC set a carbon emissions reduction target of about 65% in 2030 compared with 2005, to achieve carbon peak, while also setting the share of non-fossils-based energy in primary energy consumption at 20% and increasing forest stock by 4.5 billion cubic meters (Chi et al., 2021).

In the 2020 United Nations (UN) Climate Summit, the PRC reaffirmed its intention to reduce carbon emissions by 65% by 2030, compared with 2005, and revised the contribution of non-fossils-based energy to primary energy to 25%, the increase in forest stock to 6 billion cubic meters, and the increase in total wind and solar power installed capacity to above 1.2 billion kilowatts.

Kazakhstan initiated the first step toward carbon neutrality in 2013, by declaring the transition to a green economy. Kazakhstan had earlier legislated different laws compatible with carbon-neutral pathways, such as the Environmental Code in 2007 and Law on Use of Renewable Energy Sources in 2009, to improve energy efficiency, ensure sustainable waste management, and lower air pollution. Kazakhstan Strategy 2050 aims at socio-economic-environmental sustainability and the transition to clean and green energy options by 2050. The revision of the Environmental Code in 2019 and 2021 aimed to monitor industrial emissions and reiterated the intention to foster carbon-neutral goals. Kazakhstan's Environmental Code outlines carbon trading and NDCs targets to lower carbon emissions by 15% from 1990 levels by 2030. Green investment projects aim to lower carbon emissions drastically by switching from fossils-based energy and improving energy efficiency via gasification efforts in Nur-Sultan and Almaty and greater application of renewable energy. The CAREC Institute is keen on helping CAREC member countries address environmental issues. Moreover, Germany has supported Kazakhstan in developing policies to tackle climate risks. Under a sustainable consumption and production program, Kazakhstan has promoted energy-efficient buildings. In 2019, the UN supported sustainable development practices that have been initiated in many central Asian countries, including Kazakhstan.

The European Commission has financed different projects to limit climate change in the Central Asia region. Notably, climate financing needs substantial investment up to 2050 to achieve carbon neutrality and green growth in the region. During the past decade, Kazakhstan leveraged USD2 billion of climate financing in green projects from different international organizations. Since 2018, the UN Environment Programme (UNEP) facilitated the revision of many laws and development of novel strategies aimed to achieve sustainable development, green growth, and a low-carbon and circular economy. Many German players and the World Bank have helped Kazakhstan develop a database for climate risk. The ADB, European Bank for Reconstruction and Development (EBRD), and Astana Green Finance Centre have financed many green projects in the energy and gas sectors to aid Kazakhstan in achieving its carbon-neutral targets by 2060.

Turkmenistan has established an institutional framework to foster carbon-neutral pathways, such as the promotion of green economy, minimization of waste, implementation of efficient technologies, monitoring of sustainable manufacturing, and adoption of R&D practices to transition to environment-friendly technologies, including recycling. Turkmenistan has also created laws to protect the air (1996), conserve hydrocarbon resources (2008), ensure sanitation and radiation safety (2009), implement chemical safety (2011), and guarantee nature and ecological protection (2014).

Turkmenistan has planned to reduce carbon emissions via energy conservation, improved energy efficiency, and the transition from fossils-based energy to renewable energy resources. Notably, Turkmenistan has shown a decline in carbon emissions since 2015, reflecting its path toward carbon neutrality through greater financial investment and technological upgrading. Along with the UN, Turkmenistan has co-financed many sustainable and green urban development projects to improve energy efficiency, sustainable mobility, carbon emissions, and waste management, with a goal to reach a carbon-neutral economy. Turkmenistan has also leveraged green financing from different international organizations, such as the UNEP, and co-financed various climate projects.

Tajikistan lacks long-term strategies for achieving its carbon neutrality targets, which can hamper its climate resilience planning. In 2007, Tajikistan embraced carbon neutrality reforms through social-economic-environmental sustainability to boost renewable energy generation through bolstering infrastructure for the deployment of biomass, geothermal, hydropower, solar, and wind energy. Tajikistan has also initiated policies to improve energy infrastructure efficiency and investment. Since 2010, Tajikistan has implemented various environmental laws compatible with its carbon-neutral goals. The country has tapped only 5% of its hydropower potential, which already covers more than one-third of the domestic energy production and meets more than one-fourth of the energy consumption needs.

Tajikistan's pathways to a carbon-neutral economy should focus on the extant potential of its hydro energy resources. In Tajikistan, international organizations, such as the ADB, Eurasian Development Bank, EBRD, International Monetary Fund, United Nations Development Programme, and World Bank, and foreign governments have co-financed different hydropower projects, such as the Rogun Hydropower station, Nurek Hydropower Plant, Golovnaya Hydropower Plant, and Kairakkum Hydropower Plant, as well as environmental protection and climate projects. With domestic and international financing, Tajikistan has implemented many projects to protect the environment, improve energy efficiency, and promote sustainable mobility, manufacturing, and waste management.

The Kyrgyz Republic has numerous environmental laws aimed at the protection of clean air, natural habitats, biospheres, and ecology. The country's NDCs show that about 60% of carbon emissions come from the energy sector. Economic development goals and the country's transition to a service-based economy have required the greater application of renewable energy resources to reach carbon neutrality goals. In 2013, the Kyrgyz Republic implemented the National Sustainable Development Strategy. Subsequently, it has developed renewable energy, pursued a green economy, and implemented climate projects with financial support from the UN Industrial Development Organization and World Bank. Apart from green financing from international organizations, the Kyrgyz Republic has also developed policy support to attract domestic green financing to improve energy efficiency.

In Uzbekistan, about 82% of carbon emissions emanate from energy production. Thus, concerted policy efforts are needed to achieve carbon neutrality goals. Despite immense potential to generate solar energy, Uzbekistan's renewable energy generation has remained very low, except for hydropower production. Uzbekistan has made considerable advancement toward carbon-neutral pathways in the past decade via reforms aimed at railway electrification, waste management, industrial energy efficiency, renewable energy deployment, and greening of the transport sector. Uzbekistan's strategy for 2019–2030 aims to significantly lower carbon emissions through improving energy efficiency and switching to renewable energy generation. With the support of international organizations, Uzbekistan has initiated policy

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reforms to promote sustainability and innovation, bolster its regulatory framework for environmental protection, improve energy efficiency, reduce carbon emissions, and implement green projects to reach carbon neutrality targets.

All the CAREC member countries have endorsed the Paris Agreement and developed regulations and laws to achieve carbon neutrality goals, albeit indirectly. For instance, Azerbaijan has continuously revised its legal regulations for electricity generation using renewable energy resources and Georgia has framed a national energy efficiency plan and laws on energy and water supply. Kazakhstan has implemented carbon pricing and developed emissions trading plans, as well as regulated GHGs emissions through national allocation plans. The Kyrgyz Republic has executed regulations to lower the technical squandering of energy firms, whereas Tajikistan has developed a mechanism to enhance the financial outcomes of electricity companies. Turkmenistan has legislated the development of hydrocarbons, whereas Uzbekistan has developed a low carbon energy strategy for 2030. Azerbaijan, Georgia, and Uzbekistan have successfully implemented projects that produced certified emissions reductions.

Currently, Uzbekistan leads in implementing certified emissions reductions projects in Central Asia. CAREC member countries have considerably changed their energy intensity and efficiency through cross-border cooperation among governments and relevant institutions. Achieving carbon neutrality is influenced by the application of novel skills, clean R&D, green technology, green growth policy, green financial development, green taxation, low-carbon strategies, public–private investment, and regional cooperation and collaboration.

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2.7 CONCLUSION

Currently, the manufacturing sector in CAREC countries consumes substantial carbon-intensive energy and suffers from low value addition and upgrading. The transition to a clean and low-carbon economy is highly difficult. However, the PRC's transition time from carbon peaking to carbon neutrality is almost half that of the European Union.

Reaching carbon neutrality entails substantial clean and low-carbon investment in the CAREC region, which currently lacks a robust carbon neutrality model that accounts for the region's resources. CAREC member countries should institute robust laws and regulatory mechanisms to transform the regional carbon market. Regional cooperation is imperative for capacity building and skills development to foster green and low-carbon energy systems that can achieve carbon neutrality.

Financial and fiscal incentives should be provided for the sustainable transition to low-carbon manufacturing activities. Financial institutions should be supported to participate in regional carbon trading markets. Many CAREC member countries have substantial coal reserves, which continue to be significantly used in the industrial sector. Improving coal efficiency and effective use can significantly reduce carbon emissions. CAREC member countries should promote green coal mining practices to increase efficiency and clean application. Underground coal gasification should be developed to use deep coal and minimize the adverse effects of coal mining.

2.8 POLICY RECOMMENDATIONS

Government commitment is essential to achieving carbon neutrality, and policy support is needed for efficient fossils-based energy usage in all production activities. Market development strategies are needed for sustainable energy transition and energy-efficient innovation for carbon reduction. Legislative and regulatory mechanisms are likewise essential. Economic activities vary among CAREC member countries; thus, national carbon reduction strategies must be instituted. The departure from fossils-based energy should be smooth and compatible with development goals. Fiscal incentives for fossils-based technologies should be stopped and carbon-neutral technologies must be fostered by instituting tax benefits to attract private investment in green investment. Carbon-neutral industrial standards should be bolstered to reduce carbon emissions. Carbon emissions should be made more costly by devising a carbon tax. Government policy support is necessary to develop the knowledge and skills to foster low carbon technologies. The mechanism of carbon emissions trading should be strongly developed and implemented, including budgetary support. Policies in the following areas are needed to reach carbon neutrality.

Policies for Carbon Reduction. CAREC member countries should foster a low-carbon circular economy to realize high-quality development pathways to achieving carbon neutrality targets for mitigating the impacts of global warming and climate change. They must target comprehensive carbon circulation and its sink, emissions, and use. They must develop sound green financing to foster clean technologies and green projects with a goal to achieve sustainable development and carbon neutrality. Reaching carbon neutrality entails the swift retirement of fossils-based energy to the adoption of green energy in the industrial, construction, transport, and household sectors. Existing natural gas markets should be strengthened to meet the growing consumption requirements through sustainable natural gas supply chains and networks. This calls for substantial investment in natural gas infrastructure, including storage and transport. Compatible regulations should be instituted to build and maintain the pipeline network.

Policies for Augmenting Carbon Sinks. Increasing carbon sink can be a primary means to reaching carbon neutrality. This entails the enhancement of the carbon-seizing capacity of soils, forests, and grasslands. Novel carbon sink regulations should be instituted to defend, conserve, and restore ecosystems. CAREC countries should safeguard ecological systems, avoid forest and land degradation, conserve biodiversity, and improve ecosystems' carbon sink to lower associated carbon emissions.

Sustainable forest management projects should be implemented to recover forests and improve carbon sequestration. Integrated ecosystem conservation programs should be operationalized for rejuvenating degraded ecosystem resources.

Policies for Low-Carbon Technologies. CAREC member countries also need robust policies for carbon neutrality compatible skills and technology development. CCS technology can realize low-carbon use of fossils-based energy. However, the application of CCS technology involves substantial costs and more energy use.

Therefore, the development of cost-effective CCS technology is imperative to realize carbon neutrality targets. R&D in future CCS technology requires substantial investment to allow use at the commercial scale. CCS technology can be applied for reducing carbon emissions from power projects. Its development entails instituting incentives and standards. CCS technology can store carbon in oil, gas, and paddy fields. Policies on carbon tax, trading, and subsidies can be formulated to lower carbon emissions.

Policies for Clean Energy Substitution. CAREC member countries should focus on greater clean energy substitution to reach carbon neutrality goals. Novel technologies should be used to generate power from renewable resources. Solar thermal energy can significantly substitute coal-based energy. CAREC member countries should give greater emphasis on the application of natural gas to lower carbon emissions and realize carbon neutrality. The available conventional natural gas in major basins of the CAREC region should be exploited to boost gas production.

Integrating Carbon Neutrality in Different Sectors. Carbon neutrality can be integrated in different sectoral programs. In the forest sector, carbon storage capacity and carbon sink should be improved through participatory carbon-neutral forest projects. In the building, roads and highways, and construction sectors, greater emphasis should be given to the use of carbon-neutral construction and building materials. The capital market can be leveraged to foster investment in carbon-neutral transport, industry, energy, and waste recycling. Incentive to support green projects financing can be instituted. As in the PRC, carbon-neutral bonds can be promoted in other CAREC member economies to support green industries. Green insurance and green credit should also be promoted to achieve carbon-neutral targets. In the urban residential sector, the recycling of electronic and municipal solid wastes can potentially help reach carbon neutrality targets. Sewage treatment and water reuse can substantially contribute as well. The segregation of recyclables, enhancement of biogas generation, and reuse of waste derivatives in manufacturing can improve municipal carbon-neutral capacities. In the agriculture sector, green agricultural techniques and waste recycling should be promoted to reduce GHGs.

Green Hydrogen Development. Green hydrogen development requires a robust hydrogen supply chain. Green hydrogen can be used in transport, energy generation, and chemical and steel production. Cost-efficient green hydrogen is likely to significantly reduce the price of hydrogen energy compared with the gray hydrogen generated by fossil fuels. It is likely to constitute a significant proportion of end-energy use by 2050. CAREC member countries should use green hydrogen energy in different sectors to meet the expected surge in demand in the future. The hydrogen supply chain should be bolstered via substantial investment in hydrogen infrastructure, such as fuel cells and refueling stations, and hydrogen integration with oil and gas networks should be intensified.

2.8.1 Recommendations

Country-specific policy recommendations are expected to help CAREC member countries realize their carbon neutrality goals. In Azerbaijan, robust measurement, reporting, and verification should be implemented for the efficient achievement of NDCs goals. Azerbaijan aims to lower net emissions by 35% by 2030 from 1990 levels. This entails technological innovations, regulatory transformation, and knowledge dissemination.

Azerbaijan needs technological upgrading and cost efficiency to realize its renewable energy potential and lower carbon emissions. Azerbaijan’s carbon intensity can be lowered by boosting the efficiency of natural gas-based electricity production and deployment of renewable energy by instituting financial incentives and energy market reform in the short term and fostering CCS technology in the long term. Electricity production should switch away from fossils-based energy toward renewable energy sources by gradually ceasing subsidies for fossils-based energy generation and instituting carbon pricing. A long-term low-carbon strategy is needed to reduce carbon emissions. Azerbaijan needs to set renewable energy targets to be realized over the short and long term using compatible policies. Novel financing is needed to exploit the hydro, solar, and wind power potentials by instituting suitable financial incentives and payment mechanisms, cost efficiency, and carbon pricing to lower carbon emissions.

Local small renewable energy firms should be offered suitable incentives to bolster renewable energy production. Robust energy data should be collected to assess achievements and revise domestic policy as needed to reach carbon neutrality targets. Energy efficiency indicators should be used to monitor and evaluate the effects of strategies focusing on lowering energy intensity.

Georgia developed the National Energy Efficiency Action Plan in 2015 to set domestic energy efficiency goals and achieve the same by 2030. Effective implementation of the Strategy entails detailed planning to prioritize energy-efficient renewable projects based on sound data. Robust data are also essential for the effective monitoring and evaluation of renewable energy projects. Cooperation among different ministries and local administrations should be promoted. Georgia should substantially lower its energy intensity with technological upgrading and financial support. Robust legal structures are needed in Georgia to track energy efficiency in buildings. Georgia requires energy-efficiency plans across sectors that enable collaboration across different layers of governance.

Kazakhstan's carbon neutrality goals entail switching to low-carbon development, increasing the share of renewable energy sources in power production, and total phasing-out of fossils-based energy by 2050. Despite strong efforts to improve energy efficiency, Kazakhstan needs robust legal and institutional mechanisms to implement its energy efficiency plans across sectors and leverage novel and efficient technologies and green financing to realize the goals of a carbon-neutral economy. Energy tariff reforms, including phasing-out of subsidies and cost-efficient electricity tariffs, should be vigorously implemented.

The Kyrgyz Republic can conserve electricity through technological upgrades on existing energy projects. Energy efficiency technologies should be used in new buildings. Considerable untapped opportunities exist for developing hydro, biogas, solar, and wind energy, which can potentially lower dependence on energy imports. Renewable energy producers should be given fiscal incentives, relaxed licensing, sale rights to consumers, and assured purchase by distribution firms. With its geographic and climatic advantages, the Kyrgyz Republic should tap the potential of solar and wind energy. Regional cooperation and integration in the electricity market and transmission development should be bolstered. Improvement in energy security demands tapping the country's substantial hydro potential, strengthening transmission and distribution, and bolstering regional integration.

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Tajikistan can realize energy security by increasing energy efficiency and switching to renewable energy. It has a substantial solar energy capability, which needs to be tapped to achieve energy security. Notably, wind energy potential is low but it can supplement hydro energy in mountainous regions. Tajikistan should guarantee conformity to social, environmental, technical, and safety standards in establishing novel hydro energy projects. The population affected by the development of hydro energy projects should be provided adequate resettlement. The development of renewable energy projects should be geared toward achieving carbon neutrality targets and green economy. Tajikistan should develop robust energy data and foster domestic and international cooperation to build knowledge and skills in carbon-neutral technologies. Energy efficiency indicators should be developed across sectors.

Uzbekistan aims to reach the targets of the Paris Agreement through the Green Economy Transition Strategy 2019–2030 and Roadmap to Carbon Neutral Electricity Sector by 2050. Uzbekistan needs substantial investment to realize the goals of NZEs. It should promote strong collaboration among relevant ministries to develop and execute domestic and local carbon-neutral activities and to realize green growth.

Energy market reforms—improving the financial capacity of public enterprises, raising power tariffs, phasing-out of subsidies, and attracting private investment—are essential to the transition from fossils-based to renewable energy production. The country should establish a robust energy data system to develop sound policies for improving energy efficiency. The efficient deployment of solar power needs adequate information, knowledge and skills, compatible regulations, sufficient investment, and technological integration in the energy system. Uzbekistan needs to encourage the active participation of energy producers in the wholesale electricity market and institute independent market regulators. The country must unravel the prospects of solar power deployment in different sectors. Information on solar power generation, markets, transmission, and distribution should be highly transparent, which should attract substantial private investment in solar power development. The significance of off-grid and floating solar power projects is not over-emphasized. Meanwhile, fossil fuel subsidies should be completely ceased. Solar parks should be developed to improve the cost efficiency of solar energy. Regional integration in solar power storage technologies should be developed. The development of solar and wind energy can significantly bolster regional collaboration in renewable energy deployment and switch to a green hydrogen economy. Uzbekistan should promote novel innovations and technological transformations in the energy sector and tap the energy trade potential with regional economies. Novel data and information are required to grasp the climate change impacts on hydro energy conditions, which can aid effective policy formulation.

Government-corporate collaboration is needed for implementing sound tariffs and efficient electricity pricing, ensuring the financial viability of public enterprises, utilizing the effective capacity of renewable energy production, and ensuring energy security in Uzbekistan. The switch to renewable energy will also help achieve NDCs to lower carbon intensity by 35% in 2030 from 2010 levels. Reducing energy intensity in Uzbekistan entails the collection of sound and quality data that can be used to assess energy use across economic sectors and measure trends in energy efficiency. Robust energy policy governance requires transparent goals to be achieved through strong monitoring and evaluation, cooperation among the relevant ministries, tariff reforms, and phasing-out of energy subsidies.

CAREC member countries need strong regulatory and institutional frameworks to tap into the immense regional opportunities for achieving carbon neutrality goals. Stronger regional cooperation is needed to leverage transboundary river basin management that can contribute to the transition from fossils-based energy to green and renewable energy. All CAREC economies have pledged to realize the Paris Agreement via greater awareness toward green growth policies, resource conservation, application of green technologies, and circular economy strategies. Regional cooperation in carbon-neutral green projects financing and capacity building should be bolstered.

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In Kazakhstan, the transition from a rigorous application of fossils-based energy to natural gas and renewable energy resources is needed. Tajikistan and the Kyrgyz Republic have immense hydropower potential to generate green energy compared with Kazakhstan, Turkmenistan, and Uzbekistan; such potential needs to be tapped to aid carbon neutrality goals. In the Kyrgyz Republic, substantial untapped potential exists in geothermal, hydropower, and solar energy, which should be given considerable attention in the transition to a carbon-neutral economy.

Tajikistan has immense freshwater resources, for which an integrated water resource management system needs to be developed and implemented. Tajikistan should pay considerable attention to sustainable and efficient waste management to reach its carbon neutrality targets. Turkmenistan should focus on exploiting its potential for renewable energy development, such as solar energy, to mitigate the problems of energy insecurity and smooth the transition to a carbon-neutral economy. Experienced international agencies can support the capacity building of local organizations in developing and implementing carbon-neutral strategies and green investment projects. Kazakhstan, Tajikistan, and the Kyrgyz Republic have initiated concrete steps in attracting green investment projects in the Central Asia region.

Global warming and climate change are global challenges and require collective actions. CAREC member countries should strengthen their regional cooperation to reach carbon neutrality targets. Shared knowledge and regional agreements are essential to control and reduce carbon emissions and achieve sustainable energy transition. Presently, fossils-based energy use remains substantial, requiring sustainable solutions. Therefore, achieving carbon neutrality is a solid step toward clean energy transition in CAREC member economies.

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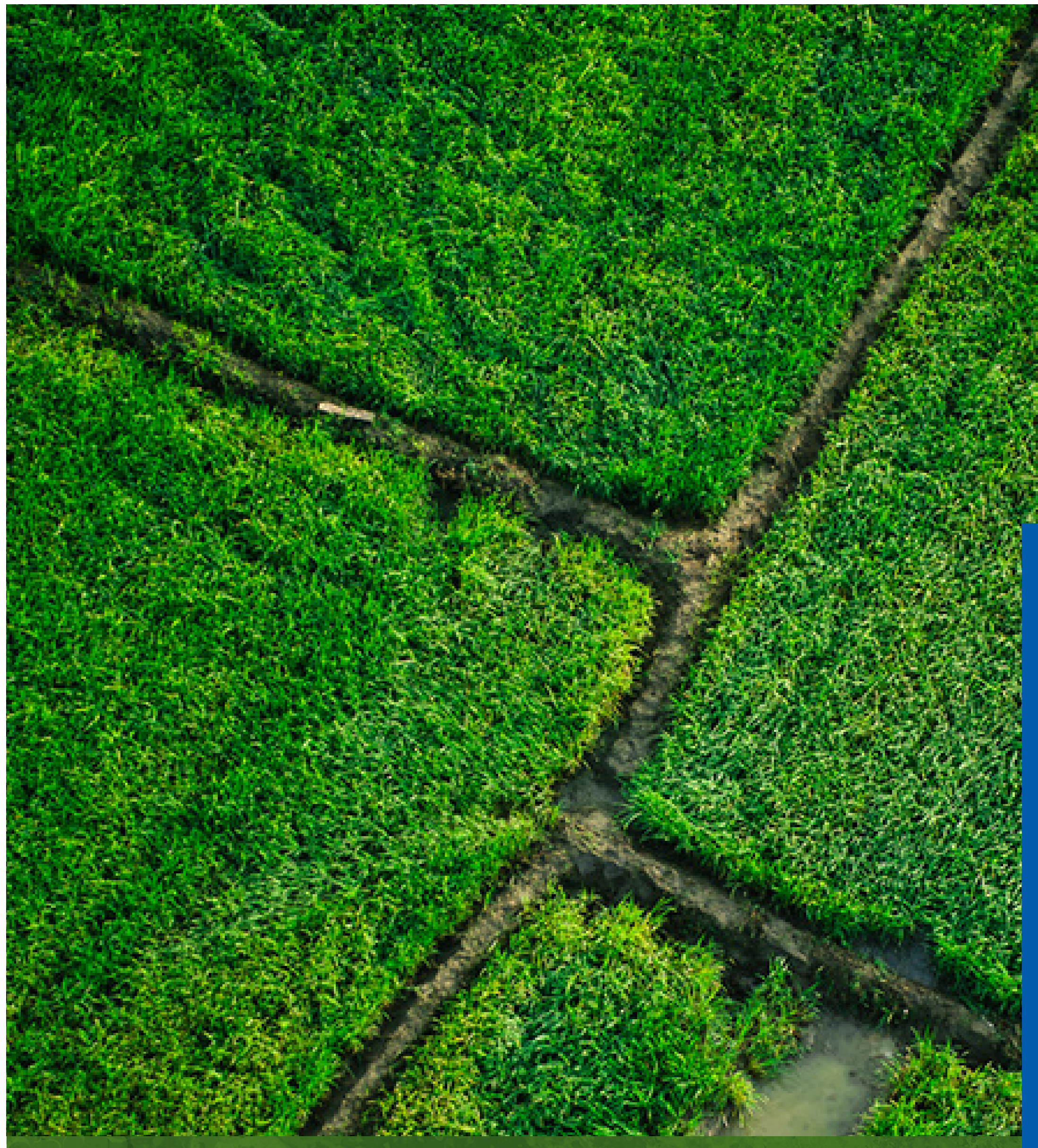


CHAPTER 03

PRODUCTIVE CAPACITIES AND GREEN PRODUCTIVITY GROWTH IN THE CAREC REGION

Asif Razzaq

3.1 INTRODUCTION

The concept of green growth (GG) has emerged in response to susceptible environmental integrity to achieve progressive economic growth. In developed countries, owing to the enormous availability of resources that promote GG, higher prosperity leads to inclusive growth. In 2011, the Organization for Economic Cooperation (OECD) identified that GG promotes economic growth, while ensuring resource efficiency without depleting the available natural resources to facilitate the human well-being of future generations(OECD, 2011). Thus, GG differs entirely from traditional economic growth by considering environmentally adjusted economic output in monetary

terms(Sohag et al., 2019). Green growth (GG) is an indispensable strategy for balancing environmental sustainability and economic growth in both developed and developing countries and encompasses four dimensions: efficient resource utilization, social inclusion, green economic opportunities, and natural capital production (Peyriere et al., 2019). Productive capacities are integrated to GG across all four dimensions, and it is crucial to elucidate the catalytic role of productive capacity in stimulating GG, particularly in the CAREC region.

Multilateral agencies and international organizations, such as the United Nations and World Trade Organization, have underscored the need to expand the productive capacities of developing economies to make them more resilient and to uncertain shocks and put them on course toward GG(Lin et al., 2023).

The United Nations Conference on Trade and Development (UNCTAD) launched a comprehensive productive capacities index (PCI) based on 46 subindices to assess PC performance and explore improvement strategies. According to UNTCAD, PCI refers to the economy's entrepreneurial capabilities, productive resources, and production connections that aggregately evaluate the country's capacity to produce economic output (goods and services) and trigger growth and development(UNCTAD, 2021).

This demonstrates the association between PCI and GG. Therefore, confiscated and targeted policies can enhance their ability to assist each other. According to this definition, UNTCAD has identified eight categories, namely energy transition, human capital, transportation, natural resources, institutions, structural change, private sector, and information and communication technology (ICT) to boost a country's PC degree and each measure specifies several metrics. Developing, preserving, and employing PCI illustrates a holistic approach, as GG and PCI components are mutually reinforced and interdependent. Evaluating the influence of the PCI and its elements on GG is the cornerstone of long-term sustainability(Xin et al., 2023).

Concerning GG, all CAREC economies are committed to Nationally Determined Contributions (NDCs) to reduce carbon emissions by 35% by 2030(CAREC Energy Outlook, 2022). This ambition is ensured through energy transition, which is a PCI component that contributes to GG via sustainable consumption, production activities, and reduced emissions(Malinauskaite et al., 2020). The International Renewable Energy Agency anticipated that transitioning from conventional to renewable energy sources would mitigate 90% of carbon emissions, attaining net-zero emissions(IRENA, 2021). It is important to reduce the energy intensity and dependence on conventional energy resources by promoting renewable energy sources, green technological innovations, and practices(Ofori et al., 2023).

It improves industrial and energy structure using innovative technologies and efficiency gains. This indicator also combats resource scarcity and upsurges sustainable waste management, leading to green transformation(Ramzan et al., 2022). Human capital (HC) is an imperative part of PCI that directly and indirectly encourages GG at the micro and macro levels. Intellectual and talented HC instigate sustainable resource allocation through knowledge and productivity spillover effects, generating higher economic output, with lower emissions and resources. Educated and skilled HC adopt ecologically friendly and energy-efficient technology, products, and clean energy resources, transforming their consumption pattern from carbon-intensive to low-carbon products. Thus, human investment in healthcare facilities, higher education and awareness, professional training, innovative skills, improved living conditions, and social settings complement society with multiple economic, social, and environmental benefits, which are the core pillars of GG(Sun et al., 2023). Human capital triggers sustainable waste management, resource preservation, and energy efficiency through recycling and advanced innovation.

Human activity is responsible for environmental degradation (Demiral & Demiral, 2023). Environmental governance through high-quality institutions, such as the Environmental Protection Agency, has emerged as a distinct policy area. Institutions are essential for the design, execution, and monitoring of stringent environmental conservation laws and sustainable practices related to GG(Abid et al., 2021). Preemptive measures and sequestering actions against polluting industries (i.e., toxic materials, soil erosion, and wastewater) reduce the carbon footprint and improve human health conditions (Bibri, 2021). Various market and non-market policy instruments are involved in restricting negative environmental repercussions. Incentivizing subsidies to eco-friendly enterprises engaged in green energy supply chains and products assists in transforming production processes(Lin et al., 2023). Thus, institutions accelerate longer-term green growth agenda.

Manifestly, natural resources (NR) foster economic progress, eradicate poverty, and offer employment opportunities. The CAREC region is resource-intensive and has vast NR portfolios, including hydrocarbon reserves (oil and natural gas), water resources (hydropower), biomass, and coal. This region has tremendous technical potential to significantly increase GG through efficient resource allocation, energy transition, and sustainable policies(CAREC Energy Outlook, 2022). In developing and emerging economies, pursuing high economic progression leads to unsustainable and persistent extensive exploitation of NR, which causes severe ecological breakdowns, such as biodiversity reduction, resource depletion, soil degradation, water scarcity, desert encroachment, destructive flooding, climate change crisis, and storms(Ahmed et al., 2022; Ismaila & Bununu, 2020). Therefore, urgent action is required to decouple economic growth from resource utilization by minimizing atmospheric pollution. Apart from this, NR provide a material foundation for infrastructure and logistics development in the transport (TRP) sector.

In the landlocked CAREC region, the TRP promotes integration of regional trade and economic growth among CAREC countries and enhances social welfare by ensuring efficient, reliable, and convenient travel of products(Liu & Yuan, 2023). Sustainable TRP facilitates poverty alleviation, inequality reduction, and food transportation(United Nations, 2022). However, the TRP is the second-largest fossil fuel energy consumer, accounting for 30% of global energy consumption(Zhang et al., 2022). Transport (TRP) demands greater resource usage in infrastructure development because natural resources are finite reserves(Guo, 2022). Amid these challenges, a green and intelligent transportation system is the predominant approach to increase GG through the sustainable utilization of fossil fuels and technology enhancements. Digitalized booking and ticket sales are commercialized across all variant modes (railway, road, air transport), and sustainable power supplies, integrated digitalized devices, sustainable urban transit systems, and smart traffic controls are included in the green TRP (Collaço et al., 2022;Xin et al., 2023). Thus, a convenient TRP increases energy and resource efficiency, mitigates carbon emissions, and provides a roadmap for GG.

Information and communication technology (ICT) is the primary metric among PCI, and ICT applications are a remarkable development in this digitalized world(Abid et al., 2023). In fact, ICT shares knowledge, improves worldwide connectivity, enhances competitiveness through spillover effects(Chien et al., 2021),generates socio-economic and ecological impact on society, moving toward GG. Human well-being improves and ICT offers employment opportunities through cost reduction, market efficiency, and technical efficiency. Besides, ICT also improves ecological sustainability through dematerialization and substitution effects(Razzaq et al., 2021). It transforms traditional production technology into energy-efficient and digitally driven innovative production methods (high-tech industries), emits less pollution, and consumes

fewer resources(Yuan et al., 2022). Information and communication technology (ICT) builds the foundation for developing green innovation, carbon capture and storage technology, electric vehicles, green buildings, resource-efficient grids, recycling, and digital devices. Digital infrastructure is formed for digital trade, online shopping, fintech, virtual meetings, e-learning, and AI-based products, apps, and platforms(Ulucak et al., 2020). Thus, ICT reduces resource dependency, increases efficiency gains in

every economy sector, and promotes green economies. However, extensive ICT consumption deteriorates environmental quality and ICT a double-edged sword(Park et al., 2018; Raheem et al., 2020).

These successive changes trigger output productivity through lower emissions and resources, and create the term structural change (SC), which brings profound and dramatic variations in traditional economies. This structural transformation involves economic, technological, institutional, and industrial improvements. Energy(Sahoo & Sethi, 2022), efficiency determines structural changes through sectoral comparisons in national outputs. Transiting economies shift from agriculture to industry (composition effect) and from industry to services (technical effects), producing more with less effort. During this phase, these countries spend more time on research and development (R&D), eco-friendly innovations, and renewable energy transition(Bilgili et al., 2020). In improving GG, the private sector's contribution cannot be overlooked as it improves the private sector dramatically. With fewer resources, the country cannot meet the proposed objective; subsequently, the private sector becomes pivotal e because it promotes technology enhancements, employs labor at a standard wage rate, diversifies the market structure, and raises the government's tax revenue(Hancock et al., 2011).

Efficient resource allocation by the private sector raises potential environmental concerns about higher emissions due to expanded interventions(Talukdar & Meisner, 2001). Private investment in the viable sector encourages sustainable development, attributable to financial constraints. The private sector's key stimulator role fulfills individual desires and preserves the ecosystem through investments in the green sector; thus, it is an indispensable determinant for attaining GG(Rashed et al., 2021).

The remainder of this paper is structured as follows. Section 3.1 introduces the productive capacities indicators and their relationships with economic growth and green productivity. Section 3.2 presents the literature review, demonstrating the existing empirical evidence. Section 3.3

outlines the research methodology and core indicators. Empirical findings (descriptive, correlation, and regression analysis) and a discussion are presented in Section 3.4; Section 3.5 concludes the study suggesting policy recommendations.

3.2 STUDY OBJECTIVES

Although several empirical studies have employed different proxies to illustrate the PCI, such as trade diversification, economic complexity, industrial structure, and export concentrations, these indicators capture only the partial economic impact of PCI and ignore other directions(Sun et al., 2022). Few studies have investigated the individual effects of PCI on economic growth and environmental sustainability(Adebayo et al., 2023; Lin et al., 2023). Thus, there is an empirical dearth in evaluating the influence of PCI on green total factor productivity (GTFP) in the CAREC region. This study contributes to the extant literature by estimating the GTFP index through the Malmquist productivity index and Data Envelopment Analysis (DEA) using annual data from 2000 to 2022.

Moreover, this study investigates the overall influence of PCI on economic growth. It provides sustainable, integrated, and targeted policies to promote inclusive green development in CAREC economies.

The specific study objectives are as follows:

-Analyze trends in PCI, economic growth, and green productivity.

-Explore the linkages between PCI, economic growth, and green productivity.

-dentify and address areas of intervention and recommend country-level strategies for green transformation.

[2] ADB. (2022). 2022 climate finance SDCD database.

3.3 LITERATURE REVIEW

A summary of the literature (Table 1) shows empirical studies in this domain, identifying the nexus between the elements of PCI, environmental quality, and green growth individually for different countries. For instance, Lee et al. (2022) ascertained the positive impact of HC on GG, and Ahmed et al. (2022) examined the interplay between institutions (INS) and GG in the South Asian region. Likewise, Ze et al. (2023) determined the association between ICT and gross domestic product (GDP) per capita for the G10 economies. Xin et al. (2023) assessed the impact of PCI on the resource footprint in China. From Table 3.1, it is observed that these studies did not analyze the aggregative influence of PCI and its components to measure GDP per capita and GG for the CAREC countries. This study bridges the research gap by estimating the descriptive (mean and interquartile range), correlation analysis, and regression coefficients between PCI and GDP per capita across each CAREC country. Accordingly, this study provides comprehensive policy recommendations for the CAREC region based on these estimations.

Table 3.1. Summary of Literature Reviewed

Author(s)	Data	Countries	Methodology	Findings
Jiang et al. (2023)	1996-2019	E7 countries	Panel Quantile Regression	↑RENE ↑GG
Razzaq et al. (2023)	2010-2020	37 IEA countries	Dynamic Panel Threshold model	↑RET ↑GG Index when the threshold level is higher
Wang et al. (2023)	1990-2019	BRICS	MMQR	↑RENE ↑GG
Ofori et al. (2023)	2000-2020	23 African economies	Dynamic GMM model FMOLS, DOLS	↑EE ↑GG

Usman et al. (2023)	1990-2018	five Mercosur countries	CS-ARDL	↑RENE, ↑HC ↓GHG emissions, and ↑NR ↑GHG emissions
Adebayo et al. (2023)	1990-2019	BRICS	ARDL	↑RENE ↓CO_2 emissions ↑NR ↓CO2 emissions
Sohag et al. (2019)	1980-2017	Türkiye	CUP-FM and CUP-BC	↑RENE ↑GG
Liu et al. (2023)	1992-2018	G7 countries	DOLS	↑NR, HC ↓ Ecological footprint
Ma et al. (2022)	2006-2017	30 Chinese provinces	CS-ARDL	↑NR ↑GDP
Hao et al. (2021)	1991-2017	G7 countries	CS-ARDL	↑HC, ↑RENE, ↑GG, ↓CO2 emissions
Lee et al. (2022)	1990-2017	South Asian	Panel Smooth	↑HC↑GG
Çakar et al. (2021)	1994-2018	EU countries	Transition model	↑HC ↓CO_2 emissions
Ahmed et al. (2022)	2000-2018	South Asian countries	DOLS, FMOLS	↑INS ↑GG
Oteng-Abayie et al. (2022)	2005-2017	29 African	System GMM	↑INS ↓CO_2 emissions
Sun and Razzaq (2022)	1996-2018	OECD	MMQR	↑INS ↓CO_2 emissions
Chien et al. (2021)	1995-2018	BRICS	MMQR	↑ICT ↓CO_2 emissions at lower quantiles
Ze et al. (2023)	1992-2020	G-10 countries	CS-ARDL	↑ICT ↑GDP
Zhang et al. (2022)	1990-2018	BRICS	CS-ARDL	↑TRA, ↑GHG emissions
Lin et al. (2023)	2000-2018	40 Belt and Road countries	System GMM and FGLS methods	↑HC, RET, ICT, and INS ↓ CO2 emissions while ↑TRA, PS, and SC ↑ CO_2 emissions
Xin et al. (2023)	2000-2018	China	Bootstrap ARDL	↑PCI ↓ resource footprint

Note: RENE- Renewable energy; GG - Green growth; ETI - Energy transition Index; MMQR - Method of moment quantile regression; GMM - Generalized method of the moment; EE - Energy Efficiency; CUP-FM - continuously updated fully modified; ICT - information and communication technology; CUP-BC - continuously updated bias-corrected; HC -Human capital; NR - Natural resources; INS, Institutions; TRA, Transport; GHG, Greenhouse gases; PCI, productive capacity index; ARDL, Autoregressive distributed lag; PS - Private sector; DOLS - Dynamic ordinary least square; CS-ARDL - Cross-section autoregressive distributed lag; FMOLS - Fully-modified ordinary least square; ↑, increase; ↓, Decrease.

Source: Author compilation

3.4 METHODOLOGY AND VARIABLE DESCRIPTION

This study explored the impact of the PCI on the GTFP Index from 2001 to 2022. The annual panel data of 10 CAREC countries encompassing Azerbaijan, China, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan are considered. This study estimated country-level descriptive statistics based on mean and interquartile ranges (pp.25-90) and correlation analysis to analyze the relationships in the sampled countries. Moreover, this study employs regression estimation to assess the relationship after controlling for potential growth factors. From this perspective, we applied the Hausman test to select the correct empirical method between random and fixed effects. The explained variable is the green total factor productivity (GTFP), calculated using the Malmquist Productivity Index (MPI) proposed in Caves et al. (1982).

The estimation of the index follows non-parametric data envelopment analysis (DEA) in which GDP per capita (constant $ 2015) is adjusted by inflation and is assumed to be a desirable output. In addition, carbon emissions (metric tons per capita) are considered undesired outputs and employed labor (in million headcounts) and capital stock (in million dollars in 2017) are used as inputs. If GTFP>1, green productivity is higher, if GTFP< 1, green productivity is lower, and if GTFP=1, green productivity remains the same.

The PCI is retrieved from UNCTAD (2022), whereas GDP, labor, and capital stocks are taken from Penn World Table 10. Carbon emission data were obtained from the Global Carbon Atlas. This section explains the PCI and its main components for providing a better understanding in Table 3.2.

Table 3.2. Description of Variables

Variables	Descriptions
Productive Capacities Index (PCI)	The UNTCAD defines productive capacities as the economy's entrepreneurial capabilities, productive resources, and production connections that aggregately evaluate the country's capacity to produce economic output (goods and services) that assist growth and development.
Human Capital (HC)	Human capital encompasses education, innovative skills, public health conditions, and cumulative research and development expenditure on society's research process, while the fertility rate depicts the gender dimension that reduces the human capital score through increments.
Natural Capital (NC)	Natural capital comprises extractive and agricultural resources available in the country, including revenues generated from resource extraction, excluding their cost of extraction. Further, the increase in material intensity reduces natural capital to reflect commodity dependency.
Energy	This indicator measures the sustainability, availability, and efficiency of energy sources. It is established through energy utilization and access, distribution losses, renewability of energy resources and their components, and economic output produced per oil unit to indicate the significance of the optimal energy structure.
Transport (TRP)	This indicator defines the system's capacity to move people and goods from one location to another and is measured by the capillaries of railway networks, roads, and air connectivity.
Information and communication technology (ICT)	This indicator incorporates accessibility and integration of communication systems, Including internet access, fixed line and mobile phone users, and server security.
Institutions (INS):	The effectiveness of the regulatory framework, success of the efforts to combat crime, corruption, and terrorism, and protection of citizens' freedom of expression and association are metrics that institutions employ to measure political stability and efficiency.
Private Sector (PS):	The private sector is the ease of cross-border trading activities that include the time and monetary costs related to import and export and support for the business in terms of speed of contract enforcement, domestic credit, and time required to initiate the business.
Structural Change (SC):	Structural change transits lower productive labor and productive resources to higher productivity during economic development. This shifting is highlighted through a variety of sophisticated exports, fixed capital intensity, and share of industries and services in overall national output. It also occurs when all constraints are analyzed and resolved efficiently in a particular economic sector.

Source: UNCTAD (2022)

3.5 FINDINGS AND DISCUSSION

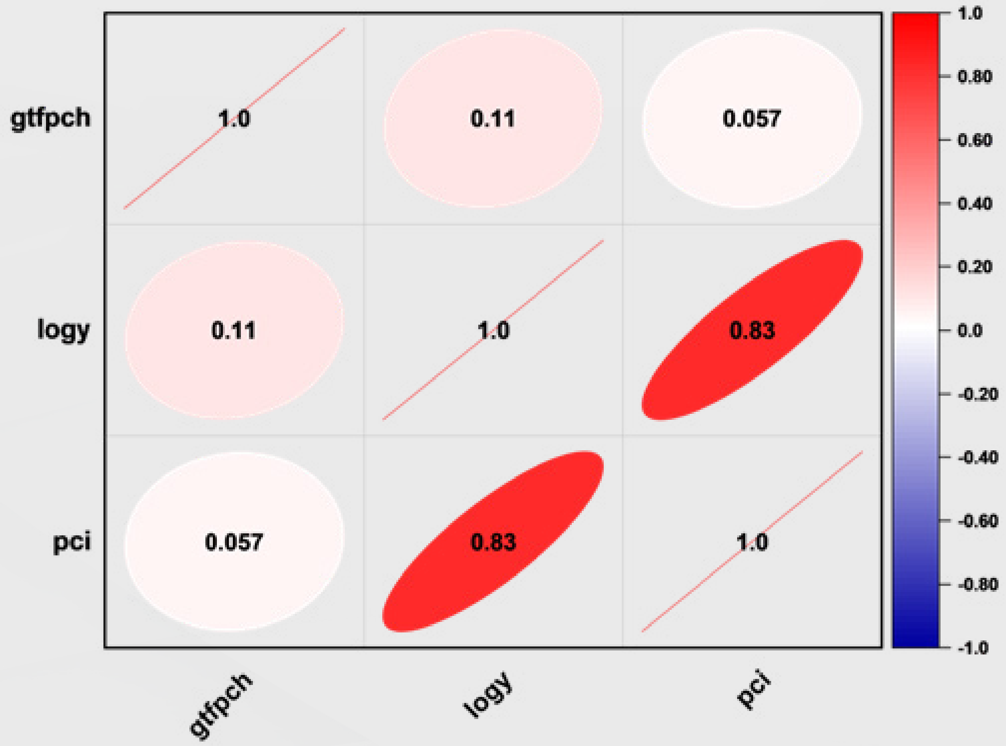
3.5.1. Correlation between PCI and Growth

This study examines the correlations between PCI, GDP per capita, and green productivity in the CAREC region. The Appendix (Table A1) reports the correlation between the PCI and growth indicators at the country level and for the overall CAREC region. In the CAREC region, the correlation between the PCI and GDP per capita was 0.833, indicating that the PCI is highly correlated with growth.

Figure 3.1 shows a consistent correlation matrix between PCI and GDP per capita, indicated by a dark red ellipse (0.83), while a correlation of 0.057 exists between PCI and green productivity (gtfpch). At the country level, a higher correlation between PCI and GDP per capita has been observed in China (0.998), followed by other countries, Kazakhstan (0.981), Pakistan (0.975), Uzbekistan (0.973), Turkmenistan (0.966), Mongolia (0.960), Georgia (0.948), Tajikistan (0.911), Kyrgyz Republic (0.893), and Azerbaijan (0.814).

Table A1 shows a positive correlation between the PCI and GDP per capita in each CAREC economy, except for NC and TRP, which report a negative correlation between both. Figure 3.2 shows the correlation between the eight PCI elements (energy, HC, ICT, INS, PS, SC, TRP, and NC) and growth measures, primarily supporting the positive association between GDP per capita and green productivity.

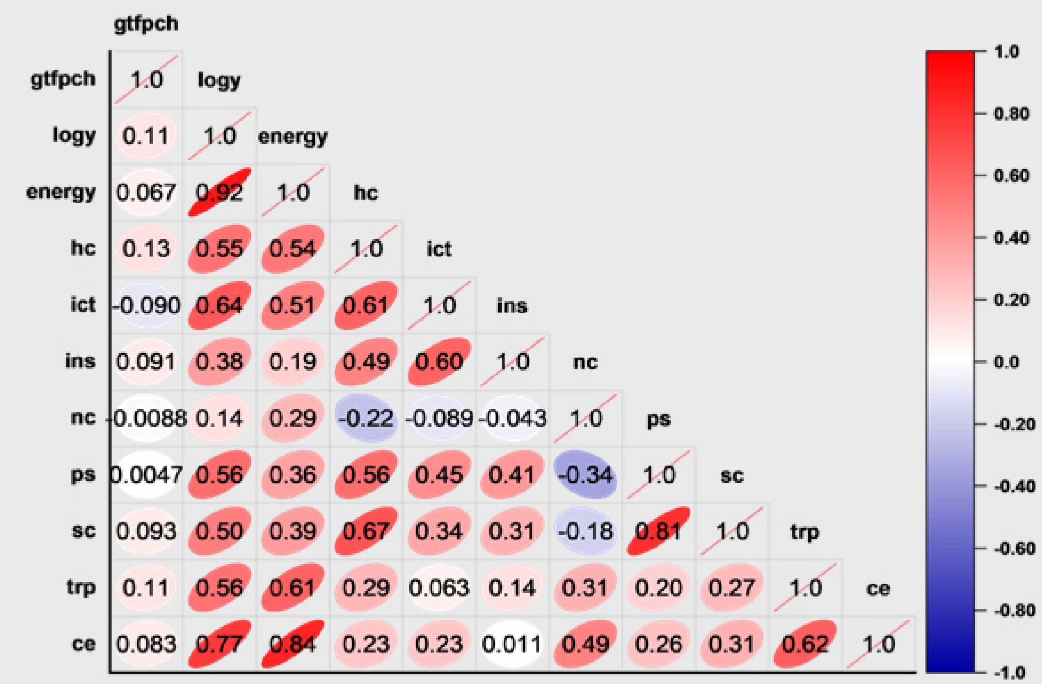
Figure 3.1. Correlation Analysis between PCI, GDP per capita (logy), and green productivity growth (gtfpch).



Source: Author construction using UNCTAD (2022) data

Productive Capacities and Green Productivity Growth in the CAREC region
CHAPTER 3

Figure 3.2. Correlation Matrix of PCI sub-components, GDP per capita (logy), and green Productivity growth (gtfpch)



Source: Author construction

3.5.2. Descriptive Analysis

This section presents the descriptive statistics of all variables based on the average and interquartile scores for each CAREC country. As shown in Table 3.3, the interquartile descriptive statistics comprise lower (p.25), middle (median or p. 50), and higher (p. 75 and p. 90) scores, which provide a more comprehensive and in-depth mechanism of these productive indices for sustainable development in the CAREC region. The details of each PCI are mentioned from Subsections 4.2.1. to 4.2.9.

Table 3.3. Summary statistics

Variables	p25	Median	p75	p90
Azerbaijan				
GDP per capita	3501.166	5173.881	5345.441	5500.504
GTFP	0.946	1.035	1.075	1.214
PCI	39.961	43.433	45.464	46.394
Energy	58.482	61.406	65.960	67.265
HC	36.663	39.119	43.110	44.103
ICT	22.688	45.351	53.296	56.099
INS	35.264	37.727	39.803	40.993
NC	49.889	50.771	52.348	52.576
PS	36.736	37.621	38.334	38.622
SC	42.054	44.486	49.815	61.222
TRP	36.283	37.894	38.527	39.837
CE	3.239	3.298	3.451	3.543
China				
GDP per capita	3800.766	6372.18	9053.229	10358.171
GTFP	0.979	1.025	1.036	1.049
PCI	48.052	53.539	57.606	59.02
Energy	58.536	64.015	66.812	67.966
HC	46.6	52.313	57.042	61.202
ICT	28.442	41.148	54.464	59.932
INS	42.625	43.347	47.877	50.112
NC	41.346	46.236	47.838	48.099
PS	60.881	65.213	78.700	79.796
SC	87.505	96.171	97.422	98.645
TRP	34.828	37.394	38.285	38.538
CE	4.91	6.973	7.320	7.645
Georgia				
GDP per capita	2563.496	3477.037	4327.648	4773.335
GTFP	0.974	1.071	1.098	1.111
PCI	41.337	45.711	47.691	49.194
Energy	49.724	55.318	60.749	60.969
HC	45.672	46.242	49.088	50.871
ICT	25.205	48.68	59.290	62.054
INS	48.779	58.732	64.729	65.192
NC	33.565	34.578	35.400	36.139
PS	42.227	45.613	47.649	49.072
SC	53.723	55.449	58.057	58.522
TRP	30.435	32.758	36.202	37.279
CE	1.212	1.833	2.633	2.775
Kazakhstan				
GDP per capita	7837.628	9665.212	10758.520	11290.897

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GTFP	0.993	1.022	1.071	1.091
PCI	42.806	48.778	50.550	51.211
Energy	68.746	71.437	73.315	74.196
HC	36.37	38.071	39.098	39.567
ICT	22.584	51.794	58.639	60.927
INS	39.91	43.337	46.694	48.367
NC	63.3	64.26	65.041	65.272
PS	36.251	42.376	43.002	43.167
SC	49.498	50.467	51.994	52.789
TRP	37.215	40.092	41.820	43.339
CE	11.051	11.636	13.274	14.825
Kyrgyzstan				
GDP per capita	837.134	1002.526	1146.103	1197.611
GTFP	.952	1.015	1.063	1.144
PCI	35.097	38.256	41.082	42.208
Energy	39.317	43.647	46.134	47.31
HC	38.194	39.379	40.137	40.884
ICT	19.607	31.522	43.991	46.754
INS	35.398	37.52	39.577	40.699
NC	55.438	56.472	57.212	57.936
PS	29.142	31.842	34.461	36.333
SC	49.143	51.508	54.235	55.504
TRP	28.487	29.726	32.090	32.628
CE	1.106	1.397	1.592	1.723

Mongolia				
GDP per capita	2197.695	3215.878	4023.786	4242.117
GTFP	1.005	1.02	1.055	1.068
PCI	42.744	46.8	47.997	48.95
Energy	53.034	55.721	59.735	61.316
HC	35.151	37.722	38.118	38.783
ICT	20.982	35.097	48.855	54.25
INS	50.975	53.112	55.659	57.307
NC	71.37	72.131	73.046	74.261
PS	33.872	40.32	43.291	43.623
SC	47.498	52.01	58.294	61.629
TRP	36.05	39.19	40.324	40.721
CE	4.811	5.784	6.431	6.8
Pakistan				
GDP per capita	1120.585	1159.898	1377.969	1452.851
GTFP	0.945	0.981	1.002	1.038
PCI	29.978	30.652	32.722	33.412
Energy	34.538	37.089	39.161	39.852
HC	17.669	19.076	22.465	24.519
ICT	12.796	18.704	26.778	28.128
INS	31.149	33.169	34.191	35.631
NC	45.546	46.394	47.106	47.171
PS	39.585	41.142	43.656	44.176
SC	40.419	41.701	42.121	42.893
TRP	21.043	26.738	27.104	27.413
CE	.711	.75	0.821	.848

Tajikistan				
GDP per capita	649.177	834.602	1060.997	1197.211
GTFP	1.013	1.024	1.036	1.041
PCI	28.401	33.21	35.178	35.715
Energy	36.012	38.574	41.707	44.203
HC	32.212	33.978	35.924	36.779
ICT	12.244	22.535	31.583	33.316
INS	28.608	29.287	30.293	31.1
NC	42.399	44.588	50.155	51.191
PS	30.205	31.414	32.120	34.005
SC	30.136	43.887	49.297	54.245
TRP	21.767	28.049	30.829	31.583
CE	.335	.404	0.757	.96
Turkmenistan				
GDP per capita	2968.113	4854.774	6784.174	7192.25
GTFP	0.999	1.023	1.039	1.061
PCI	34.894	39.301	43.528	44.27
Energy	67.292	69.313	69.735	69.817
HC	32.86	34.229	40.458	40.937
ICT	9.762	22.739	32.737	36.526
INS	23.918	24.671	25.723	27.198
NC	53.332	55.55	59.741	60.491
PS	35.007	40.712	41.810	42.494
SC	49.37	65.682	65.962	66.281
TRP	33.102	42.694	43.818	44.9
CE	10.242	10.46	11.233	11.639

Uzbekistan				
GDP per capita	1656.223	2292.823	2943.099	3187.049
GTFP	0.94	0.97	1.000	1.019
PCI	31.606	36.677	40.111	42.039
Energy	58.153	58.739	59.758	60.438
HC	35.533	36.353	37.083	37.329
ICT	10.827	24.497	43.353	46.891
INS	25.328	26.404	32.112	34.379
NC	53.493	56.03	61.361	63.311
PS	30.277	33.519	34.933	36.055
SC	35.484	38.903	40.426	52.98
TRP	27.469	32.451	32.954	33.332
CE	3.42	3.998	4.721	4.827

Source: Author construction

3.5.3. Natural Capital (NC) Index

The 26th meeting of the United Nations Framework for Climate Change declared sustainable resource consumption as the primary objective of all emerging countries. Notably, CAREC countries have abundant natural resources (including oil, natural gas, coal, biomass, water-intensive agricultural resources, and other minerals) that contribute profoundly toward economic growth. However, hazardous climate change severely damages agricultural output and vulnerable disruptions in resource prices reduce NR-led growth, supporting the resource curse hypothesis. Table 3.4 presents NC as a negative change of 4.22% in the CAREC region when comparing the figures for the years 2001 and 2022. Similarly, except Tajikistan, all other CAREC countries face a declining trend in NC. Table A1 supports these results by showing a negative correlation between NC and GDP per capita, affirming the resource curse problem, except in Tajikistan. The Asian Development Bank has assisted Tajikistan toward resilient and inclusive growth through 25 years of trusted partnership (ADB, 2023a). Efficient resource allocation, improved labor productivity growth, and spurring standardized livelihoods are the objectives of their strategy. Table 3.3 shows the means and interquartile ranges for all countries. Owing to the resource-intensive nature of the region, it is estimated that exporting NR enormously spurs economic growth and transfers the curse into a boon. It is imperative to efficiently allocate NC to maintain high standards of living, provide job opportunities, and boost social inclusion through fostering economic growth (OECD, 2011).

3.5.4. Institution (INS) Index

The role of institutions in environmental stewardship seems crucial since the Paris Agreement (2015) and climate change commitments to encourage inclusive growth(Khan et al., 2021). When comparing the NR index values (Table 3.1) for 2001 and 2022, an 18.37% increase in institutional quality is observed in the CAREC region. In an institutional capacity, Georgia showed economic resilience even during the post COVID-19 shocks, and the government implemented improved institutional reforms, social sector expenditures, and enhanced transparent and predictable public spending to commit the GG (ADB, 2023b). Therefore, Georgia dominates with a proportion change of 73.04% from 2001 to 2022, while Mongolia, Turkmenistan, and Kyrgyzstan have shown lower growth. Table 3.3 shows identical findings for all interquartile ranges, mean statistics, and correlation outcomes (Table A1). Well-developed institutions limit undesirable output and ensure a sustainable environment through green and stringent ecological policies. The ecological governance system designs green policies by incentivizing eco-friendly enterprises and imposing carbon taxes on energy- and carbon-intensive commodities. Green investments are a significant part of the GG process; better institutions allocate more funds to R&D and develop ecofriendly technologies and innovations.

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3.5.5. ICT Index

Over the past two decades, the Fourth Industrial Revolution has dramatically transformed economies worldwide into digitalized and innovative modes. As CAREC is a landlocked region, and in the aftermath of the COVID-19 pandemic shocks, integrating ICT utilization across the spectrum of regional operations is the ultimate policy agenda of all CAREC countries. The CAREC Digital Strategy 2030 is a milestone that was introduced in 2021 to disseminate ICT developments and connectivity across the region to achieve resilient and inclusive growth. Over the past two decades (2001–2022), the revolutionary transformation of the ICT sector has had significant policy implications.

As shown in Table 3.4, ICT sector has shown remarkable growth in all CAREC countries, and more than 0.90 correlations are present. Table 3.3 shows the descriptive statistics. The endogenous growth theory contends that ICT-led growth reduces costs, promotes sustainable business, and offers employment opportunities through advanced products, processes, and models(Ze et al., 2023). Additionally, ICT reduces resource dependency on conventional energy sources (fossil fuels) and stimulates resource optimization(Abid et al., 2023). Through the dematerialization and decarbonization channels, ICT encourages low-carbon economies and fosters GDP per capita without degrading the environment, thus supporting a long-term strategy for green growth.

3.5.6. Human Capital (HC) Index

Human capital-based investments have spurred economic dynamism through improved healthcare services, educational facilitation, technical innovation, and spillover effects(Cruz & Rosario, 2021). The HC Index (Table 4) of all CAREC countries increased by 24.76% during the period 2001–2022. Pakistan shows a considerable percentage change, owing to a higher proportion of young people in the working-age population (Pakistan Labor Survey, 2017). China is ranked second worldwide for its human resources capabilities. Table A1 presents the empirical outcomes obtained by depicting the correlation values. Table 3.3 shows the descriptive analysis. Thus, HC stimulates labor productivity through higher GDP per capita with efficiency gains, and plays a fundamental role in reducing income inequality and eradicating poverty. At the micro- and macro-levels, human skills are improved through higher education, training, orientation, technical assistance, and health facilities, thus boosting knowledge sharing, earning capability, output productivity, and innovation(Son, 2010). An intellectual HC deploys eco-friendly products, low-carbon and green technologies, and renewable energy sources for consumption. Similarly, on the supply side, firms and business enterprises adopt advanced green innovations, renewable energy, and advanced technology in production operations, subsequently consuming fewer resources with efficient outputs and driving GG.

3.5.7. Private Sector (PS) Index

The private sector's contribution is dominant in GG investments in advanced economies, as public-private partnerships (PPPs) have made considerable investments in various green projects. In contrast, private sector investments are insufficient in developing countries because of political, financing, legislative, technological, regulatory, and institutional factors. In the CAREC region, private investments are required in agriculture-based water resources, energy and transport sectors, digital development, and regional trade integration projects. When compared values for the period 2001 and 2022, private sector index of the CAREC region increased by 22.27% (Table 4). Pakistan, Tajikistan, and Azerbaijan are challenged by slow private sector contributions. Tables A1 and 3 provide identical results for this sector. Table 3.3 supports the findings of the descriptive analysis.

The concerned sector increases GDP per capita to overcome financial barriers, diversify market composition, and enhance technical development, employment, and tax revenues(Hancock et al., 2011). Green productivity allocates resources effectively and is a primary source of green financing; thus, all CAREC countries should focus on attracting private investors to achieve GG.

3.5.8. Structural Change (SC) Index

Structural changes are shifting from traditional, economic, industrial, and sectoral to energy-efficient, innovative, and productive structures. However, this transformation is a long-term process. Table 3.4 shows significant changes in SC for CAREC countries.

While Azerbaijan, Georgia, Mongolia, and Kazakhstan lack structural transition, the entire CAREC region enhanced by 15.44%. These results are consistent with those of the correlation analysis. Table 3.3 shows interquartile-based and mean descriptive statistics in the concerned countries. Transiting the energy sector, improving institutional frameworks, upgrading industrial structures, diversifying product composition, and developing a digital economy encompass structural reforms. For example, China has stimulated energy efficiency by adopting energy-conserving technologies and substituting traditional carbon-intensive sources with clean, reliable, and renewable energy(Huang et al., 2021). These measures and policies improve the economic structure in higher GDP per capita returns. Structural transformation increases GTFP through higher GDP per capita, with minimum inputs and low emissions.

3.5.9. Transport (TRP) Index

The Second United Nations Global Sustainable Transport Conference, held from 14–16 October 2021 in Beijing, China, focused on efficient transport and logistics structures in assuring the 2030 sustainable development goals (SDG)(X. Liu & Yuan, 2023).

The COVID-19 pandemic affected the transport sector severely, causing substantial disruptions ; therefore, sustainable and resilient transport systems remain a priority in the CAREC strategy (CAREC Institute, 2021). Table 3.3 indicates the transport statistics, where Kazakhstan, Turkmenistan, and China have higher mean and quantile value scores. Compared with other indices, TRP scores are for Central Asian countries. The percentage change in this sector (Table 4) is expected to decrease by 23.62% between

2001 and 2022. The Transport and Trade Facilitation Strategy (TTFS) was announced in 2020. However, lagging policies and loopholes have also been observed. Therefore, under the new CAREC 2030 framework, the CAREC Transport Strategy (2030) and the new CAREC Integrated Trade Agenda (2030) were formulated in 2019 to guarantee the aim of "Good Neighbors, Good Partners, and Good Prospects" (CAREC Transport Strategy, 2020). Development of transport and logistics infrastructure are likely to boost regional integration in the CAREC region through trade, tourism, digital connectivity, and economic corridors. The TRP mitigates transaction costs, supports exchange of knowledge and ideas, and promotes trade development. It has also upsurged tourism and connectivity(An et al., 2021). Through these channels, TRP drives the growth process. It also promotes GG by ensuring resource efficiency, technical innovations, sustainable energy trade, and reduction in carbon emissions.

3.5.10. Energy Index

During the 26th session of the UNFCCC in 2021, 200 countries expressed commitment to reduce coal usage to overcome the climate change crisis. The Glasgow Climate Pact has encouraged countries to expedite efficiency gains through energy transition(CAREC Energy Outlook, 2022).

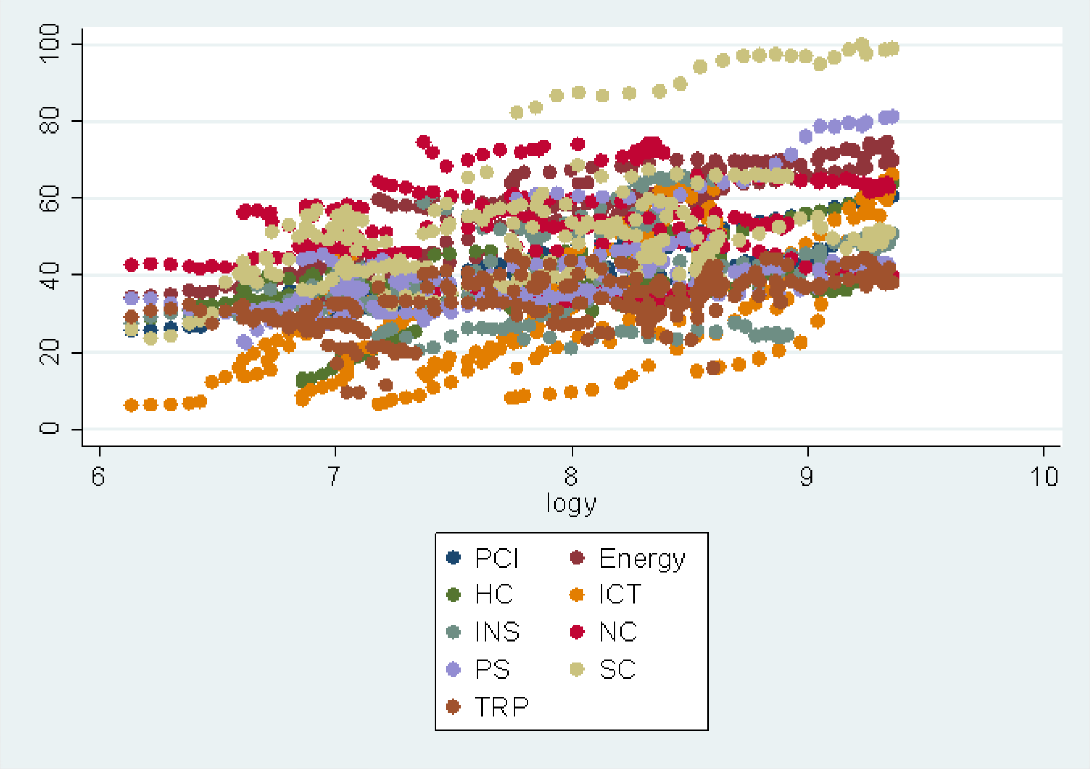
In addition, the CAREC countries (China, Georgia, Mongolia, Pakistan, Tajikistan, Uzbekistan, and Kyrgyzstan) have also pledged to limit emissions as per their NDCs. Most CAREC countries have intensified hydrocarbon and hydropower resources, showing tremendous potential for energy transition and renewable energy deployment. Table 3.4 shows that energy transition has improved in the CAREC countries by 21.69% when compared the values for year 2001 and 2022, and Table A1 shows CAREC's correlation between energy and GDP per capita at 0.916. Reporting a value of 0.994, China dominates the correlation estimation over the other countries. With the implementation of the 13th Five-Year Plan, a substantial increment has been observed in China, and the country aims to reach net-zero emissions by 2060(Diala Hawila et al., 2022). Energy

transition will trigger GG through energy efficiency and generate maximum output with fewer resources. Moreover, it creates a win-win situation, reduces carbon emissions, and improves public health. It also improves social living conditions and reduces poverty by increasing green job opportunities. As shown in Table 3.3, the energy transition index significantly stimulates the interquartile and mean-based values. The percentage increments in energy consumption and GDP per capita are shown in Table 3.4, with Uzbekistan and Turkmenistan recording lower growth rates.

3.5.11. Association between PCI and Growth

Figure 3 visualizes the positive trends of PCI and GDP per capita in the CAREC countries, showing that the core PCI pillars (Energy, ICT, HC, TRP, INS, PS, SC, NR) stimulated GDP per capita, implying that PCI is an imperative factor. Table 3.4 highlights that the PCI increased by 29.13% on average, and GDP per capita grew by 192.39% from $1808.991 to $5289.314 during the period 2001–2022. Table A1 shows a significant 0.833 correlation between PCI and GDP per capita over the past two decades. At the country level, China has a remarkable growth in PCI and GDP per capita with a 0.998 correlation, followed by Kazakhstan (0.981), Pakistan (0.975), Uzbekistan (0.973), Turkmenistan (0.966), Mongolia (0.960), Georgia (0.948), Tajikistan (0.911), Kyrgyz Republic (0.893), and Azerbaijan (0.814).

Figure 3.3. Positive association between PCI and GDP per capita (logy) in CAREC countries.



Source: Author estimation

These outcomes imply that PCI pillars are the core drivers of GDP per capita, indicating that countries with higher economic development have sufficient capacities to divert their domestic resources to achieve green productivity. Increased economic growth provides adequate investment, digital and integrated physical infrastructure, institutional regulations, and intellectual capital, which are crucial for GG. Figure 3.4 shows the stimulating trend of the PCI and GDP per capita in each CAREC country. It further depicts the downward trend between the PCI and GTFP, highlighting policy gaps and the necessary reforms in different PCI elements. For instance, visible positive changes are observed in ICT by 313.51%, followed by energy (21.69%), HC (24.77%), INS (18.37%), PS (22.27%), and SC (15.44%), while NC and TRP reduced by 4.22% and 23.62%, respectively, in the CAREC region during the period 2001–2022 (Table 4).

The descriptive and correlation analysis explicitly revealed the divergent nature of the PCI, attributable to variations in resource dependency, private sector reforms, institutional frameworks, technological revolutions, human development, structural reforms, and economic landscapes. These pillars contribute to GDP per capita while producing heterogeneous relationships with green productivity in each country. The dynamic nature of green productivity indicates the need for sequestering measures and long-term policies in the country's economic context, instead of a one-size-fits-all approach. Table 3.3 shows the descriptive statistics for PCI, GTFP, and GDP per capita across all CAREC countries.

Table 3.4. Percentage Changes

Country	Energy	HC	ICT	INS	NC	PS	SC	TRP	PCI	GDP Per Capita
Azerbaijan	17.83	20.61	267.59	29.36	-4.24	8.45	-7.13	-1.94	26.09	245.03
China	34.67	54.67	317.43	16.93	-15.94	35.56	20.21	28.59	43.43	389.93
Georgia	34.47	12.37	262.28	73.04	1.40	26.67	-5.49	-48.36	24.94	225.32
Kazakhstan	16.95	9.11	293.91	30.06	-3.55	25.83	2.34	26.15	33.75	123.35
Kyrgyzstan	32.80	15.09	252.12	-1.64	1.38	60.06	25.82	-67.89	16.83	61.69
Mongolia	36.18	20.92	280.21	-9.65	-0.47	60.60	-6.75	-27.77	25.34	166.90
Pakistan	27.25	107.46	289.16	9.22	-1.42	-10.39	16.00	-29.47	29.91	61.19
Tajikistan	29.07	30.76	445.62	13.86	19.81	-5.87	87.04	-60.59	31.08	193.84
Turkmenistan	8.96	27.87	366.90	-13.65	-14.50	25.03	22.72	-26.73	23.46	210.63
Uzbekistan	-1.69	3.01	620.18	59.76	-16.84	15.11	37.62	-32.40	33.97	164.50
CAREC	21.69	24.77	313.51	18.37	-4.22	22.27	15.44	-23.62	29.13	192.39

2001-2022

Source: Author estimation.

3.6 REGRESSION ANALYSIS

Apart from the correlation and descriptive analysis, the fixed effects method estimated the interplay between PCI and its constituents, GDP per capita, and GTFP. Table 3.5 shows the influence of the PCI and its sub-components on GDP per capita (logy), while Table 3.6 reports the elasticity coefficients for GTFP. According to the outcomes (Table 5), ICT, HC, Energy, and SC are positively related to GDP per capita, whereas TRP and NC are negatively related. Moreover, INS and PS showed insignificant outcomes. Table 3.6 shows the regression results for green productivity (GTFP). The stimulating factors were HC and INS, whereas PS and Energy reduced GTFP. In addition, TRP, NC, SC, and ICT did not influence GTFP. The coefficient's magnitude of PCI is low for green productivity than for GDP per capita.

Therefore, inclusive policy reforms are required for structural changes, resource allocation, private sector, institutional frameworks, and transport corridors at the regional level to accelerate sustainable growth. The regression outcomes support the overall conclusion that a higher PCI is associated with strong economic growth and higher potential for green productivity in the CAREC region.

Table 3.5. Regression results for GDP per capita (logy)

Logy	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
HC	0.018	0.005	0.018	3.98	0.000	.027	***
ICT	0.014	0.001	0.014	9.26	0.00	.017	***
INS	-0.003	0.003	-0.003	-1.25	0.214	.002	
NC	-0.015	0.005	-0.015	-3.19	0.002	-.006	***
PS	0.002	0.003	0.002	0.69	0.491	.009	

SC	0.003	0.001	2.32	0.021	0	.006	**
TRP	-0.004	0.002	-1.99	0.048	-.008	0	**
CE	0.029	0.013	2.25	0.026	.003	.054	**
Energy	0.011	0.006	1.88	0.061	-.001	.022	*
Constant	6.845	0.384	17.83	0.000	6.088	7.602	***

Mean dependent var	7.897	SD dependent var	0.820
R-squared	0.881	Number of observations	220
F-test	166.093	Prob > F	0.000
Akaike crit. (AIC)	-306.483	Bayesian crit. (BIC)	-272.547

Note: *** p<.01, ** p<.05, * p<.1
The Hausman test was applied to choose between the fixed and random effects models; however, it was not reported for brevity.

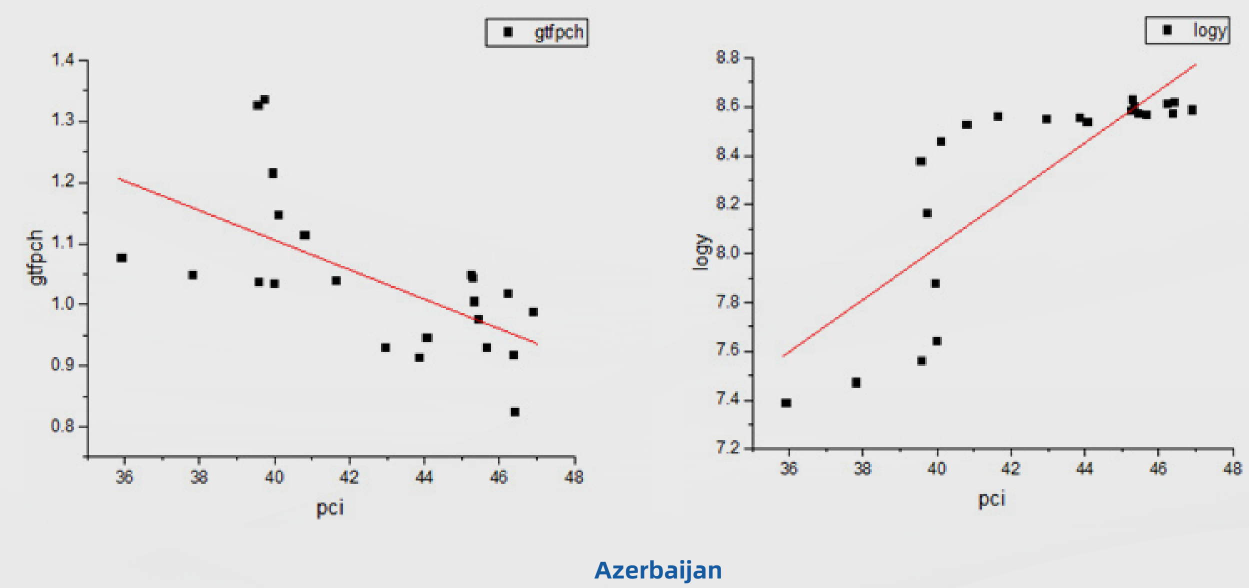
Table 3.6. Regression results for green productivity (GTFP)

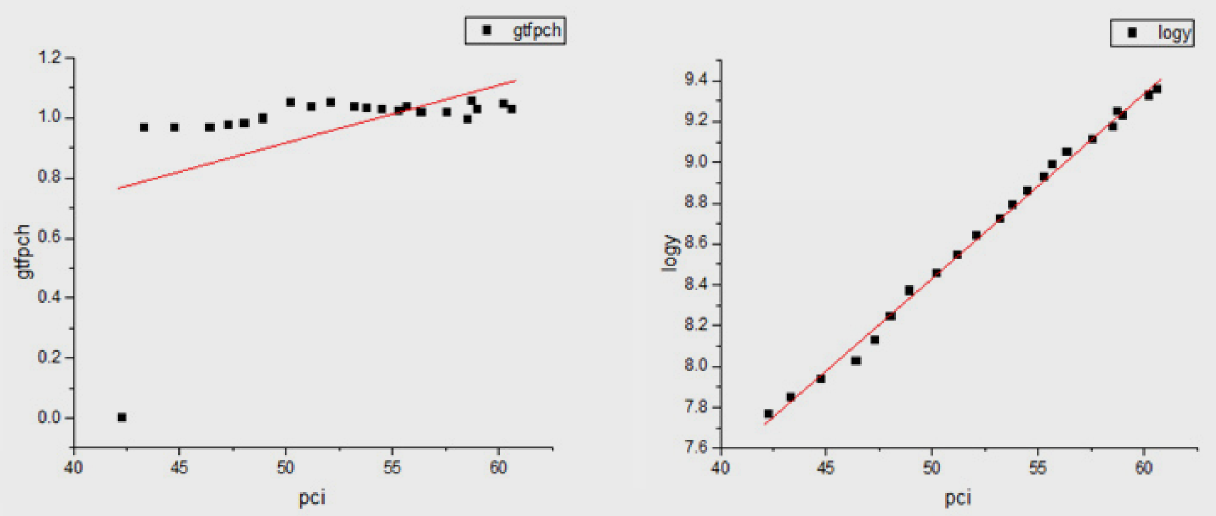
Logy	Coef.	St. Err.	t-value	p-value	[95% Conf	Interval]	Sig
HC	0.008	0.003	2.42	0.016	.002	.015	**
ICT	0.001	0.001	0.88	0.382	-.001	.003	
INS	0.005	0.002	2.35	0.02	.001	.009	**
NC	0.001	0.004	0.37	0.711	-.006	.008	
PS	-0.006	0.003	-2.41	0.017	-.012	-.001	**
SC	-0.001	0.001	-0.93	0.351	-.003	.001	
TRP	-0.003	0.002	-1.60	0.112	-.006	.001	
CE	0.025	0.01	2.52	0.013	.005	.044	**
Energy	-0.013	0.004	-2.84	0.005	-.021	-.004	***
Constant	1.363	0.294	4.63	0.000	.783	1.944	***

Mean dependent var	1.001	SD dependent var	0.094
R-squared	0.090	Number of observations	220
F-test	2.212	Prob > F	0.004
Akaike crit. (AIC)	-423.472	Bayesian crit. (BIC)	-389.536

*** p<.01, ** p<.05, * p<.1

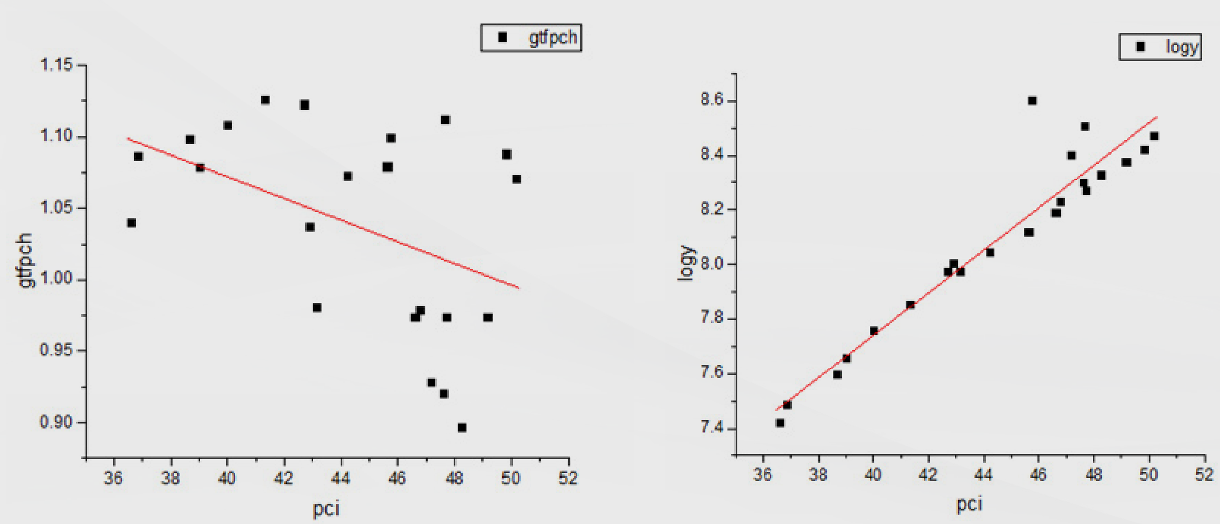
Figure 3.4. Trends of PCI, green productivity (gtfpch), GDP per capita (logy) indicators





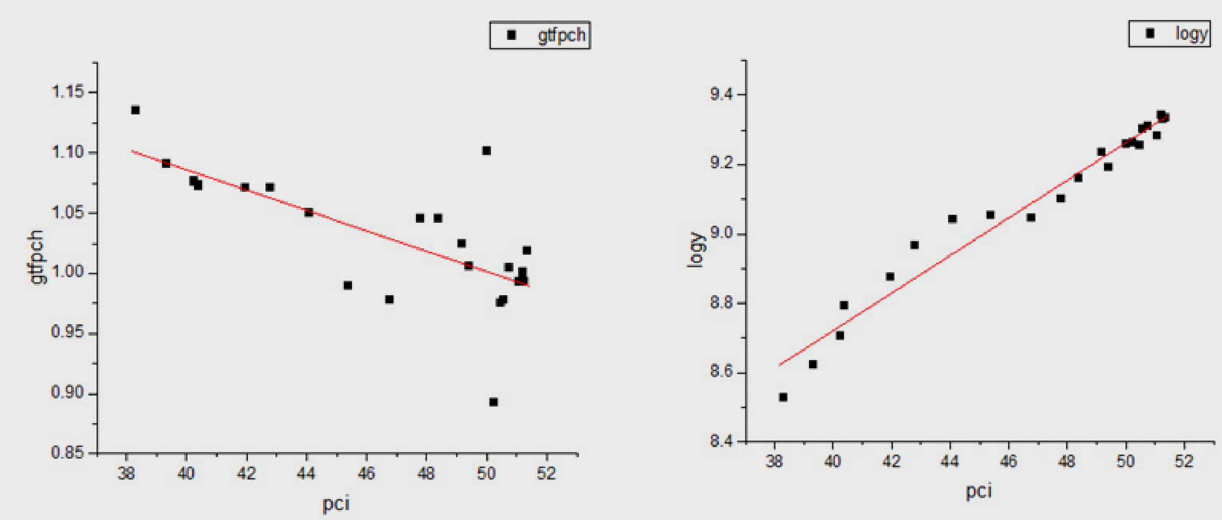
China

Figure 3.4. Continued



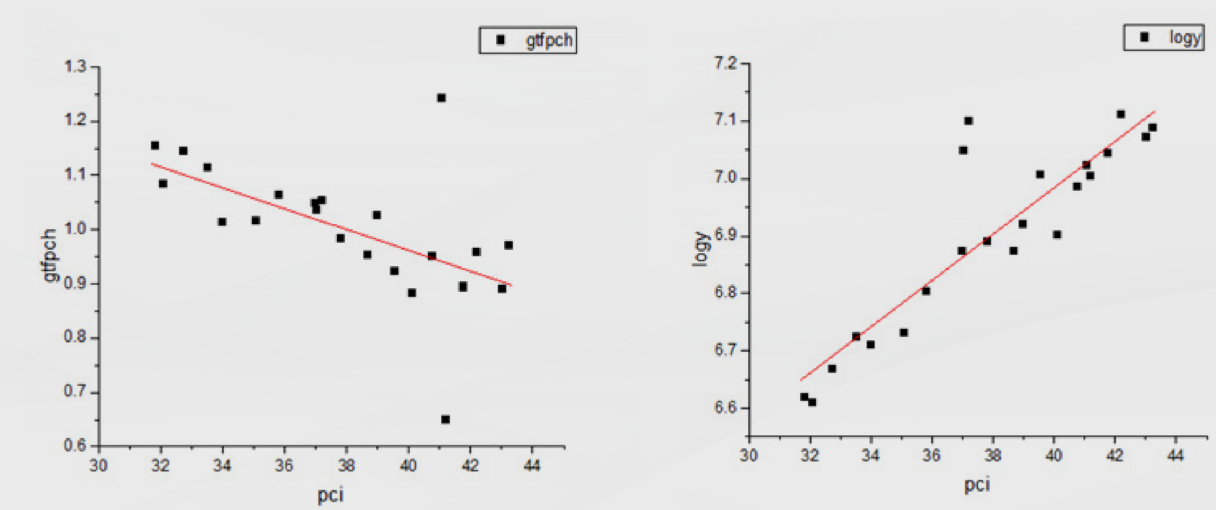
Azerbaijan

Figure 4: Continued



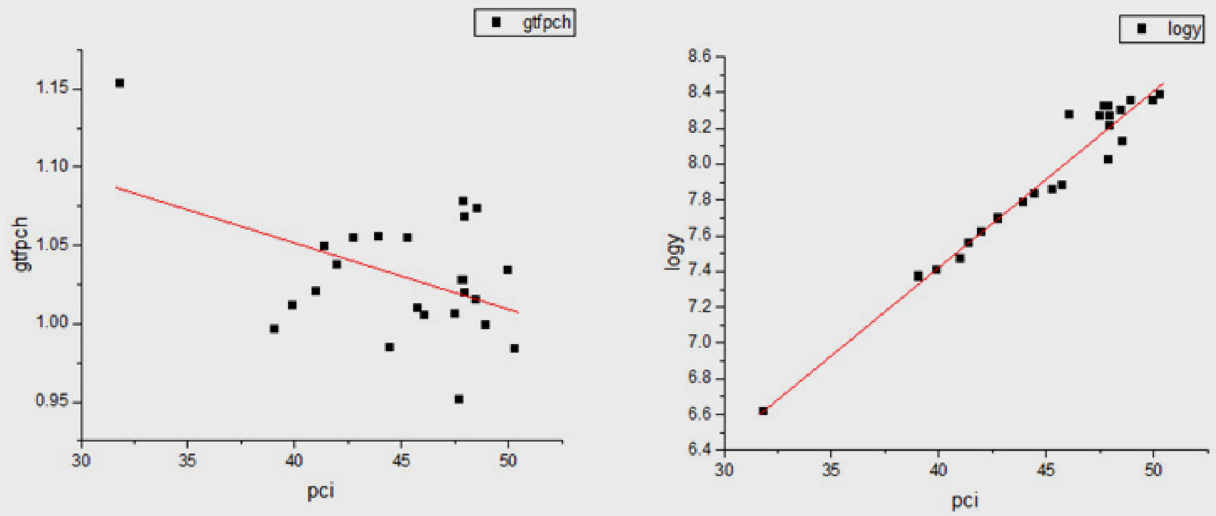
Kazakhstan

Figure 3.4. Continued



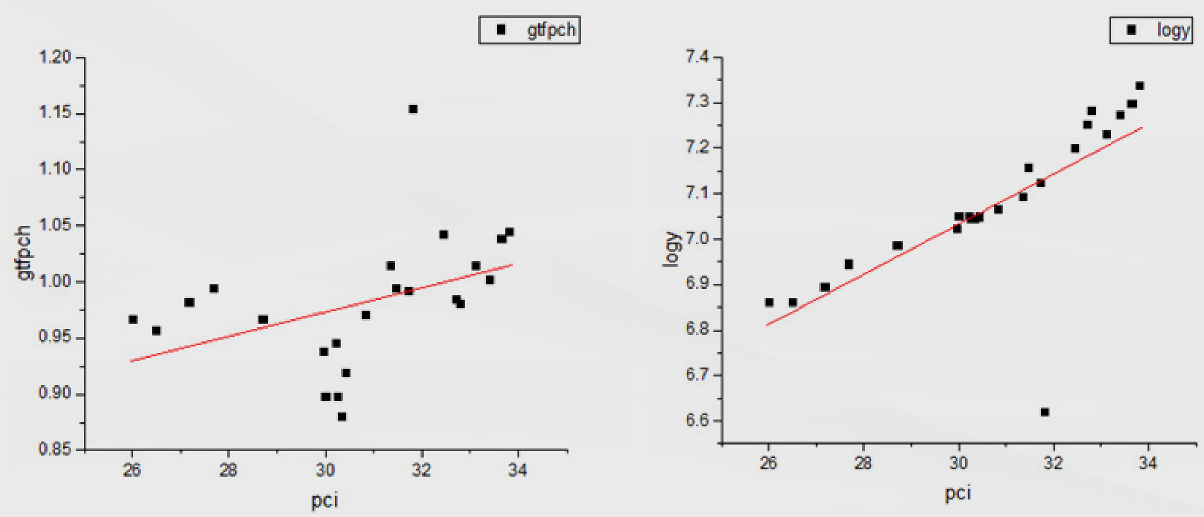
Kyrgyzstan

Figure 4: Continued



Mongolia

Figure 3.4. Continued



Pakistan

Figure 4: Continued

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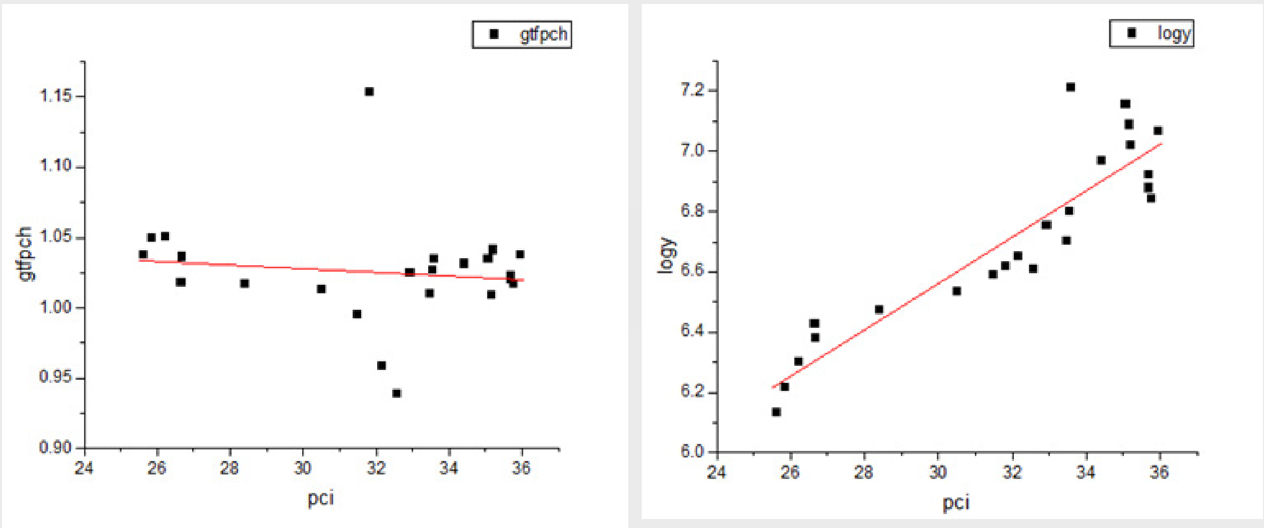
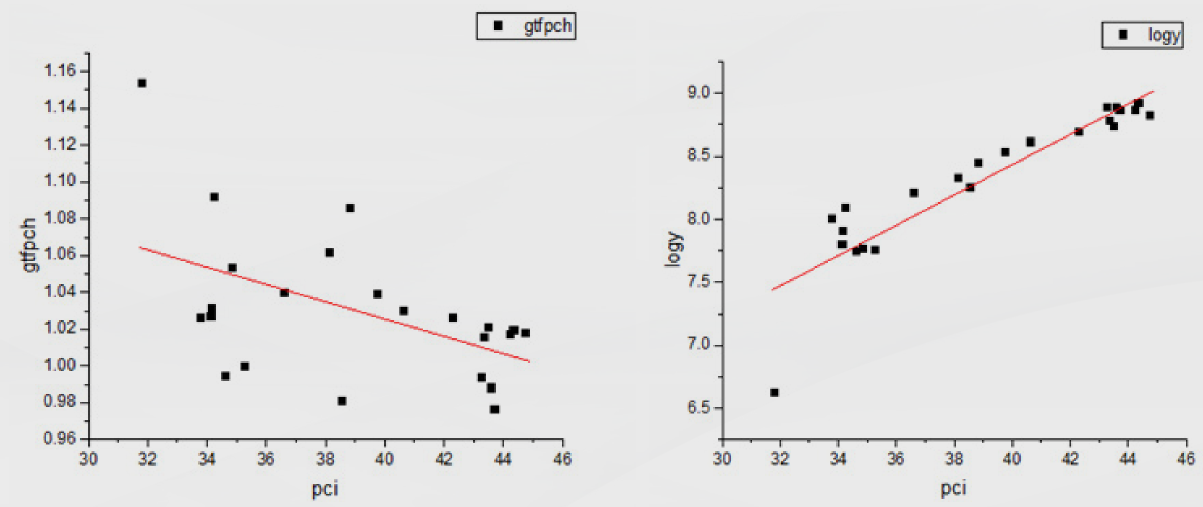


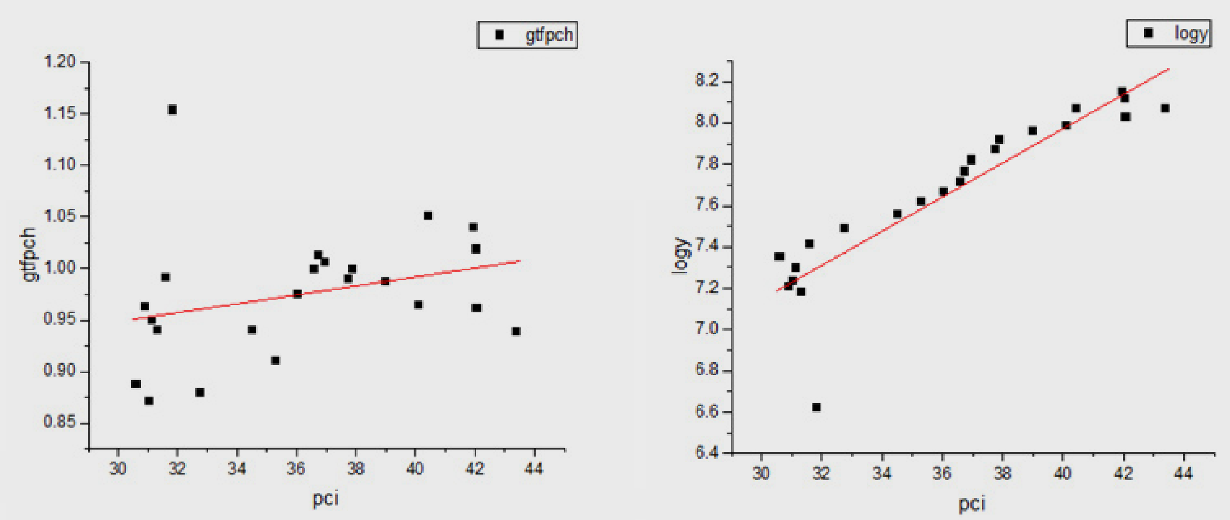
Tajikistan

Figure 3.4. Continued



Turkmenistan

Figure 4: Continued



Uzbekistan

Figure 4: Continued

3.4 METHODOLOGY AND VARIABLE DESCRIPTION

This study elucidates the association between PCI and GDP per capita in CAREC countries from 2001 to 2022. The findings show that the PCI increased by 29.13% and the GDP per capita of the CAREC region enhanced by 192.39%, from $1808.991 to $ 5289.314. The productive capacities index (PCI) is strongly associated with fostering GDP per capita, and the correlation between them is 0.833. The results illustrate that high-income economies have adequate institutional capacities, resources, technological advancements, skilled human and capital investments, and economic structures to provide a roadmap for green transformation. Among the CAREC economies, China has recorded enormous progress, and a 0.998 association is documented between GDP per capita and PCI, followed by Kazakhstan (0.981), Pakistan (0.975), Uzbekistan (0.973), Turkmenistan (0.966), Mongolia (0.960), Georgia (0.948), Tajikistan (0.911), Kyrgyz Republic (0.893), and Azerbaijan (0.814).

In all these countries, a positive relationship is evident between the PCI and GDP per capita, whereas variant associations have been explored between the PCI and green productivity, indicating variant factors, and lagging areas. All the PCI categories increased; that is, ICT, Energy, HC, INS, PS, and SC increased by 313.51%, 21.69%, 24.77%, 18.37%, 22.27%, and 15.44%, respectively; however, TRP and NR decreased by 23.62% and 4.22%, respectively. Finally, the study affirms these relationships through regression analysis using a fixed effects model, confirming that a higher PCI score promotes GDP per capita and increases the capacity for green productivity. Green growth (GG) is a dynamic and long-term process that emphasizes optimal utilization of productive resources. These pillars produce divergent outcomes, highlighting the grey areas across multiple dimensions, and policies should be designed in the context of each country's economic, social, and environmental factors. The following key suggestions are proposed:

Accelerating ICT Adoption

-Advocate policies that promote widespread adoption of ICT across sectors.
-Invest in ICT infrastructure development to enhance connectivity and accessibility.
-Facilitate digital literacy programs to ensure a skilled workforce capable of leveraging ICT tools.

Investing in Human Capital

-Strengthen educational systems to foster skill development and innovation.
-Promote lifelong learning programs to adapt to rapidly changing technologies.
-Encourage public-private partnerships to bridge the gap between the needs of academia and industry.

Promoting Energy Transition

-Implement policies that incentivize the transition to renewable and sustainable energy sources.

-Foster research and development in green technologies for increased energy efficiency.
-Establish regulatory frameworks that encourage investments in clean energy initiatives.

Facilitating Structural Changes
-Encourage policies that support diversification and innovation within industries.
-Streamline bureaucratic processes to enhance ease of doing business.
-Develop targeted incentives to spur growth in emerging sectors with high potential for green productivity.

Addressing Natural Capital Constraints

-Implement policies aimed at sustainable resource management and conservation.
-Introduce regulations to mitigate environmental degradation and promote biodiversity.
-Encourage the adoption of circular economy practices to reduce waste and optimize resource use.

Enhancing Human Capital and Institutional Governance for Green Productivity
-Strengthen institutions that oversee environmental regulations and sustainability standards.
-Promote ethical business practices through robust corporate governance frameworks.
-Invest in awareness programs to educate businesses and individuals about the benefits of green productivity.

Private Sector Development and Energy Productive Capacity
-Foster an enabling environment for private sector growth through targeted incentives.
-Support research and development initiatives focused on energy-efficient technologies.
-Collaborate with the private sector to develop and implement sustainable business practices.

Sustainable Improvement of Productive Capacities
-Develop a comprehensive strategy for sustainable development that aligns with green productivity goals.
-Establish monitoring and evaluation mechanisms to track progress in productive capacity pillars.
-Encourage collaboration between public and private sectors to ensure a holistic and coordinated approach.

Implementing these policy recommendations will enhance productive capacity, economic growth, and green productivity and contribute to the creation of a sustainable and resilient economy.

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APPENDIX

Table A1: Correlation between PCI and growth

Azerbaijan											
	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	-0.313	0.814	0.645	0.860	1.000	1.000	1.000	1.000	1.000	1.000
GFTP	-0.313	1.000	-0.617	-0.636	-0.640	-0.313	-0.313	-0.313	-0.313	-0.313	-0.313
PCI	0.814	-0.617	1.000	0.883	0.971	0.814	0.814	0.814	0.814	0.814	0.814
HC	0.645	-0.636	0.883	1.000	0.892	0.645	0.645	0.645	0.645	0.645	0.645
ICT	0.860	-0.640	0.971	0.892	1.000	0.860	0.860	0.860	0.860	0.860	0.860
INS	0.799	-0.366	0.860	0.874	0.850	0.799	0.799	0.799	0.799	0.799	0.799
NC	-0.746	0.596	-0.849	-0.844	-0.876	-0.746	-0.746	-0.746	-0.746	-0.746	-0.746
PS	0.500	-0.434	0.464	0.302	0.431	0.500	0.500	0.500	0.500	0.500	0.500
SC	-0.642	0.129	-0.321	-0.432	-0.503	-0.642	-0.642	-0.642	-0.642	-0.642	-0.642
TRP	0.029	-0.147	0.278	0.027	0.167	0.029	0.029	0.029	0.029	0.029	0.029
ENERGY	0.786	-0.419	0.867	0.909	0.892	0.786	0.786	0.786	0.786	0.786	0.786

China

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	0.751	0.998	0.985	0.988	0.828	-0.835	0.907	0.948	0.896	0.994
GFTP	0.751	1.000	0.732	0.696	0.681	0.451	-0.412	0.508	0.787	0.783	0.774
PCI	0.998	0.732	1.000	0.987	0.992	0.838	-0.835	0.910	0.947	0.892	0.993
HC	0.985	0.696	0.987	1.000	0.996	0.889	-0.886	0.938	0.911	0.820	0.970
ICT	0.988	0.681	0.992	0.996	1.000	0.891	-0.882	0.938	0.913	0.837	0.974
INS	0.828	0.451	0.838	0.889	0.891	1.000	-0.932	0.929	0.670	0.529	0.783
NC	-0.835	-0.412	-0.835	-0.886	-0.882	-0.932	1.000	-0.975	-0.702	-0.531	-0.780
PS	0.907	0.508	0.910	0.938	0.938	0.929	-0.975	1.000	0.800	0.652	0.866
SC	0.948	0.787	0.947	0.911	0.913	0.670	-0.702	0.800	1.000	0.930	0.954
TRP	0.896	0.783	0.892	0.820	0.837	0.529	-0.531	0.652	0.930	1.000	0.925
ENERGY	0.994	0.774	0.993	0.970	0.974	0.783	-0.780	0.866	0.954	0.925	1.000

Georgia

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	-0.330	0.948	0.770	0.964	0.980	-0.252	0.981	0.019	-0.665	0.975
GFTP	-0.330	1.000	-0.443	-0.195	-0.445	-0.449	0.281	-0.286	-0.033	0.258	-0.457
PCI	0.948	-0.443	1.000	0.668	0.963	0.979	-0.395	0.940	0.086	-0.471	0.966
HC	0.770	-0.195	0.668	1.000	0.754	0.695	-0.001	0.752	0.254	-0.757	0.744
ICT	0.964	-0.445	0.963	0.754	1.000	0.966	-0.219	0.948	0.028	-0.662	0.980
INS	0.980	-0.449	0.979	0.695	0.966	1.000	-0.355	0.963	0.040	-0.586	0.985
NC	-0.252	0.281	-0.395	-0.001	-0.219	-0.355	1.000	-0.283	-0.464	-0.251	-0.331
PS	0.981	-0.286	0.940	0.752	0.948	0.963	-0.283	1.000	0.054	-0.644	0.964
SC	0.019	-0.033	0.086	0.254	0.028	0.040	-0.464	0.054	1.000	-0.014	0.074
TRP	-0.665	0.258	-0.471	-0.757	-0.662	-0.586	-0.251	-0.644	-0.014	1.000	-0.655
ENERGY	0.975	-0.457	0.966	0.744	0.980	0.985	-0.331	0.964	0.074	-0.655	1.000

Kazakhstan

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	-0.694	0.981	0.705	0.949	0.817	-0.775	0.910	-0.136	0.803	0.952
GFTP	-0.694	1.000	-0.698	-0.542	-0.652	-0.613	0.485	-0.669	0.116	-0.569	-0.656
PCI	0.981	-0.698	1.000	0.719	0.985	0.818	-0.792	0.958	-0.252	0.817	0.949
HC	0.705	-0.542	0.719	1.000	0.747	0.692	-0.852	0.578	-0.134	0.456	0.645
ICT	0.949	-0.652	0.985	0.747	1.000	0.768	-0.797	0.936	-0.356	0.818	0.904
INS	0.817	-0.613	0.818	0.692	0.768	1.000	-0.748	0.721	0.077	0.424	0.806
NC	-0.775	0.485	-0.792	-0.852	-0.797	-0.748	1.000	-0.702	0.063	-0.500	-0.743
PS	0.910	-0.669	0.958	0.578	0.936	0.721	-0.702	1.000	-0.373	0.837	0.911
SC	-0.136	0.116	-0.252	-0.134	-0.356	0.077	0.063	-0.373	1.000	-0.510	-0.139
TRP	0.803	-0.569	0.817	0.456	0.818	0.424	-0.500	0.837	-0.510	1.000	0.727
ENERGY	0.952	-0.656	0.949	0.645	0.904	0.806	-0.743	0.911	-0.139	0.727	1.000

Kyrgyz Republic

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	-0.443	0.893	0.583	0.976	0.472	0.281	0.981	0.777	-0.289	0.977
GFTP	-0.443	1.000	-0.571	-0.367	-0.433	-0.141	0.049	-0.286	-0.596	-0.110	-0.406
PCI	0.893	-0.571	1.000	0.432	0.844	0.392	0.095	0.940	0.882	0.131	0.856
HC	0.583	-0.367	0.432	1.000	0.586	-0.111	-0.061	0.752	0.513	-0.417	0.629
ICT	0.976	-0.433	0.844	0.586	1.000	0.573	0.320	0.948	0.711	-0.393	0.973
INS	0.472	-0.141	0.392	-0.111	0.573	1.000	0.497	0.963	0.067	-0.249	0.505
NC	0.281	0.049	0.095	-0.061	0.320	0.497	1.000	-0.283	-0.205	-0.429	0.321
PS	0.894	-0.436	0.768	0.604	0.872	0.267	0.355	1.000	0.707	-0.417	0.880
SC	0.777	-0.596	0.882	0.513	0.711	0.067	-0.205	0.054	1.000	0.102	0.731
TRP	-0.289	-0.110	0.131	-0.417	-0.393	-0.249	-0.429	-0.644	0.102	1.000	-0.352
ENERGY	0.977	-0.406	0.856	0.629	0.973	0.505	0.321	0.964	0.731	-0.352	1.000

Mongolia

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	-0.174	0.960	0.910	0.959	-0.308	0.161	0.989	-0.622	-0.395	0.953
GFTP	-0.174	1.000	-0.030	-0.138	-0.310	-0.403	-0.176	-0.156	0.481	0.754	-0.205
PCI	0.960	-0.030	1.000	0.899	0.915	-0.392	0.172	0.950	-0.480	-0.172	0.920
HC	0.910	-0.138	0.899	1.000	0.845	-0.563	0.220	0.910	-0.605	-0.265	0.913
ICT	0.959	-0.310	0.915	0.845	1.000	-0.149	0.266	0.954	-0.744	-0.487	0.941
INS	-0.308	-0.403	-0.392	-0.563	-0.149	1.000	-0.067	-0.311	0.044	-0.423	-0.369
NC	0.161	-0.176	0.172	0.220	0.266	-0.067	1.000	0.155	-0.399	-0.145	0.153
PS	0.989	-0.156	0.950	0.910	0.954	-0.311	0.155	1.000	-0.658	-0.378	0.939
SC	-0.622	0.481	-0.480	-0.605	-0.744	0.044	-0.399	-0.658	1.000	0.598	-0.666
TRP	-0.395	0.754	-0.172	-0.265	-0.487	-0.423	-0.145	-0.378	0.598	1.000	-0.409
ENERGY	0.953	-0.205	0.920	0.913	0.941	-0.369	0.153	0.939	-0.666	-0.409	1.000

Pakistan

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	0.525	0.975	0.985	0.981	0.444	-0.777	-0.595	0.780	-0.907	0.957
GFTP	0.525	1.000	0.445	0.405	0.578	0.508	-0.376	0.183	0.004	-0.657	0.414
PCI	0.975	0.445	1.000	0.974	0.964	0.329	-0.730	-0.615	0.859	-0.821	0.974
HC	0.985	0.405	0.974	1.000	0.951	0.437	-0.760	-0.649	0.837	-0.873	0.945
ICT	0.981	0.578	0.964	0.951	1.000	0.370	-0.784	-0.586	0.728	-0.903	0.958
INS	0.444	0.508	0.329	0.437	0.370	1.000	-0.284	0.047	0.086	-0.606	0.247
NC	-0.777	-0.376	-0.730	-0.760	-0.784	-0.284	1.000	0.389	-0.628	0.834	-0.751
PS	-0.595	0.183	-0.615	-0.649	-0.586	0.047	0.389	1.000	-0.640	0.365	-0.676
SC	0.780	0.004	0.859	0.837	0.728	0.086	-0.628	-0.640	1.000	-0.540	0.831
TRP	-0.907	-0.657	-0.821	-0.873	-0.903	-0.606	0.834	0.365	-0.540	1.000	-0.812
ENERGY	0.957	0.414	0.974	0.945	0.958	0.247	-0.751	-0.676	0.831	-0.812	1.000

Productive Capacities and Green Productivity Growth in the CAREC region
CHAPTER 3

Tajikistan

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	0.013	0.911	0.988	0.979	0.375	0.889	-0.343	0.888	-0.840	0.967
GFTP	0.013	1.000	-0.174	-0.072	0.016	-0.069	0.303	0.039	-0.147	-0.291	0.124
PCI	0.911	-0.174	1.000	0.925	0.944	0.368	0.773	-0.290	0.974	-0.595	0.851
HC	0.988	-0.072	0.925	1.000	0.961	0.365	0.829	-0.393	0.901	-0.773	0.930
ICT	0.979	0.016	0.944	0.961	1.000	0.303	0.909	-0.322	0.924	-0.816	0.959
INS	0.375	-0.069	0.368	0.365	0.303	1.000	0.270	0.361	0.307	-0.257	0.320
NC	0.889	0.303	0.773	0.829	0.909	0.270	1.000	-0.311	0.786	-0.879	0.937
PS	-0.343	0.039	-0.290	-0.393	-0.322	0.361	-0.311	1.000	-0.361	0.223	-0.306
SC	0.888	-0.147	0.974	0.901	0.924	0.307	0.786	-0.361	1.000	-0.597	0.834
TRP	-0.840	-0.291	-0.595	-0.773	-0.816	-0.257	-0.879	0.223	-0.597	1.000	-0.877
ENERGY	0.967	0.124	0.851	0.930	0.959	0.320	0.937	-0.306	0.834	-0.877	1.000

Turkmenistan

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	-0.260	0.966	0.880	0.971	-0.123	-0.953	0.925	0.828	-0.480	0.871
GFTP	-0.260	1.000	-0.380	-0.461	-0.369	-0.195	0.348	-0.288	-0.297	-0.125	0.091
PCI	0.966	-0.380	1.000	0.911	0.972	0.060	-0.937	0.918	0.872	-0.377	0.753
HC	0.880	-0.461	0.911	1.000	0.946	-0.116	-0.836	0.759	0.661	-0.254	0.622
ICT	0.971	-0.369	0.972	0.946	1.000	-0.066	-0.932	0.880	0.801	-0.459	0.778
INS	-0.123	-0.195	0.060	-0.116	-0.066	1.000	0.145	-0.054	0.161	0.135	-0.328
NC	-0.953	0.348	-0.937	-0.836	-0.932	0.145	1.000	-0.959	-0.882	0.502	-0.833
PS	0.925	-0.288	0.918	0.759	0.880	-0.054	-0.959	1.000	0.926	-0.538	0.828
SC	0.828	-0.297	0.872	0.661	0.801	0.161	-0.882	0.926	1.000	-0.582	0.709
TRP	-0.480	-0.125	-0.377	-0.254	-0.459	0.135	0.502	-0.538	-0.582	1.000	-0.664
ENERGY	0.871	0.091	0.753	0.622	0.778	-0.328	-0.833	0.828	0.709	-0.664	1.000

Uzbekistan

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	0.635	0.973	0.711	0.966	0.860	-0.964	0.864	0.813	-0.881	0.172
GFTP	0.635	1.000	0.575	0.596	0.562	0.527	-0.612	0.463	0.524	-0.580	-0.170
PCI	0.973	0.575	1.000	0.750	0.980	0.911	-0.921	0.901	0.875	-0.847	0.319
HC	0.711	0.596	0.750	1.000	0.742	0.653	-0.717	0.704	0.638	-0.595	0.107
ICT	0.966	0.562	0.980	0.742	1.000	0.899	-0.926	0.862	0.844	-0.897	0.284
INS	0.860	0.527	0.911	0.653	0.899	1.000	-0.746	0.746	0.906	-0.865	0.235
NC	-0.964	-0.612	-0.921	-0.717	-0.926	-0.746	1.000	-0.872	-0.687	0.808	-0.073
PS	0.864	0.463	0.901	0.704	0.862	0.746	-0.872	1.000	0.694	-0.682	0.268
SC	0.813	0.524	0.875	0.638	0.844	0.906	-0.687	0.694	1.000	-0.810	0.397
TRP	-0.881	-0.580	-0.847	-0.595	-0.897	-0.865	0.808	-0.682	-0.810	1.000	-0.104
ENERGY	0.172	-0.170	0.319	0.107	0.284	0.235	-0.073	0.268	0.397	-0.104	1.000

Overall CAREC

	LOGY	GFTP	PCI	HC	ICT	INS	NC	PS	SC	TRP	ENERGY
LOGY	1.000	0.109	0.833	0.553	0.645	0.382	0.139	0.560	0.505	0.555	0.916
GFTP	0.109	1.000	0.057	0.130	-0.090	0.091	-0.009	0.005	0.093	0.109	0.067
PCI	0.833	0.057	1.000	0.791	0.808	0.655	0.060	0.692	0.714	0.455	0.711
HC	0.553	0.130	0.791	1.000	0.606	0.488	-0.222	0.562	0.673	0.295	0.536
ICT	0.645	-0.090	0.808	0.606	1.000	0.604	-0.089	0.450	0.343	0.063	0.510
INS	0.382	0.091	0.655	0.488	0.604	1.000	-0.043	0.406	0.315	0.136	0.189
NC	0.139	-0.009	0.060	-0.222	-0.089	-0.043	1.000	-0.342	-0.178	0.311	0.286
PS	0.560	0.005	0.692	0.562	0.450	0.406	-0.342	1.000	0.812	0.196	0.362
SC	0.505	0.093	0.714	0.673	0.343	0.315	-0.178	0.812	1.000	0.265	0.390
TRP	0.555	0.109	0.455	0.295	0.063	0.136	0.311	0.196	0.265	1.000	0.606
ENERGY	0.916	0.067	0.711	0.536	0.510	0.189	0.286	0.362	0.390	0.606	1.000

PART TWO

ENERGY TRANSITION, GREEN GROWTH AND SUSTAINABILITY IN THE CAREC REGION

PART TWO

CHAPTER 04

BIBLIOMETRIC ANALYSIS OF RENEWABLE ENERGY RESEARCH IN THE CAREC REGION

Research Trends and Future Prospects

Burulcha Sulaimanova, Aisha Manasova and Nuraiym Talantbekova

4.1 INTRODUCTION

Research on climate change and renewable energy sources is becoming increasingly relevant because of the vulnerability of this sector and the constant development of methodologies and data availability. Most studies in the energy sector have also focused on renewable generation because their primary resources are closely related to climatic factors such as precipitation, temperature, irradiation, or wind (Solaun & Cerdá, 2019). Therefore, improving energy efficiency and shifting from fossil fuel sources to renewable energy sources play key roles in achieving sustainable energy solutions (Grin et al., 2010).

Although the amount of power produced from renewable energy sources is increasing (IRENA, 2023) and research on the development of renewables in developed countries is abundant, less attention has been paid to decarbonization of energy systems in less developed countries (Apfel et.al. 2021; Vakulchuk et al., 2020). The CAREC region consists of 11 countries, namely, Afghanistan, Azerbaijan, China, Georgia, Kazakhstan, Kyrgyz Republic, Mongolia, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan, which are particularly susceptible to energy transition challenges. Since COVID-19 had a substantial impact on the economies of the CAREC program countries (except China), they lagged behind in achieving their pre-COVID levels of economic growth. All CAREC countries are expected to boost their economic growth by 10% by 2030, as forecast by the CAREC Energy Outlook 2030. Furthermore, an increase in population growth is anticipated.

Consequently, these countries have experienced an increase in energy consumption. With the exception of China, the total energy consumption in the CAREC region is expected to increase significantly. The CAREC report "Energy Outlook 2030" predicts an average growth of almost 32%, from 204 million tons of oil equivalent in 2020 to 254-290 million by 2030. However, significant improvements in energy efficiency could lower this energy demand. Improving energy efficiency could help address the financial and environmental aspects of energy concerns. Given that several CAREC countries are among the 20 least energy efficient states, efforts must be made to assess the existing situation and future development of renewable energy. The lack of this information complicates informed energy policy decisions in the region. Therefore, this paper fills a gap in this area by conducting a literature review that focuses on analyzing the current trends and prospects of renewable energy transition across the CAREC region. Energy transition in CAREC countries could have a notably larger impact on the renewable energy transition process worldwide and on global sustainability.

Transitioning to renewable energy will allow these countries to improve their energy security and reduce their dependence on conventional fossil fuels, thereby stabilizing their energy supply. This could have a significant effect on the broader energy sector.

In addition, the shift to renewable energy in CAREC countries will reduce greenhouse gas emissions, which is crucial for global sustainability, and add to international efforts to combat climate change. Producing fewer emissions entails less environmental degradation and harm, which would help mitigate climate change.

This study aims to provide a comprehensive analysis of the state of research and identify the main directions of development associated with this topic. The analyzed data were based on the Social Sciences Citation Index (SSCI) from the WoS Core Collection Database among CAREC regions from 1991 to 2023. Additionally, this research examines recent developments; identifies notable authors, organizations, sources, and trend topics; and conducts a factorial analysis in the field of renewable energy. This helps address the following questions: 1) How can we characterize the current research trends, key topics, authors, organizations, and countries in renewable energy within the 11 CAREC countries? 2) What is the scope for future research on renewable energy in the CAREC region?

The remainder of this paper is structured as follows: Section 2 describes the methodology and programs used, Section 3 details the results, and Section 4 concludes the study and provides policy implications.

4.2 METHODOLOGY

This chapter uses a bibliometric method to provide a quantitative analysis of written publications on renewable energy (Ellegaard & Wallin, 2015). Bibliometric analysis is used for a variety of purposes, such as studying the intellectual framework of an existing field and identifying developing trends in article and journal performance, collaboration patterns, and research constituents (Donthu et al., 2020). It enables identification of relevant and significant studies across various knowledge domains while providing qualitative and quantitative insights into the research (Ellegaard & Wallin, 2015).

With its extensive database covering a wide range of scientific disciplines, WoS has made it relatively easy to acquire large volumes of bibliometric data, and bibliometric software such as VOSviewer and RStudio (RStudio Team, 2020) allow the analysis of such data in a very practical way (Kumar et al., 2021).

4.2.1 Data Collection

The data in this research were collected following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement developed by Moher et al. (2007), focusing on English-language scientific publications indexed in the WoS database from 1991 to 2023. Therefore, any article from a database other than WoS and in a language other than English were excluded from the selection. Although the articles on the CAREC region predominantly encompass 11 countries, it is noteworthy that the existing literature contains a significant emphasis on China. To enable a more detailed analysis of the CAREC region by eliminating the dominance of the keyword “China”, we designed two distinct samples: the “Total sample” that includes articles with the keyword “China”, and a “Fragmented sample” that excludes any articles with references to "China". By adopting this approach, we aim to offer a more balanced perspective and better capture the full spectrum of renewable energy research across the entire CAREC region.

The search routine was recognized by applying this advanced search string to the topic:

((TS=(("renewable energy" OR "solar energy" OR "solar power" OR "wind energy" OR "wind power" OR "hydropower" OR "hydroelectric energy" OR "biofuel" OR "geothermal energy" OR "geothermal power" OR "power plant" OR "agrofuel" OR "bioenergy" OR "green energy" OR "clean energy" OR "energy efficiency" OR "energy consumption" OR "energy transition" OR "nuclear energy" OR "fossil fuel" OR "coal" OR "decarbonization" OR "low carbon" OR "petrol*" OR "gasoline" OR "oil" OR "fuel" OR "electricity" OR "natural gas ") AND ("Kazakh*" OR "Georgia*" OR "Kyrgyz*" OR "Tajik*" OR "Turkmen*" OR "Uzbek*" OR "Mongol*" OR "Pakistan*" OR "Azerbaijan*" OR "China*" OR "Afghan*"))) AND PY=(1991-2023)) AND LA=(English).

These keywords were selected because they provide direct or indirect relationships with the topics of energy, energy transition, and renewable energy in the region. Articles not containing these keywords were excluded from analysis.

Initially, 93 293 publications were collected. These numerous publications were then narrowed down to 20 688 by choosing the document type of "Articles" and the data based on the online version of SSCI. By including only articles in the sample, we aimed to select peer-reviewed documents, which are typically articles, rather than reviews, letters, or other document types. Moreover, SSCI was chosen because in the initial results, we noticed that many of the articles were domain-specific and associated with areas such as chemistry and biology. These publications use technical language and content that did not correspond to our research topic. Hence, the social sciences realm was selected to narrow down the results and find data that correlate with the research questions and objectives. The information obtained from WoS comprised article titles, authors, publication years, name and location of the research organization, keywords, and citation details. Finally, 20 688 publications were exported to VOSviewer in a table-delimited format and plain text format to the Rstudio software.

4.2.2 Bibliometric Programs

Data obtained from the WoS were analyzed by performing a statistical analysis and visualizing the results using two bibliometric programs: VOSviewer (version 1.6.19) and Rstudio (version 2023.06.1+524; RStudio Team, 2020). Both VOSviewer and RStudio are open-source, free software tools used to perform statistical and mathematical analyses and science mapping.

VOSviewer was used to create and analyze the bibliographic networks (Van Eck & Waltman, 2022). The program creates co-authorship and citation maps using network analysis and clustering techniques. Co-authorship maps show co-authorship networks between authors, countries, institutions, and so forth, which enable us to observe collaboration patterns and networks between them. A citation map helps to determine the number of citations of documents, sources, and organizations, suggesting their popularity and influence in the field (Van Eck & Waltman, 2022). These maps can then be displayed in several ways such as network and overlay visualizations, both of which were employed in the analysis. Network maps depict the relationships between authors or documents in co-authorship and citation networks; for example, the size of the cluster may indicate the significance of the author in the field, whereas the proximity between clusters represents the closeness and relatedness between authors and organizations (Van Eck & Waltman, 2022). Overlay maps allow new information, such as the average number of citations and publication years, to be added to existing maps to obtain new information about the patterns and trends in the obtained data.

RStudio is an Integrated Development Environment used to manage and run R code (RStudio Team, 2020). This chapter utilized an R-based package, bibliometrix, to execute the core code and an interactive web application called biblioshiny to visualize and export the findings. Biblioshiny allows a bibliometric analysis to be performed without resorting to the traditional bibliometrix code in RStudio, making it easier for social scientists to use. Through biblioshiny, we were able to conduct various bibliometric techniques, such as creating conceptual thematic and structural maps, identifying trend topics, and mainly conducting data preprocessing such as data cleaning and manipulation, and statistical analysis (Xie et al., 2020). The Results section includes more detailed explanations for each of these strategies, as well as the associated graphs and tables, to allow readers to thoroughly familiarize themselves with them. This was intended to provide a better understanding of the bibliometric techniques and strategies used in this study.

4.3 METHODOLOGY AND VARIABLE DESCRIPTION

4.3.1 Summary statistics

Table 4.1 provides a basic overview of the total and fragmented samples. Over the period from 1991-2023, 20 078 articles were published in the total sample, whereas less than two thousand were published in the fragmented sample. This indicates differences in research priorities or degrees of development of the field in these countries. Similarly, there are 1 386 journals that published in the total sample, whereas only 486 sources existed in the fragmented sample. This considerable difference indicates China's influence on renewable energy research in the CAREC region.

[2] ADB. (2022). 2022 climate finance SDCD database.

Table 4.1. Summary statistics.

	Total Sample	Fragmented Sample
Documents	20 078	1792
Sources (Journals)	1 386	486
Annual Growth Rate	16.73%	10.89%
Authors	25 904	4658
Authors of single-authored articles	1 377	232
International Co-Authorship	31.37%	46.09%
Co-authors per articles	3.74%	3.79%
Keywords	35 762	4 792
References	524 470	78 531
Document Average Age	4.6	5.17
Average Citations per article	28.58	24.86

Source: WoS data, RStudio

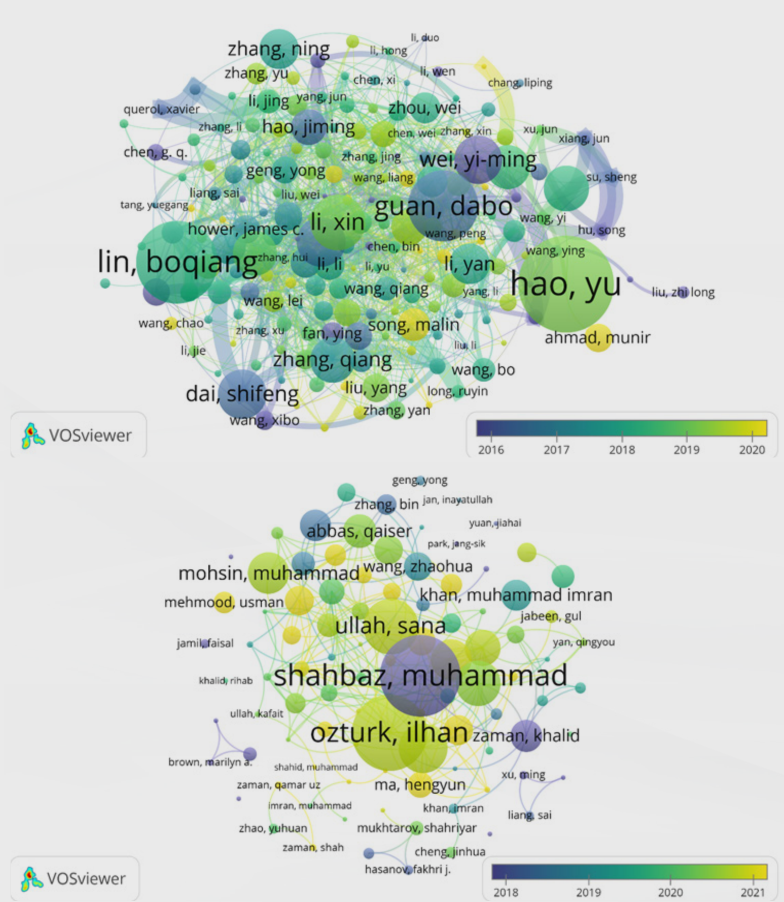
Descriptive statistics of annual growth in the total sample are higher than those in the fragmented sample, indicating that China-related studies boost research in CAREC regions. This is also justified by the number of authors in the two samples, which shows a considerable difference exists between the number of authors working on the total and fragmented samples.

However, the percentage of international coauthorships in the fragmented sample was higher than that in the total sample, showing that almost every second article was written and published in collaboration with international authors. This demonstrates the interest of international authors in the CAREC region.

4.3.2 Overview of authors, articles, journals, countries, and organizations

In this study, a comparative analysis of authors actively involved in scientific research on renewable energy within CAREC countries was conducted. The figures below present the authors with a minimum of 20 articles published between 1991 and 2023.

Figure 4.1. Co-authorship map of authors (normalized by citations). Figure 4.1a: Total Sample (at the top). Figure 4.1b: Fragmented Sample (at the bottom).

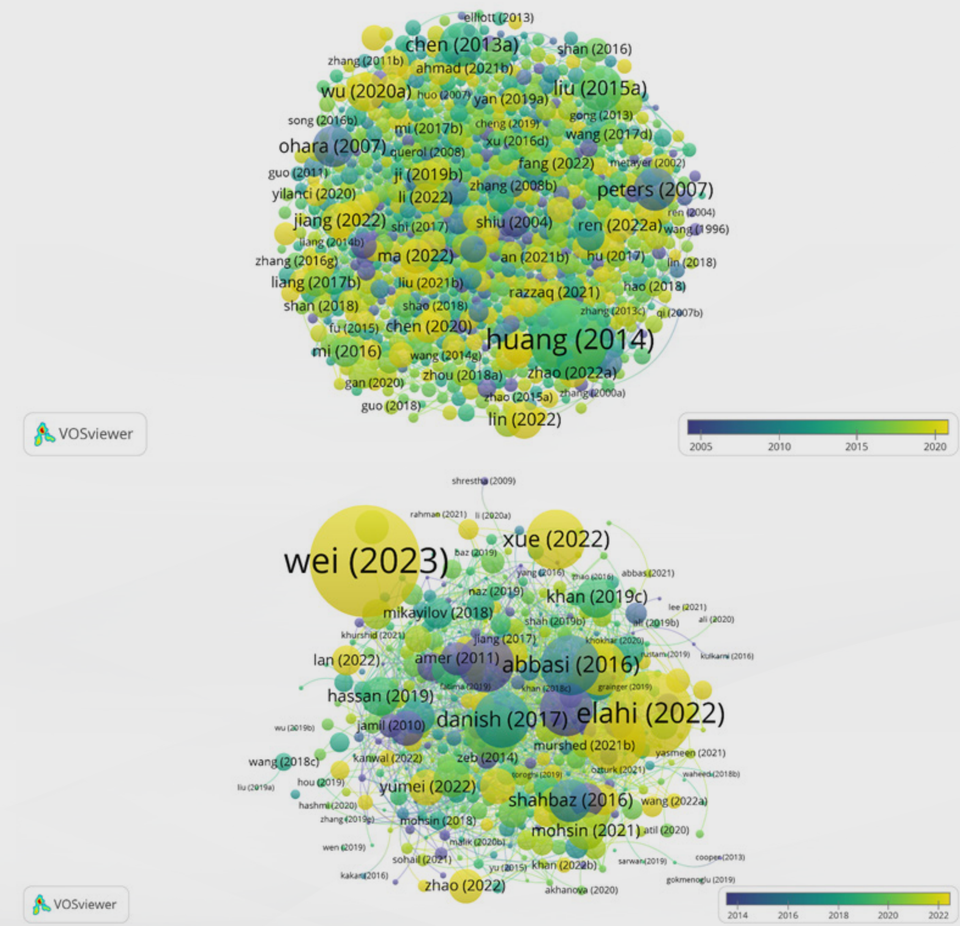


Source: WoS data, VOSviewer

Figure 4.1a shows that the top producers in the total sample were Yu Hao, Boqiang Lin, Dai Guan, and Yi-Ming Wei. When we exclude "China" as a keyword in our search engine, we observe a change in the structure of the authors. Thence, as shown in Figure 4. 1b, the top four authors were Muhammad Shahbaz, Ilhan Ozturk, Sana Ullah, and Muhammad Mohsin.

Figure 4.2 shows an overlay map of the most representative articles from 1991 to 2023 obtained by narrowing the search to articles that garnered at least 50 citations.

Figure 4.2. The most cited documents (normalized by citations). Figure 4.2a: Total Sample (at the top). Figure 4.2b: Fragmented Sample (at the bottom).



Source: WoS data, VOSviewer

Examination of the most-cited articles in the total sample (according to normalized citations) revealed that, among the entire CAREC region, articles written by Huang et al. (2014), Lin and Ma (2022), and Wu (2020) have been the most cited by studies since 2015. An article by Huang et al. (2014), "High secondary aerosol contribution to particulate pollution during haze events in China", investigated the chemical nature and sources of particulate matter at urban locations in Beijing, Shanghai, Guangzhou, and Xi'an during January 2013. The authors emphasized the need to reduce the emissions of secondary aerosol precursors to control China's PM2.5 levels and to reduce the environmental, economic, and health impacts resulting from particulate pollution (Huang et al., 2014).

Lin and Ma (2022) in the paper, "Green technology innovations, urban innovation environment and CO2 emission reduction in China: Fresh evidence from a partially linear functional-coefficient panel model", explored the impact of the urban innovation environment on the effect of green technological innovations on CO2 emissions. The empirical results indicate that green technological innovations have heterogeneous impacts on different types of cities.

Wu's (2020) article investigates the relationship between environmental regulation and China's green total factor energy efficiency using panel data of 30 Chinese provinces for the period 2005–2016. The results indicate that an improvement in the decentralization of environmental supervision and monitoring can increase the negative influence of environmental regulations on green total factor energy efficiency.

Figure 4.2b illustrates the fragmented sample and shows that studies by Wei et al. (2023), Elahi et al. (2022), Xue et al. (2022), Abbasi et al. (2022), Mohsin et al. (2021), Zhao (2022), and Ramzan (2022) are the most cited articles in recent years.

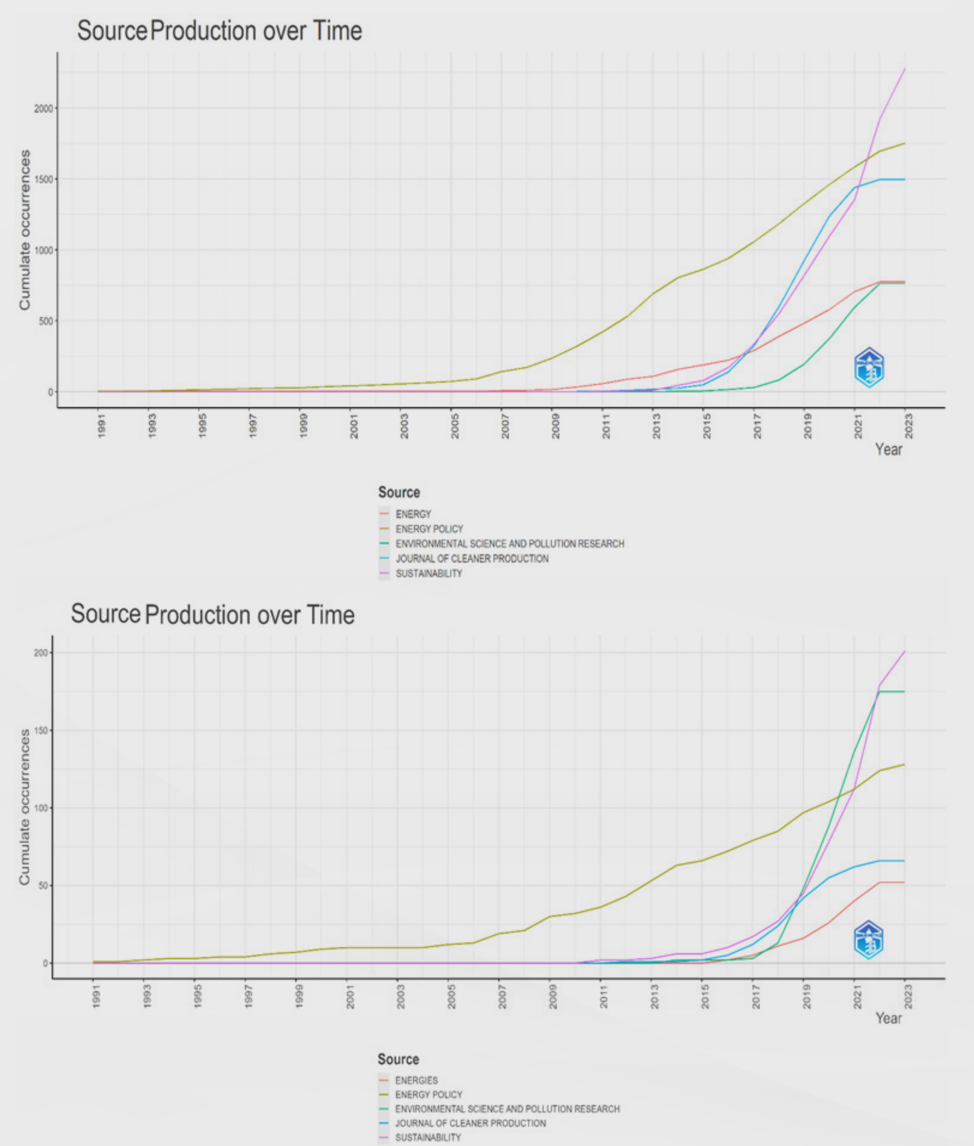
Studies by Elahi et al. (2022), Abbasi et al. (2022), Zhao (2022), and Ramzan (2022) drew attention to various aspects of sustainable development and the role of clean energy in reducing environmental impacts in Pakistan. These studies examined the adoption of green technologies among farmers and identified the factors promoting their use. The impact of financial development and technological innovation on emissions was also explored, and measures to achieve the Sustainable Development Goals were suggested. Potential solutions to the country's energy problems were examined that use renewable green energy for hydrogen production.

Finally, these authors explored the impact of information and communication technology and financial development on Pakistan's ecological footprint, emphasizing their role in reducing negative environmental impacts.

Other studies by Wei et al. (2023), Xue et al. (2022), and Mohsin et al. (2021) mostly focused on important aspects of sustainable development, such as the role of eco-entrepreneurship, clean energy, and energy sector reforms in achieving the Sustainable Development Goals and reducing negative environmental impacts. For example, Xue et al. (2022), in the paper, "Clean energy consumption, economic growth, and environmental sustainability: What is the role of economic policy uncertainty?" assessed the effects of clean-energy consumption on CO2 emissions in France. They also analyzed the impact of economic political uncertainty on environmental sustainability. This study confirmed that economic uncertainty threatens the environment by increasing CO2 emissions.

The study, "Does environmental entrepreneurship play a role in sustainable green development? Evidence from emerging Asian economies", by Wei et al. (2023) focused on the role of eco-entrepreneurship in sustainable green development in Asian countries. They studied the utilization of renewable energy, nuclear energy, and renewable energy generation in developing Asian countries. They found a positive impact of renewable electricity on green growth in the short and long term.

Figure 3. Source production over time. Figure 4.3a: Total Sample (at the top). Figure4.3b: Fragmented Sample (at the bottom).



Source: WoS data, RStudio

In the study, “Nexus between energy efficiency and electricity reforms: A DEA-Based way forward for clean power development”, Mohsin et al. (2021) investigated the impact of energy sector reforms on energy efficiency in different countries. Their study showed an improvement in efficiency after implementation of these reforms.

Figure 4.3 presents a list of journals with the most recent publications on renewable energy transitions. In recent years, the journals Sustainability and Energy Policy have published the highest number of papers in the total sample. In the fragmented sample, Sustainability and Environmental Science and Pollution Research published the most documents in recent years, especially from 2017-2018. This analysis helps identify journals that scholars from CAREC regions select to publish their work. Moreover, this could assist future CAREC researchers in identifying potential journals to publish their papers and reference research publications on renewable energy transition topics.

The overarching themes of these journals include sustainable development, renewable energy sources, clean production techniques, energy policies and technology, energy storage and conservation, and climate-change mitigation. Most journals in the list overlapped in both samples, except for the journals Energies and Energy. The fact that most journals are the same implies that these journals are at the forefront of renewable energy research in the CAREC region, and similar journals are selected by the region’s researchers in both samples.

Figure 4.4 presents a map of countries, with the minimum number of articles published narrowed to 20. A comparative analysis of renewable energy studies among CAREC countries in the total sample revealed strong collaborations between China and the US, Australia, the UK, France, and Canada. This shows the significance and extensiveness of cooperation between these countries in the renewable energy transition. In the fragmented sample, most of the authors were from China or Pakistan. In the total sample, authors from countries such as Saudi Arabia, Malaysia, and United Arab Emirates have emerged as leading researchers in recent years. In addition to these countries, the fragmented sample included Romania, Ecuador, Vietnam, Poland, and Turkey.

Figure 4.5 represents the 126 most productive research organizations among 11 166, based on the minimum number of documents (50) published by these institutes. An analysis of the total sample revealed that authors from several Chinese institutions, namely the Chinese Academy of Sciences, Tsinghua University, China University of Mining and Technology, and China University of Geosciences, received the highest number of citations since 2016. These institutions have made significant contributions to their respective fields. Moreover, recent years, specifically since 2020, have witnessed the rise of other Chinese institutions, such as Jiangsu University, Zhengzhou University, and South China University of Technology, which have also garnered substantial citation counts.

In the fragmented sample, we observe that the leading institutions are from China. Notably, the Beijing Institute of Technology, North China Electric Power University, and Chinese Academy of Sciences have shown exceptional performance in terms of research output and citation counts. In recent years, universities such as Nanjing University of Science and Technology, City University of Macau in China, and Asia University in Taiwan have emerged as leading contributors since 2021. Nanjing University of Science and Technology published 15 documents that received 448 citations. Similarly, Asia University in Taiwan contributed 14 documents with 676 citations, and City University of Macau produced nine documents with 463 citations. Overall, the research landscape portrayed in Figure 4.5 shows the prolific output and impact of various institutions in China.

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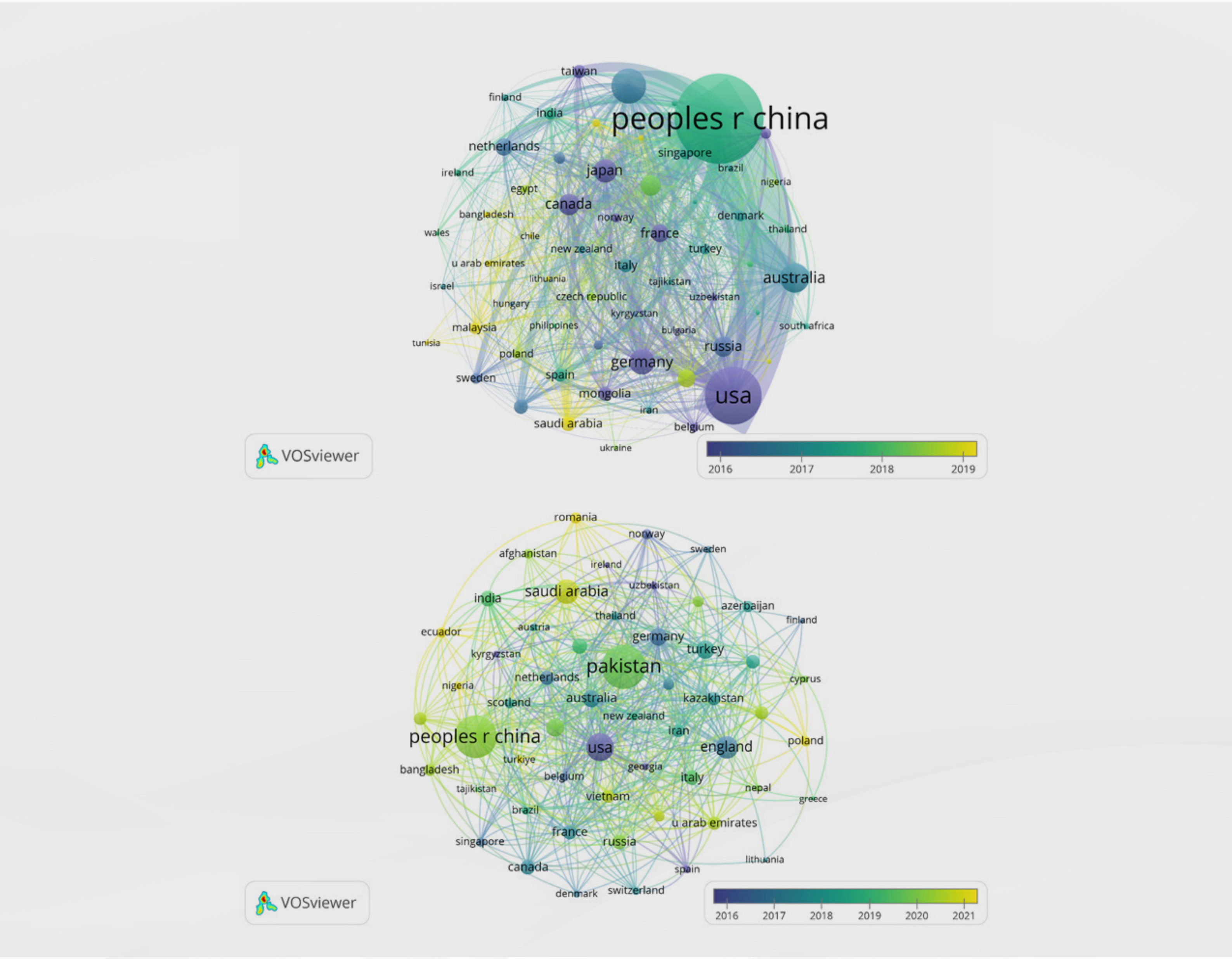
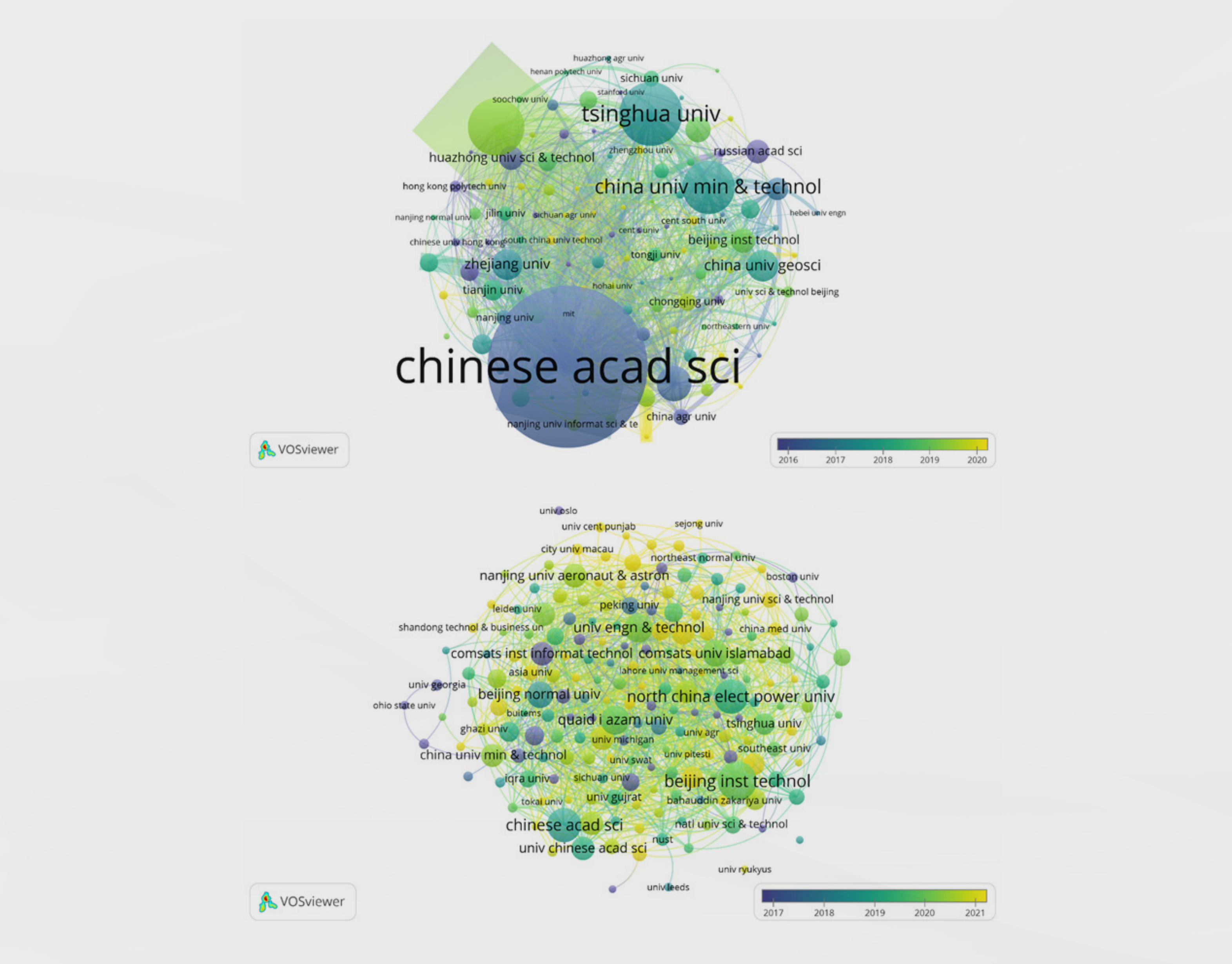
Figure 4.4. Co-authorship map of countries. Figure 4.4a: Total Sample (at the top). Figure 4.4b: Fragmented Sample (at the bottom).



Source: WoS data, VOSviewer

Figure 4.5. Co-authorship map of research organizations. Figure 4.5a: Total Sample (at the top). Figure4.5b: Fragmented Sample (at the bottom).



Source: WoS data, VOSviewer

4.3.2 Research trends and Future prospects

4.3.2.1 Thematic map

A thematic map was generated based on the authors' keywords, and displayed in Figure 4.6. It is a two-dimensional graph with each dimension representing density and centrality. Density refers to the level of development of certain topics, whereas centrality refers to the relevance of research topics based on the use of keywords in the two samples (Bretas & Alon, 2021). The map consists of four quadrants: basic, motor, niche, and emerging or declining themes (Cobo et al, 2011). Basic themes (low density and high centrality) are general and fundamental themes in the research field; motor topics (high density and high centrality) are highly relevant and closely linked topics; niche themes (high density and low centrality) are isolated and have limited connections with other areas of research in this field; emerging or declining themes (low density and high centrality) reveal topics that are just beginning to attract the attention of scientists or are losing their importance in this field.

As shown in Figure 4.6a, articles on China, energy, emissions, energy efficiency, and productivity are highly relevant topics that appear to mostly utilize data envelopment analysis to investigate these themes. Moreover, keywords such as "risk", "crude oil", "shocks", "prices", and "volatility" demonstrate that in the total sample, researchers are looking into risk assessment, energy prices, and market volatility. These themes imply that scholars are interested in understanding the implications of energy shocks and market dynamics. Therefore, in the total sample, renewable energy was examined from a more economic perspective.

Academic articles on economic growth, energy consumption, CO2 emissions, and their impacts are central to renewable energy transition studies. These broad topics serve as the foundation for this research field. On the other side, niche themes include words such as "adoption", "attitudes", "knowledge", and "willingness to pay", which could indicate a narrowed focus of scholars on behavioral patterns and decision-making processes of customers, organizations, governments, and so on, regarding sustainable usage of energy and policies. Because it is a niche topic, this area of research has few connections with broader research in the field of renewable energy.

Emerging or declining themes contain words such as "exposure", "politics and state", and "health and mortality". To identify whether these themes were emerging or declining, we checked publication trends in WoS by adding these keywords to a search query (see Section 2.1). Consequently, we discovered that the interest in these topics has declined in recent years.

It is important to note that, although these are the results of the total sample, the vast majority of articles in this sample are related to China. These results are primarily related to China's research on renewable energy.

In Figure 4.6b, "China", "Kazakhstan", "energy", "energy security", and "electricity" are highly relevant keywords and are well developed in articles from the fragmented sample. Based on the co-occurrence pattern of keywords, we can infer a connection between these terms and that they are closely linked to each other. This indicates that the issues of energy security and electricity have mainly been investigated in Kazakhstan and China.

In Pakistan, energy consumption, renewable energy, CO2 emissions, and economic growth are basic topics that concern the general research areas of renewable energy transition and are significant in the field. In addition, this section includes words such as "wind energy" and "rural electrification", which implies that wind energy and access to electricity in rural areas are important subtopics in the field of renewable energy. Furthermore, Pakistan has been researched the most in the fragmented sample.

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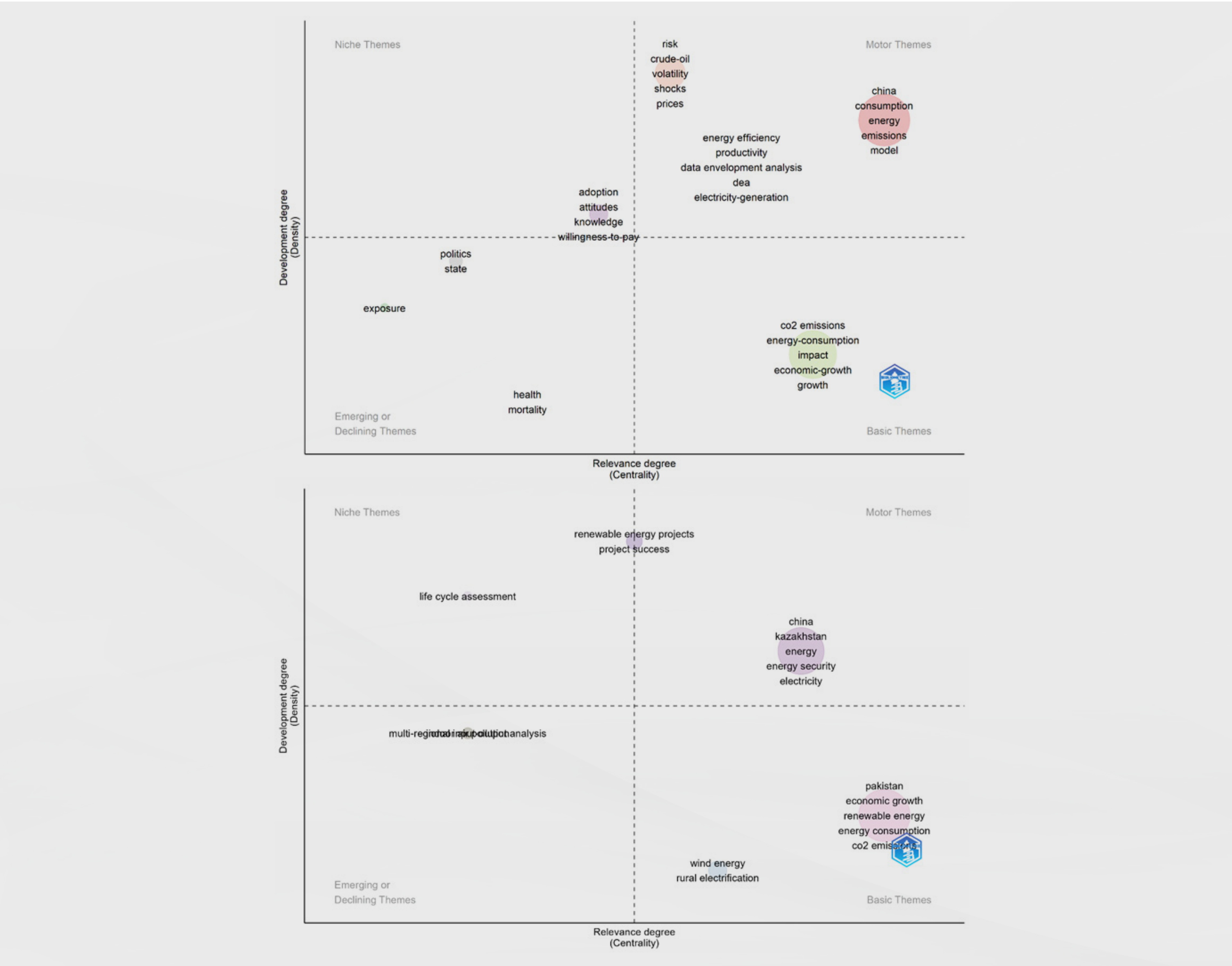
Figure 4.6. Thematic map. Figure 4.6a: Total Sample (at the top). Figure 4.6b: Fragmented Sample (at the bottom).



Source: WoS data, RStudio

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Niche themes include life cycle assessment, which has been of significant interest to CAREC region scholars since 2017. Scholars have used this model to evaluate and compare the environmental impacts of various technologies and products to find eco-friendly and sustainable solutions (Yadav & Samadder, 2018). Finally, according to trend publications in WoS, multi-regional input-output analysis is a declining theme.

From the results of the fragmented sample, we can conclude that Pakistan leads in renewable energy research, whereas Kazakhstan (in the second sample) has mostly explored energy security and electricity issues. There is no mention of other CAREC program's countries on this map.

4.3.2.2 Trend topics

Trend topics showcase the evolution of authors' keywords based on keyword co-occurrence analysis using the R-based bibliometrix package. Figure 4.7a reveals that from 2005-2016, the research in the total sample concentrated on topics such as biofuels, global climate change, clean development mechanisms, and acid rain.

Scholars have mainly explored the impacts and characteristics of various clean energy sources and ways to develop them, including eco-cities, technology transfers, biofuels, and CO2 capture methods, to understand the opportunities and problems associated with them to combat climate change.

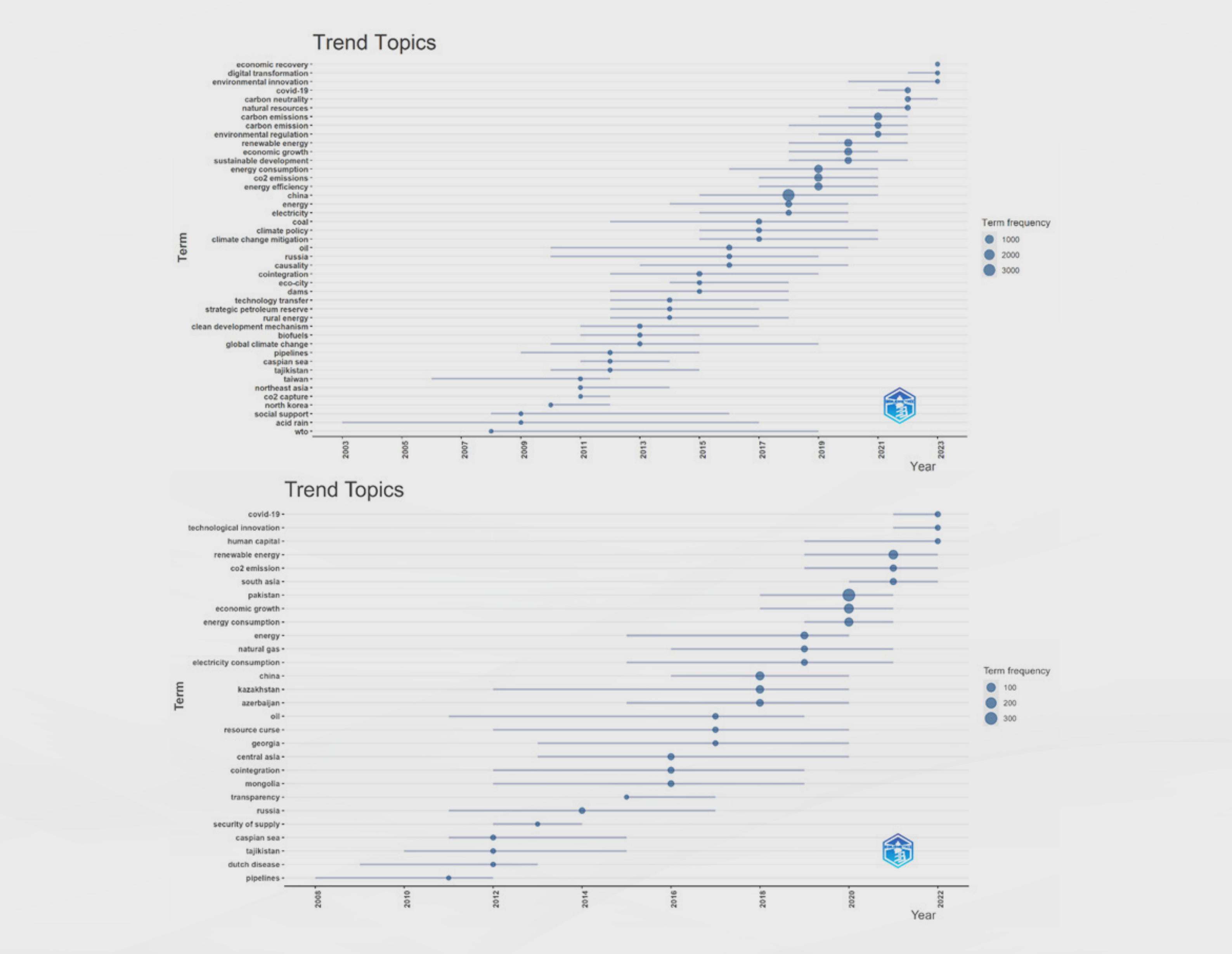
Since the mid-2010s, research has focused on energy efficiency and China, including sustainable development, renewable energy, economic growth, CO2 reduction, technology, and innovation in general. Although use of the keyword "renewable energy" peaked in 2020, the broader concept of sustainable energy and related terms are still frequently mentioned, indicating the prominence of this topic by scholars in the CAREC region in discussions on climate change mitigation. Clearly, there has been a smooth transition towards research on sustainable energy solutions and energy efficiency topics related to China across the entire CAREC region.

Figure 4.7b depicts trend topics from a fragmented sample, showing that the CAREC countries were often cited in terms of the sample and that most of these countries were mostly researched in relation to their natural resources, such as oil, natural gas, the resource curse, and Dutch disease.

However, unlike Figure 4.7a which demonstrates a smoother transition, there has been a clear shift in the fragmented sample to renewable energy, energy consumption, and energy research from studies focused on natural resources. These topics, as well as clean and green technologies, are only now gaining traction among regional scholars.

In the second sample, Pakistan is at the forefront of renewable energy research. The difference between the two samples is that, while in the total sample, mainly China was investigating different climate change mitigation strategies and clean sources, most other countries in the region are only starting to focus heavily on renewable energy transition.

Figure 4.7. Keyword trend topics. Figure 4.7a: Total Sample (at the top). Figure 4.7b: Fragmented Sample (at the bottom).



Source: WoS data, RStudio

4.3.2.3 Factorial Analysis

Figure 4.8 shows the conceptual structure of keywords associated with renewable energy transition in the two CAREC region samples. The map was based on a reduction technique called multiple-correspondence analysis (MCA). It is divided into eight clusters, each of which represents a subset of keywords that often appear together, signaling common research areas (Meghana et al., 2021). In other words, the MCA method classifies the data and places them on a two-dimensional graph in which terms close to each other indicate stronger connections, whereas a larger distance between keywords indicates a weaker connection between terms (Meghana et al., 2021).

Keywords near the center of the graph show those that have received more attention, demonstrating their importance and prevalence in the field of renewable energy transition studies (Meghana et al., 2021).

In Figure 4.8a because the majority of articles in the total sample were related to China, the research topics and clusters in the graph were also primarily related to China. The blue cluster is located at the center of the graph and is the most significant: keywords such as "China", "climate change", "pollution", "impact", and "consumption" at the center are not only frequently discussed together but are the most frequently used terms in the sample. This indicates that research articles explore the relationship between these terms, for example, the determinants that contribute to climate change or CO_2 emissions in China's efforts to address climate change. In addition, technology and innovation are frequently used as keywords. Other clusters demonstrate various common research topics in the field of renewable energy sources. For example, in the orange cluster, articles are related to energy systems and how they are studied in relation to management and policies.

Figure 4.8b shows that all the CAREC countries are present in the second sample, except for Georgia. From the graph, we can see that Kazakhstan has mostly conducted research related to its natural resources, such as oil, natural gas, and the resource curse, over a period of 30 years.

Pakistan has conducted extensive research on renewable energy, emissions, decarbonization, and electricity consumption. This has also been explored in other Southeast Asian countries. The orange cluster is the largest and most significant cluster in the fragmented sample, implying that most documents in this sample are related to Central Asia, Mongolia, China, and Afghanistan.

Thus, factor analysis revealed common research topics in the two samples: in the total sample, most of the documents were related to China, CO_2 emissions, and environmental pollution. In addition, research has been conducted from an economic perspective. In the fragmented sample, Pakistan leads in renewable energy transition research. Central Asia as a region is largely unexplored, except for Kazakhstan; thus, there is a need to investigate each country independently. While Azerbaijan and Mongolia have conducted research on energy and climate change, very few studies have specifically focused on renewable energy sources and the transition to sustainable energy sources. Similarly, little research has been conducted in Georgia and Afghanistan.

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Figure 4.8. A conceptual structure map. Figure 4.8a: Total Sample (at the top). Figure 4.8b: Fragmented Sample (at the bottom).

Source: WoS data, RStudio

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4.4 DISCUSSION AND CONCLUSION

This study was a bibliometric analysis of renewable energy research in 11 CAREC countries. The study examined prolific authors, journals, research institutions, articles, and countries. Additionally, it identifies current research trends and areas, as well as declining topics in renewable energy transition studies. By employing bibliometric programs, such as VOSviewer and the R-based Bibliometrix package, we discovered that China is a leader in renewable energy research in the CAREC region. Chinese authors, articles, and research organizations dominated the analysis results, exerting significant influence on the field of sustainable energy. Research in China is mostly concerned with reducing carbon emissions through various solutions, such as digital and green innovations, clean energy sources, and improving energy efficiency. In addition, there is considerable interest in understanding the effects of energy-related shocks on market dynamics.

Chinese institutions such as Jiangsu University, Zhengzhou University, and South China University of Technology have published documents with the highest number of citations since 2020. In addition, China and the US have conducted the most research on renewable energy among the CAREC countries. As for the sources, Sustainability and Energy Policy published the highest number of papers in recent years.

However, as the results were dominated by the influence of China, it was difficult to explore countries other than China in the CAREC region. Hence, to obtain detailed and meaningful insights about the entire CAREC region, we added one more sample in our analysis, excluding the keyword "China". This fragmented sample allowed us to delve deeper into renewable energy research in each CAREC program's country. The results of the second sample revealed that Pakistan is the only CAREC country, in addition to China, that conducts extensive research on renewable energy and sustainable solutions. The most popular themes across studies in Pakistan are related to sustainable green development, green technologies, clean energy consumption, and carbon emissions reduction. Similar to the first sample, Sustainability and Environmental Science and Pollution Research have published the most articles in recent years. Pakistan and China have contributed significantly to studies in the CAREC region. However, there has been an influx of articles from countries such as Saudi Arabia, Malaysia, United Arab Emirates, and more over the past few years. Nanjing University of Science and Technology, Asia University in Taiwan, and City University of Macau in China are the most productive research institutions. Notably, Quaid-i-Azam University in Pakistan was among the most cited organizations in the fragmented sample.

The findings suggest that CAREC countries, as a region, have only started paying attention to renewable energy and energy transition concerns. China and Pakistan are both leaders in renewable energy transition research among the 11 CAREC countries and explore various sources of clean and renewable energy solutions for the rest of the region. The trend topics and thematic map analyses (Sections 3.2.2 and 3.2.1) show that both countries have started to extensively examine the relationship between financial development, economic growth, renewable energy, energy consumption, and CO2 emissions, as well as the topic of green technology over the past few years.

Future research will likely delve deeper into the adoption of green technologies and digital innovations and the factors affecting them to reduce carbon emissions and achieve carbon neutrality. Such research will help to identify the most optimal and targeted policies to address climate change and support renewable energy transitions in these countries. Central Asia, Mongolia, and Azerbaijan have conducted research on climate change mitigation and sustainable development; however, little attention has been placed specifically on the renewable energy transition. Thus, it is important to obtain more insights into the state of renewable energy studies and investigate the capacity to transition to renewable or green sources of energy that are contextually relevant to these countries. Further research on individual countries in Central Asia is required.

Overall, based on the results of the bibliometric analysis of energy research in the CAREC region, the following recommendations can be made. First, investments should be made in initiatives to build capacity and improve research capabilities in the field of renewable energy sources in CAREC countries, which can be achieved through training programs, research grants, and academic exchanges. Furthermore, renewable energy research must be aligned with national and regional energy policies, and researchers should work closely with policymakers to ensure that research results inform and shape sustainable energy policies in the CAREC region. Third, we recommend focusing on new trends, as the thematic map analysis shows that interest in green technologies and digital innovation is growing. Policymakers and researchers should focus on these new trends to find innovative solutions for reducing carbon emissions and achieving carbon neutrality.

This study had several limitations. The first limitation concerns WoS, which was the only source of our dataset. This potentially omits a large portion of articles on renewable energy transition from other databases, such as Scopus and PubMed. Future studies should collect data from various databases to complement the WoS results. Second, the language of the publications was English. As a result, the publications of CAREC region scholars who prefer to publish in their native languages or languages other than English, such as Chinese, Russian could not be analyzed.

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CHAPTER 05

ROLE OF RENEWABLE ENERGY TRANSITION AND DIGITALIZATION IN PROMOTING GREEN GROWTH

Evidence from CAREC Countries

Ilma Sharif

5.1 INTRODUCTION

5.1.1 Green Growth and its Drivers

The connotation of green growth (GG) emerged in response to exacerbated environmental turmoil and deterioration. The Organisation for Economic Co-operation and Development (OECD, 2011) defined GG as fostering economic progress while ensuring efficient resource allocation to maintain environmental sustainability and human well-being. This definition explicitly demonstrates the interdependence among economic prosperity, environmental preservation, and intergenerational equity. GG is entirely different from traditional economic growth. Sohag et al. (2019) explained that conventional growth only incorporates the production process in monetary terms and neglects its environmental repercussions, whereas GG considers the environmentally adjusted monetary value of output. Therefore, the GG agenda is imperative in formulating policies for sustainable development goals (SDGs), and all emerging economies are interested in exploring the drivers of GG. Among all factors, GG is highly associated with renewable energy transition (RET) to achieve the SDGs.

Notably, countries in the Central Asia Regional Economic Cooperation (CAREC) have abundant natural gas, oil, and other energy resources that exploit these resources. However, the economic performance of this region has been explicitly hampered (World Bank Economic Prospects, 2022) by the Russian invasion of Ukraine, which has disrupted the energy supply chain and prices, generating uncertain fluctuations in the energy market and leading to energy insecurity (Hsu et al., 2023). From this perspective, RET is an effective strategy that efficiently allocates natural resources and limits CO2 emissions, consequently preserving scarce resources and managing waste generation (Ramzan et al., 2022). RET encourages renewable energy deployment and restricts the import of and investments in carbon-intensive products. Thus, RET enhances resource efficiency and energy conservation (Sun et al., 2023). Moreover, RET reinforces stringent environmental policies and embraces climate technologies related to sustainable growth. Over the past two decades, RET has enhanced renewable energy consumption (REC) to meet the energy demand (Hu et al., 2022). RET ensures sustainable economic growth (SDG-8), clean energy access and affordability (SDG-7), and climate action (SDG-13). RET transforms economies from traditional energy and economic structures into innovative green economies by substituting fossil fuels with clean energy resources (Adebayo et al., 2023). However, RET is a dynamic process that requires enormous financial investment and comprehensive policy plans in the long term.

Digitalization (DIG) is another indispensable cornerstone of attaining GG. In the fourth industrial revolution, DIG has helped develop energy-efficient tools to mitigate carbon emissions, protect natural resources and the ecosystem, and trigger economic progress by reducing reliance on conventional energy resources and elevating sustainable businesses (Abid et al., 2023). The COVID-19 pandemic has promoted digital connectivity and its rapid expansion worldwide. DIG improves economic and industrial structures through energy efficiency, knowledge, and technological spillover effects.

Information and communication technologies (ICT) represent one of the remarkable developments that expedite the potential of DIG in every economic sector to encourage inclusive growth. Through dematerialization and substitution effects, DIG facilitates online entrepreneurship, digital trade, financial technology, sustainable infrastructure development, and green innovations. All these digital enhancements have optimized human welfare with environmental sustainability (Chien et al., 2021). However, DIG exerts double-edged impacts in instigating economic progress by deteriorating ecological integrity (Park et al., 2018). DIG consumes high energy through excessive use and generates emissions and e-waste through consumption effects, damaging environmental sustainability. In 2021, CAREC economies designed the CAREC Digital Strategy, the core objective of which is to focus on stimulating digital transformation in the region for sustainable development (CAREC Institute, 2021).

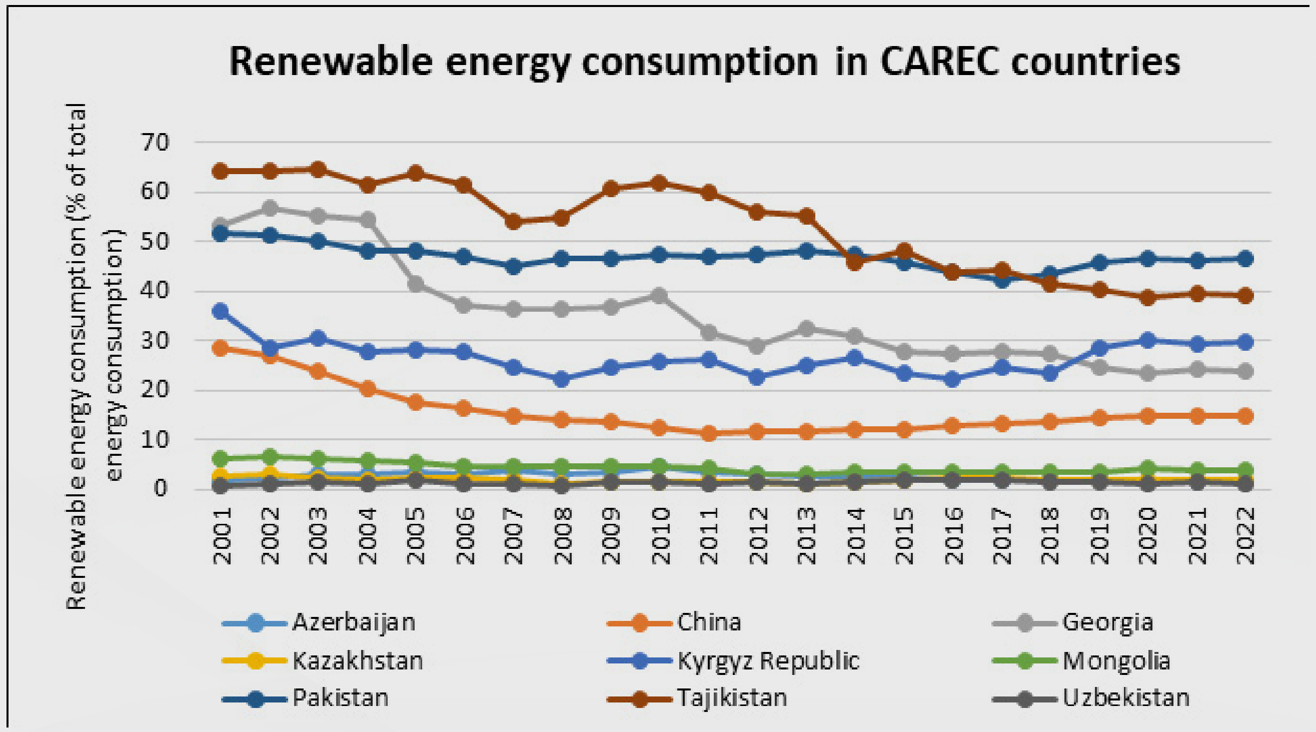
Concerning the CAREC region, integrating DIG and RET can boost efforts to reach GG. Therefore, the progress of DIG and RET in CAREC countries toward GG must be analyzed. Their combined influence is expected to elevate the pace of economies toward sustainable goals with minimum efforts. According to ecological modernization theory, economies can mitigate environmental disruptions that have evolved from anthropogenic activities through technological innovations and improved resource efficiency (Murphy & Gouldson, 2000). Sustainable technical advancements in the renewable energy sector enhance green innovations, eco-friendly products, and green projects to propel the pace of GG. Thus, the aggregation of DIG in RET promotes energy-

efficient technologies, generating a win-win situation in stimulating both ecological protection and economic prosperity (Lingyan et al., 2022).

5.1.2 Renewable Energy Transition, Digitalization, and Green Growth in Central Asia

CAREC countries differ in geographic characteristics, population size, climate conditions, resource endowment, institutional eminence, political reforms, energy infrastructures, economic landscape, and structural shifts, among other aspects. Achieving GG is the core strategy of the entire CAREC region, and RET, a long-term process, is highly interconnected with GG. Given the growing energy demand of CAREC countries, projected to increase by 2.4% annually, the CAREC region requires an additional energy capacity of 192,000 MW by 2030. However, the region has incredible potential for renewable energy deployment, with more than 380 GW in hydro, solar, and wind energy sources (Arkhangelskaya et al., 2022). From 2016 to 2020, the average growth of REC has increased by 0.57% in CAREC countries. The recent CAREC energy strategy (2030) emphasizes a clean regional energy system across borders. Figure 5.1 visualizes the trend of REC in CAREC countries from 2001 to 2022. Pakistan, Tajikistan, the Kyrgyz Republic, Georgia, and China have higher shares, whereas Uzbekistan, Azerbaijan, Mongolia, and Kazakhstan have lower contributions to REC.

Figure 5.1: Trend of Renewable Energy Consumption in CAREC Countries



Source: WDI (2022)

Research has not produced a publicly available digital index to measure the performance of the digital economy. Some scholars have used different proxies or indicators in studies that could not integrate various digital dimensions to construct an integrated, comprehensive, and reliable measure (Márquez-Ramos & Martínez-Zarzoso, 2010). As such, the present study established a weighted principal component analysis (PCA) index that utilizes three core proxies into a single DIG indicator for CAREC countries. Table 5.1 gives the recent statistics (2022) for mobile subscriptions, internet users, and fixed broadband, which are sub-indicators of the DIG index. In the CAREC region, the average rate of internet users is lower than the world average (63%). Similarly, CAREC's average fixed broadband rate is lower than the global rate of 16.91 (per 100 people).

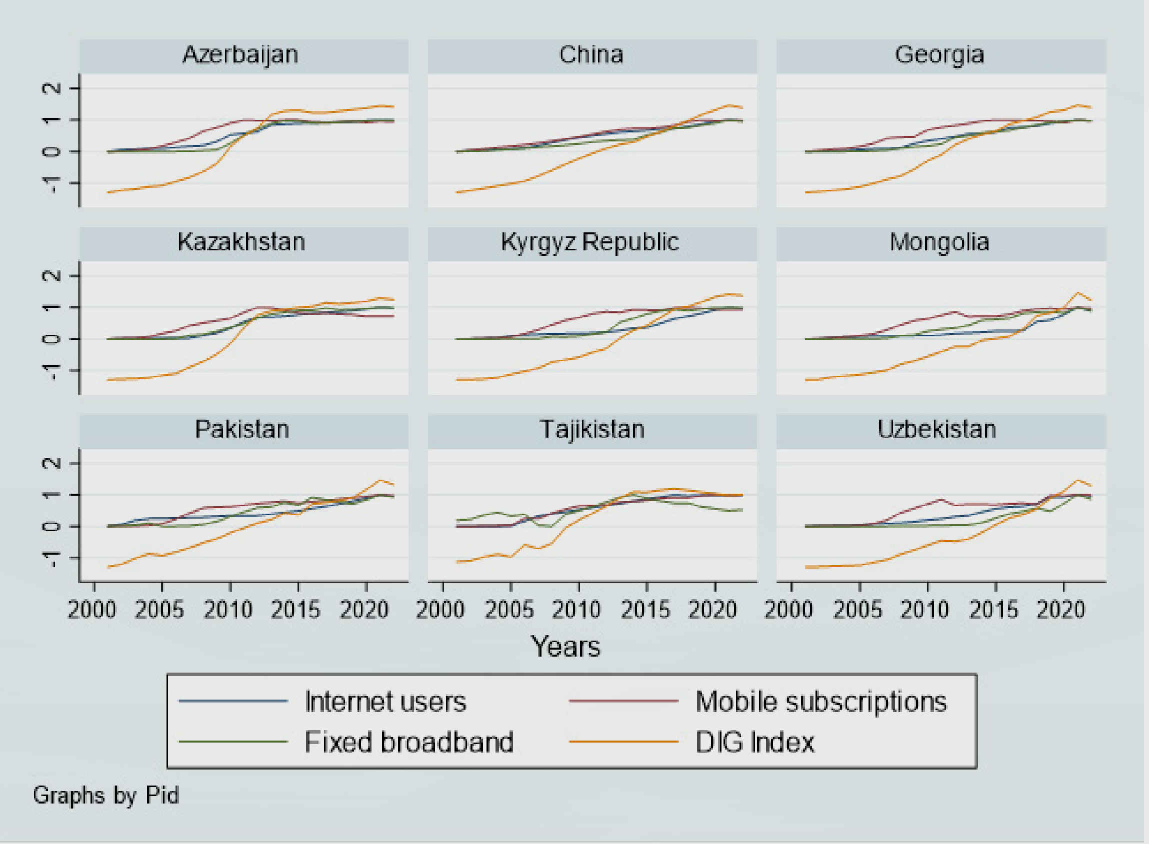
China has recorded a higher score in this measure owing to its well-developed digital infrastructure system, followed by Georgia, Azerbaijan, and Uzbekistan. The third indicator, mobile subscriptions, reveals the enhanced growth in all CAREC countries—the average rate is higher than the global rate (107.31). The CAREC Digital Strategy (2030) aims to develop an inclusive digital ecosystem across all countries using regional integration and development policies. Figure 5.2 visualizes country-wise trends of the DIG Index and its sub-indicators from 2001 to 2022, where all economies are shown to be improving. Pakistan and Tajikistan show slower growth owing to gray areas in digital development.

Table 5.1: Core Digital Indicators (2022)

Countries	Mobile Subscriptions (per 100 people)	Internet Users (% of population)	Fixed broadband (per 100 people)
Azerbaijan	102.732	85.300	19.667
China	121.067	71.551	35.755
Georgia	141.591	74.487	26.288
Kazakhstan	127.740	88.431	14.075
Kyrgyz Republic	131.426	74.960	4.463
Mongolia	136.240	74.980	10.351
Pakistan	79.426	19.986	1.175
Tajikistan	120.097	21.448	0.062
Uzbekistan	101.241	73.845	18.917
Afghanistan	57.372	18.200	0.067
Turkmenistan	98.627	20.130	0.159
CAREC	110.687	56.665	11.907

Source: WDI (2022)

Figure 5.2: Trend of DIG Index and Its Indicators



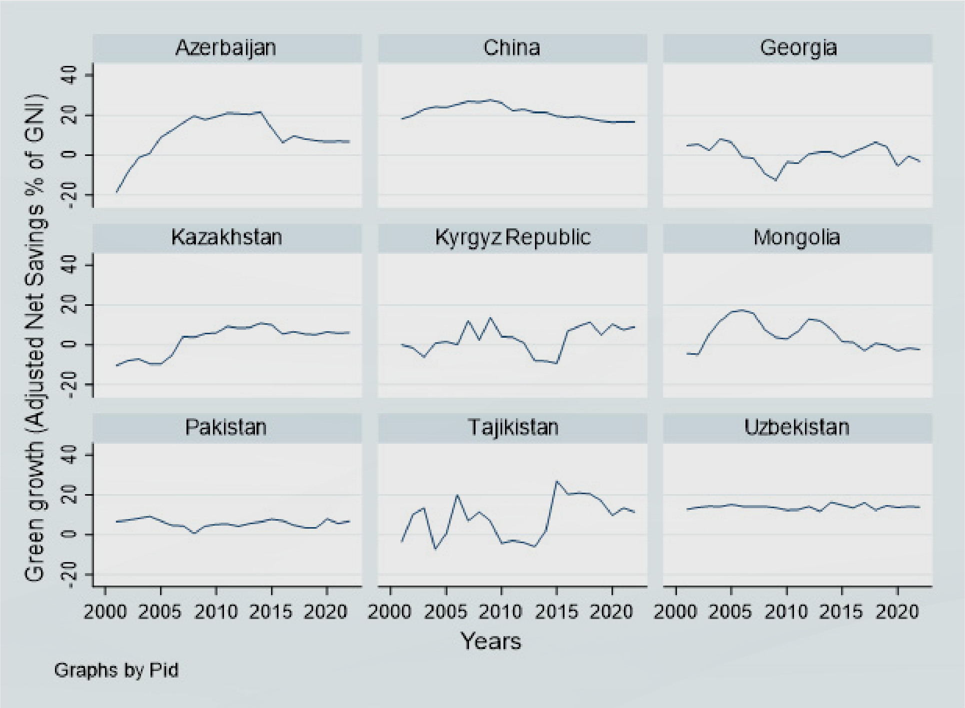
Source: WDI (2022)

Research on GG primarily addresses two aspects. One is to develop a framework to construct an index for measuring GG performance based on system theory. In this scenario, the OECD has proposed the model framework of GG for Asia-Pacific countries, focusing on four categories, including policy responses and resource-efficient economic developments (OECD, 2011). Likewise, the United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP, 2013) established a comprehensive indicator index to promote GG in the emerging Asia-Pacific region; the index allows analysis of GG performance on 66 indicators in five dimensions: structural transformation, productivity and efficiency, capital investments, access and equity, and awareness. In 2019, according to a Global Green Growth Institute report, a composite GG Index for 115 countries measures four dimensions: sustainable and efficient resource use, natural capital protection, social inclusion, and green economic opportunities.

Thus, the conceptual definition of GG is defined by this report as fostering economic growth that is socially inclusive and environmentally sustainable. Moreover, GG is credited with driving opportunities and promoting a low-carbon and resilient economy, preserving a healthy and productive ecosystem, impeding pollution, creating green jobs, enhancing social inclusion, and eradicating poverty (Peyriere et al., 2019).

Another aspect explores the direction of GG by identifying the factors that are imperative for GG. Jiang et al. (2023) evaluated the catalyst role of renewable energy, institutional quality, and economic complexity in seven emerging economies. Razzaq et al. (2023) scrutinized the influence of renewable energy transition on GG for 37 International Energy Agency (IEA) countries. Likewise, scholars have analyzed the impact of human capital, environmental policy, and financial liberalization on GG in different countries (Hao et al., 2021; Lee et al., 2022). Notably, fewer studies have employed adjusted net savings as a proxy for GG that accounts for the output through efficient RET after excluding emissions, resource depletion, and negative externalities (Ahmed et al., 2022; Sohag et al., 2019). Therefore, the present study employed adjusted net savings as a reliable and accurate measure for depicting GG performance. Figure 5.3 shows the trajectory of GG for selected CAREC countries between 2001 and 2022. Most CAREC economies showed unstable growth trends, implying the need for effective policy measures. Henceforth, this research constructed a weighted composite DIG Index and investigated the influence of the RET and DIG Index in a multidimensional framework to promote GG in CAREC countries.

Figure 5.3: Trend of GG (Adjusted Net Savings) in CAREC Countries



Source: WDI (2022)

5.2 RATIONALE AND OBJECTIVES OF THE STUDY

This research explored the determinants of GG by considering the RET and DIG in an integrated framework for CAREC countries. For the empirical investigation, the study utilized annual data from World Development Indicators for the period 2001–2022 and employed the cross-section autoregressive distributed lag (CS-ARDL) estimator. In addition, the study established a comprehensive digital index using PCA to reflect the impacts of DIG on inclusive growth. The study's novel contribution is its evaluation of the moderating impact of DIG and RET in attaining GG and investigation of the direct and indirect channels of RET and DIG with respect to GG. Evaluating inclusive GG policies will provide fascinating and valuable policy implications for CAREC countries.

5.3 METHODOLOGY AND DATA

5.3.1 Theoretical Underpinning and Model Specification

The study employed classical production theory proposed by Cobb and Douglas (1928) in the theoretical framework. According to this theory, a functional relation exists between labor (L), capital (K), and technological progress (A) to produce economic output (Y). The articulation of endogenous production theory can be expressed as follows.

$$Y=f(L,K,A) \qquad \text{Eq. (1)}$$

This study modified equation (1) by incorporating RET and substituting the Y, A, K, and L with GG, DIG, CAP (for capital investments), and LAB (for labor employed). After modification, the new regression form for Model 1 is as follows:

$$GG_{it}=\alpha_{it}+\beta_1 RET_{it}+\beta_2 DIG_{it}+\beta_3 LAB_{it}+\beta_4 CAP_{it}+\varepsilon_{it} \qquad \text{Eq. (2)}$$

The above equation included the interaction term (RET*DIG) to determine the aggregate effects of the core variables through indirect channels. Thus, the expression is formulated for Model 2:

$$GG_{it}=\alpha_{it}+\beta_1 RET_{it}+\beta_2 DIG_{it}+\beta_3 RET_{it}*DIG_{it}+\beta_4 LAB_{it}+\beta_5 CAP_{it}+\varepsilon_{it} \qquad \text{Eq. (2)}$$

The explained variable is GG, and the explanatory variables are RET, DIG, LAB, and CAP. In the model specification, the symbols β, α, and ε indicate the variable's coefficients, intercept form, and stochastic term, respectively. The time and cross-section dimensions are represented by t and i, respectively.

5.3.2 Data Description

The study assessed the determinants of GG in nine CAREC countries[1] and utilized annual panel data from 2001 to 2022. All the variables are sourced from World Development Indicators (2022). For uniform standardization, all variables were transformed into their logarithmic form except for the DIG Index. The detailed description, measurement units, and sources of variables are specified in Table 5.2.

[1] Azerbaijan, China, Georgia, Kazakhstan, Kyrgyz Republic, Mongolia, Pakistan, Tajikistan, Uzbekistan. Owing to data limitations, Afghanistan and Turkmenistan are not included.

Table 5.2: Description of Variables

Description	Symbol	Variable	Measurement units	Source
Green Growth	GG	Explained	Adjusted net savings (% of gross national income, including particulate emissions)	WDI
Renewable Energy Transition	RET	Core Explanatory	Renewable energy consumption (% of total final energy consumption)	WDI
Digitalization	DIG	Core Independent	PCA Index using internet use (% of the population), fixed broadband, and mobile cellular subscriptions (per 100 people)	WDI
Labor	LAB	Control	Employed labor (headcount) in millions	WDI
Capital	CAP	Control	Gross fixed capital formation (% of GDP)	WDI

Note: WDI denotes World Development Indicators

5.3.3 DIG PCA Index

The comprehensive DIG index was established using PCA. This approach is reliable in incorporating all DIG-associated information from the different measures and developing a single composite index to illuminate the accurate DIG level while resolving the subjectivity bias (Abid et al., 2023). Three measures were combined to develop the index: internet use (% of the population), fixed broadband, and mobile cellular subscriptions (per 100 people). The PCA results are presented in Table 5.3, in which the eigenvalue of the first component is 2.706 (greater than one), and the cumulative proportion is more than 90%. The eigenvalues of other components are not demonstrated, for brevity. Figure 5.4 shows the scree plot graph of eigenvalues, affirming the accurate outcomes.

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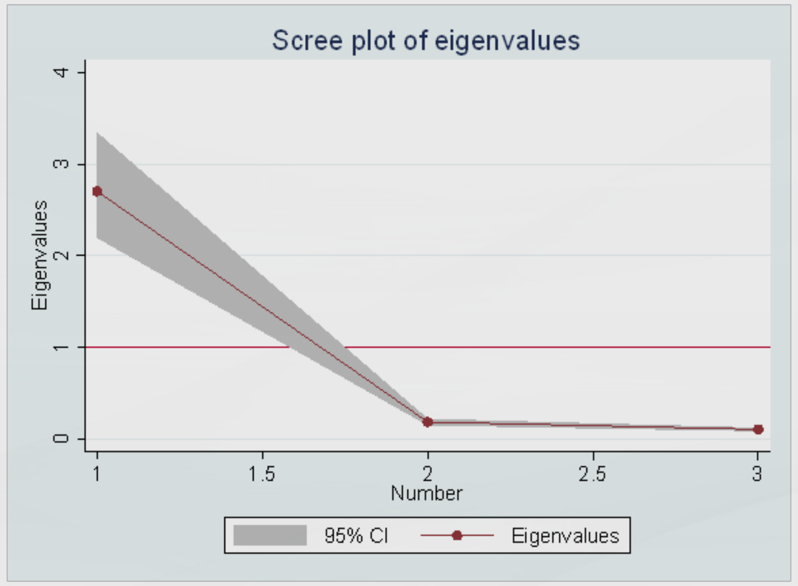
Table 5.3: Principal Component Analysis index for Digitalization (DIG)

		PCI-Factor loading		
PCI-eigenvalue	**Proportion explained by PCI**	**INT**	**MC**	**FBB**
2.706	0.902	0.9379	0.8792	0.9209
Kaiser-Meyer-Olkin (KMO)		0.7126	0.8358	0.7487
Correlation with weighted PCA index		0.9738	0.9128	0.9560

Note: INT, internet use (% of the total population); FBB, fixed broadband, and MC, Mobile cellular subscriptions (per 100 people). Abbreviations: KMO measures sample adequacy; PCI, Principal component index

Figure 5.4: Scree Plot Diagram of Eigenvalues for the Principal Component Analysis Index for Digitalization (DIG)



Source: Author's estimation

5.3.4 Econometric Procedure

The pre-requisite analysis involved the examination of the cross-section dependency (CSD), unit root, slope heterogeneity, and co-integration association in the model's variables. For this objective, the study employed the Pesaran CSD test, Im Shin Pesaran unit root test, Hashem Pesaran and Yamagata (2008) slope homogeneity test, and Westerlund (2007) test, respectively. After the preliminary estimation, the CS-ARDL estimator was applied, which Pesaran (2006) proposed to ascertain the regression coefficients and efficiently yield robust outcomes while resolving CSD and heterogeneity issues. The traditional estimation techniques produce biased and inaccurate results. Meanwhile, the CS-ARDL method is the most appropriate technique, proposed by Chudik and Pesaran (2015), considering the variables with slope heterogeneity and non-stationary issues. When the cross-sections are correlated, robust outcomes are produced. Finally, the study utilized the fixed-effect ordinary least squares (OLS) method as robustness check.

5.4 EMPIRICAL RESULTS

5.4.1 Results of Preliminary Analysis

In the empirical procedure, the descriptive properties results are illustrated in Table 5.4. The variables possessed positive mean scores and lower dispersion statistics. Before estimating regression analysis, the study applied the Pesaran CSD test. Table 5.5 gives the results. CSD was present in all variables except GG and CAP. All pertinent variables were significantly stationary at the first difference, permitting the study to continue further estimation, the outcomes of which are also reported in Table 5.5. Table 5.6 exhibits the slope homogeneity and co-integration results. Heterogeneous slope parameters were observed in the variables, which also had long-term co-integration association. Therefore, the study employed the CS-ARDL approach to produce robust and unbiased outcomes while also addressing CSD and slope heterogeneity issues.

Table 5.4: Descriptive Statistics

Variable	Mean	Standard Deviation	Minimum	Maximum	Observations
DIG	0	0.963	-1.302	1.474	198
GG	2.050	1.053	-4.378	3.317	198
RET	2.261	1.437	-0.248	4.168	198
LAB	6.933	0.850	5.994	8.892	198
CAP	1.391	0.158	0.799	1.761	198

Source: Author's Estimation

Table 5.5: Results for Cross-section Im Pesaran Shin (CIPS) Unit Root and Pesaran CSD Test

Variable	CIPS test		Pesaran CSD test
	I(0)	I(1)	
GG	-2.420	-4.561***	0.79
RET	-1.504	-3.931***	8.21***
DIG	-1.885	-3.947***	26.85***
LAB	-1.799	-3.533***	14.56***
CAP	-2.234	-3.359***	-1.05

Note: Significance level is denoted by *** for 1%, ** for 5%, and * for 10%.

Table 5.6: Slope Heterogeneity and Panel Co-Integration Test Results

Pesaran and Yamagata slope homogeneity test		
Statistics	**Model 1**	**Model 2**
Delta	6.793***	6.408***
Adjusted Delta	7.965***	7.761***
Westerlund Co-integration test		
Statistics	Model 1	Model 2
Ga	-6.164	-4.427
Gt	-4.333***	-3.854***
Pa	-19.089	-6.041
Pt	-7.588***	-17.128***

Note: Significance level is denoted by *** for 1%, ** for 5%, and * for 10%.

5.4.2 Regression Estimation and Robustness Analysis

The study used the CS-ARDL method for estimating long- and short-term results. The empirical long-term outcomes are reported in Table 5.7. RET could significantly drive GG under models 1 and 2. RET had a positive substantial relation with GG at the 1% significance level. The results were consistent with those of Jiang et al. (2023), which confirmed the positive nexus between REC and GG in seven growing economies. Meanwhile, Hao et al. (2021) identified the effect of RET on GG in G7 countries and documented RET's promoting growth impacts in advanced nations.

Table 5.7: Results of Long-run of CS-ARDL Method (Dependent Variable, GG)

Variables	Model 1		Model 2	
	Coefficient	Stand. Errors	Coefficient	Stand. Errors
RET	0.376**	0.161	0.179*	0.095
DIG	0.089***	0.010	0.053***	0.013
LAB	0.051*	0.029	0.090***	0.014
CAP	-0.279***	0.063	-0.261***	0.071
RET*DIG	-	-	0.365***	0.082
Constant	0.063***	0.012	0.725***	0.098

Note: Significance level is denoted by *** for 1%, ** for 5%, and * for 10%.

Likewise, DIG could stimulate GG prominently under both models and showed a direct linkage with GG. The findings were consistent with Ke et al. (2022), which reported DIG's enhancing effects in improving ecological sustainability by impeding emissions in 77 developing countries. Hao et al. (2023) also investigated the role of DIG in motivating green sustainable growth in China by optimizing the industrial structure. In model 2, the interaction term RET*DIG profoundly elucidates a positive association with and exerts an enhancing effect on GG. Thus, RET*DIG could encourage sustainable development in CAREC countries. Lv et al. (2022) analyzed panel data from 90 countries and elucidated that DIG significantly increases RET to reach SDG. Utilizing the 12 top carbon-emitting nations, Habiba et al. (2022) analyzed that RET and green technologies are imperative for inclusive clean growth. As a controlling variable, LAB instigated GG in the two models, implying the necessity of skilled and educated human capital in increasing GG. LAB and GG were positively associated. In contrast, CAP reduced GG, indicating a negative association between the two.

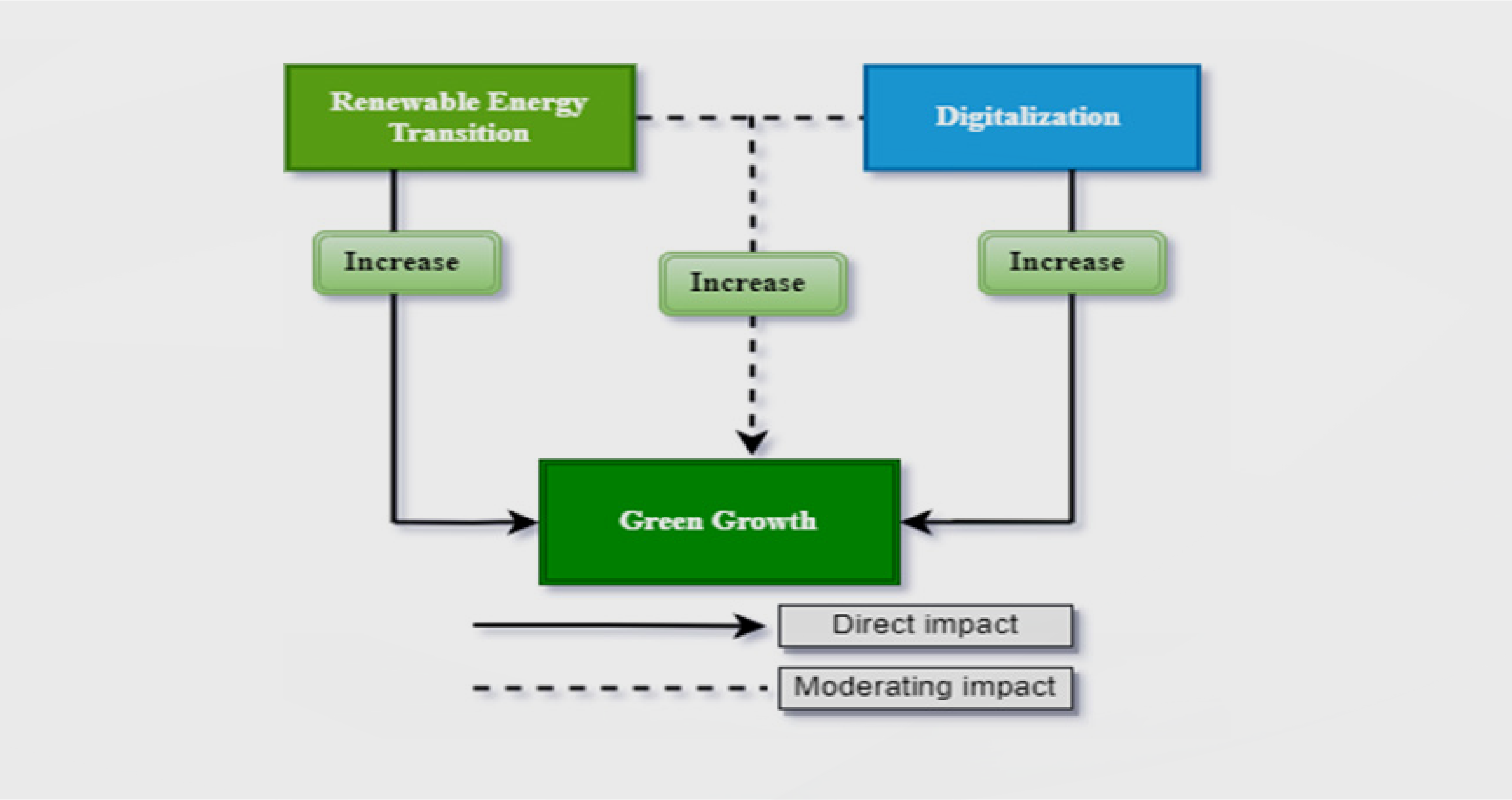
Table 5.8 exhibits the short-term estimations for models 1 and 2. The study followed the Akaike information criterion for models 1 and 2 for optimal lag structures. For this purpose, the study included two lags of the explained variable (GG) and one lag of all explanatory variables for each cross-section. The error correction terms ECM(-1) converged models 1 and 2 toward the long-term equilibrium position with an adjustment rate of 36.9% and 35.8% per annum, respectively. The outcomes were consistent with the long-term coefficients with the same signs, although the magnitudes were lower. According to the results, RET could stimulate GG under models 1 and 2. DIG could contribute to GG under models 1 and 2, whereas the moderation term RET*DIG could drive GG under model 2. Among the controlling factors, LAB increased whereas CAP decreased GG under both models. Figure 5.5 indicates the estimated relation between RET, DIG, and GG through direct and indirect channels.

Table 5.8: Results of Short-run of CS-ARDL method (Dependent Variable, GG)

Variables	Model 1		Model 2	
	Coefficient	Stand. Errors	Coefficient	Stand. Errors
RET	0.284**	0.121	0.127*	0.068
DIG	0.062***	0.014	0.046***	0.010
LAB	0.072***	0.008	0.085***	0.015
CAP	-0.201*	0.116	-0.189*	0.105
RET*DIG	-	-	0.250***	0.020
Constant	0.325***	0.037	0.753***	0.071
ECM(-1)	-0.369***	0.036	-0.358***	0.086

Note: Significance level is denoted by *** for 1%, ** for 5%, and * for 10%.

Figure 5.5: Depiction of Relation Estimated by CS-ARDL Model



In comparison, all antecedents produced substantial impacts in the long run, indicating that CAREC countries should design longer-term GG policies while considering these pertinent factors. Finally, the fixed-effect OLS approach was adopted for robustness check, to confirm the results estimated from the CS-ARDL model. Table 5.9 gives the results of the fixed-effect estimation. RET could trigger GG, and DIG could advance the GG. In addition, the moderation term RET*DIG could also contribute to GG. The results for the control variables were also consistent with the coefficients of the regression results.

Table 5.9: Results of Robustness Test (Fixed Effect OLS Method)

Variables	Model 1 Coefficient	Model 2 Coefficient
RET	0.521***	0.237***
DIG	0.155*	0.101**
LAB	0.049***	0.056***
CAP	-0.914***	-0.243**
RET*DIG	-	0.419***
Constant	0.680**	0.880***

Note: Significance level is denoted by *** for 1%, ** for 5%, and * for 10%.

5.5 DISCUSSION

The CAREC region is a landlocked and resource-rich region with natural gas, oil, and other precious minerals and water resources. Thus, rising volatile energy prices and slow economic growth trends owing to the Ukraine–Russia conflict and the COVID-19 pandemic's post effects have highlighted the significance of RET and DIG across CAREC countries in achieving GG progress. From the empirical outcomes, RET promotes GG in CAREC countries, reflecting that RET merits utmost priority among policy agendas for inclusive growth and relating to GG. The results are justified because CAREC countries have a vast potential for renewable energy development. According to CAREC Energy Outlook (2022) estimates, the region, excluding China, has an enormous capacity of more than 380 GW for hydropower and 2 GW for solar and wind energy. Including China, the capacity for solar and wind energy increases to 200–210 GW. The region has framed the CAREC Energy Strategy 2030 to provide a resilient and sustainable energy system through regional integration across borders.

The export of resources in natural gas, oil, and hydrocarbons has substantially contributed to the region's GDP. However, owing to the vulnerability of resource prices, the recent Russian invasion of Ukraine and the COVID-19 pandemic have dampened economic growth. Therefore, RET is crucial for CAREC countries to diversify their energy structure and implement market reforms to reduce dependence on fossil fuels. In the past five years, the growth rate of the CAREC region in renewable energy consumption has risen by 0.57%. Prominent growth has been observed in China, Mongolia, the Kyrgyz Republic, Tajikistan, Georgia, and Pakistan, and these CAREC countries can share their hydropower energy with fossil-fuel rich Kazakhstan, Turkmenistan, Uzbekistan, and Azerbaijan. However, hydro-rich countries contend with energy shortages in the winter, and the ultimate solution is RET-based energy trade, which fulfills the seasonal demand and supply in the regional energy sector. RET has a higher parameter coefficient in both empirical models, exhibiting its significance for green transformation in CAREC countries.

However, the CAREC region relies heavily on fossil fuels, accounting for 95% of its total energy supplies. By 2030, additional energy demand is projected to increase by around 2.4% yearly (CAREC Energy Outlook, 2022). As such, CAREC countries are implementing different renewable projects and policy measures. For instance, in 2022, Uzbekistan constructed two major solar projects in Samarkand and Jizzakh that generated 220 MW, in collaborations and cooperation with international financial institutions. Another solar PV project was developed in Sherabad to produce 457 MW of energy. The Uzbek government also supports and reinforces decentralized solar power systems in household buildings (Renewable Energy Agency, 2019). Recently, Azerbaijan enacted the Law on the Rational Use of Energy Resources and Energy Efficiency, which compels residential and business entities to encourage energy savings and efficiency and efficiently manage the energy structure. In Georgia, the Qartli onshore project produces 21.0 MW of wind energy, reporting more than 45% efficiency factors (Arkhangelskaya et al., 2022). As for China, it is leading among all countries—various green technologies and projects are adopted at the provincial and national levels according to the country's 13th and 14th five-year plans. All these measures indicate the CAREC's concern toward RET-led GG. Therefore, RET is a prioritized strategy for sustainable growth that ensures SDGs 7, 12, and 13 by substituting fossil fuels and improving energy efficiency. In the near future, CAREC countries will introduce the CAREC Green Energy Alliance as the first targeted joint financing platform, which supports RET and provides accessible regional funding and end-to-end solutions to RET-associated investments and projects (ADB, 2023).

As shown in Table 5.7, DIG is another cornerstone for sustainable development after RET, which expedites DIG's positive spillover effects across the region. DIG is a complex process encompassing various technologies, and no publicly available digital indicator has been formulated to measure worldwide digital growth. In the present study, the composite DIG index contains three main digital components that reflect the CAREC region's digital performance to a large extent. Over the past two decades, global mobile subscriptions have increased enormously; the CAREC region's mean mobile subscriptions stand at 110.68 per 100 people, which is above the world average.

Between 2010 and 2022, internet services usage and fixed broadband installations have also increased, and the CAREC region has recorded average index values of 56.66% and 11.90 per 100 people, respectively. Owing to prioritized digital policies, the region shows significant growth in all digital indicators (see Figure 5.2), primarily in China, Kazakhstan, Georgia, Mongolia, Azerbaijan, and Uzbekistan. The current findings are justified because all these transition economies have adopted various digital transformative strategies to build innovative digital systems. In 2021, the milestone CAREC Digital Strategy 2030 was introduced to promote the digital ecosystem, connectivity, and transformation in the entire region.

With the digital connectivity and revolution, countries can overcome the shocks of uncertain economic circumstances, such as those experienced during the height of the COVID-19 pandemic, and pave a pathway toward resilient-based economies. At the national level, Azerbaijan Digital HUB is an essential initiative in this regard. Uzbekistan introduced Digital Uzbekistan Strategy 2030 to promote inclusive digital-based GG, and Digital Tashkent is one of the leading programs for disseminating digital services in economic sectors. In the past decade, China made vast digital progress by introducing Alipay, Wechat, QR code systems, and 5G-enabled networks, bringing the digital revolution across its wide territory (World Bank and People's Bank of China, 2018).

Recently, Mongolia has adopted Estonia's model, which provides digital governance services to citizens. Likewise, different digital promotion programs have started at regional and global levels, such as the Digital Silk Road and China's Belt and Road, which are essential initiatives for digital connectivity across the region (ADB, 2022). The World Bank has started the Digital Central Asia–South Asian Program (Digital CASA) to facilitate reliable, affordable, and sustainable internet services in the CAREC region and promote digital penetration and developments (BURUNCIUC, 2021). However, the trends of DIG indicators are slower in Pakistan and Tajikistan, and the data show that they are the region's least digital economies, attributable to various policy and non-policy factors. Expensive internet coverage, low digital connectivity, and costly infrastructure investments cause CAREC countries to lag behind the world. Notably, half of the population still lack digital accessibility and adoption, and the CAREC region requires digital investments of USD 6 billion (BURUNCIUC, 2021). In this domain, public–private partnerships can be crucial in bridging the digital gap.

Using model 2, the study evaluated the integrated impact of RET and DIG in triggering GG. According to the results, when the sample countries transition from conventional to RET systems and embody DIG in green projects, the green transformation phenomenon speeds up. The coefficient magnitude of RET*DIG was substantially higher compared with the individual impacts of RET and DIG, illustrating that CAREC countries can significantly attain GG via the joint implications of DIG and RET. Therefore, the proposed model elucidated the combined effects of DIG and RET for GG. The International Renewable Energy Agency (IRENA, 2021) estimates that RET has the potential to reduce 90% of carbon emissions, whereas DIG can lower emissions by 15%; the integration of these factors produces positive energy efficiency and technical spillover effects in stimulating GG without carbon emissions. Moreover, DIG is crucial to accelerating climate action, and this sector needs to integrate with renewable energy input and green supplies for digital operations—around two-thirds of the population in developing countries have deployed digital innovations with clean energy in climate strategies because RET and DIG are complementary for green transformation (World Bank, 2023).

However, CAREC countries depend on natural gas and oil resources for their energy demand, and such dependence is incompatible with long-term GG. Technical enhancements in green energy projects and REC can reduce local energy consumption and enhance energy efficiency, thereby producing more revenue earnings through lower energy prices. CAREC countries have extensive oil and natural gas expertise; thus, accompanying digital innovations can provide novel ideas to upgrade the industrial structure and develop renewable-based green technologies, which comprise a crucial component of GG. Norway and Canada are the best examples of changing the oil and natural gas energy industries into geothermal and off-shore wind industries (Renewable Energy Agency, 2019). As another example, early warning systems based on solar and wind energy can protect crops from the effects of extreme weather. Climate-resilient technologies and green practices can maximize agricultural productivity and enhance the efficient utilization of scarce water resources. The integration of RET*DIG can mitigate water scarcity problems, food insecurity, climate change crises, energy shortages, digital divide gaps, and regional geopolitical conflicts.

A significant obstacle is the lack of financial resources. A digitalized-based financing product, known as fintech, can provide green financing loans and credit investments to elevate the RET process, consequently enhancing GG (Awais et al., 2023). Advanced developments in the green transformation agenda include low-carbon technology, recycling, carbon-capture storage, effective waste management services, electric vehicles, and green buildings. These eco-innovations are energy efficient and trigger sustainable growth without jeopardizing ecological integrity (An et al., 2021). For increasing private investments and international coordination, the role of independent regulatory authorities and all stakeholders cannot be neglected. They also play a role in surmounting all barriers in digital policy reforms and skill developments.

Meanwhile, capital formation decelerates GG and reveals a negative correlation via inefficient regulatory reforms and institutional frameworks. The results highlighted that capital investments must be allocated to socioeconomic development programs, resource-saving protection, regional integration, and digital connectivity projects to stimulate GG. Moreover, governments must improve human capital capabilities, digital infrastructure development, public sector efficiency, institutional quality, and energy sector reforms to achieve resilient-based GG. Thus, the selected CAREC economies must implement CAREC energy and digital strategies to achieve international commitments and nationally determined contributions at the regional and national levels.

5.6 CONCLUSION AND POLICY IMPLICATIONS

This research focused on the CAREC region in its exploration of the impact of RET and DIG on GG from 2001 to 2022 using the CS-ARDL method. The study performed CSD, unit root, slope homogeneity, and co-integration analyses in the pre-requisite procedure.

After confirming the CSD and stationary conditions, the study further checked the slope heterogeneity and co-integration among the variables. The presence of CSD and heterogeneity permitted the analysis to apply the CS-ARDL estimator. The long-term regression estimation of CS-ARDL revealed that RET positively contributes to GG by 0.376%. DIG is another catalyst in mounting sustainable growth directly related to GG by 0.089%. A unique and fascinating contribution of the study is that it ascertained the joint impact of DIG and RET on inclusive economic development and documented a 0.365% influential effect in triggering GG through knowledge and technological spillover effects. The short-term outcomes were aligned with the long-term coefficients at smaller magnitudes. Moreover, the robustness estimation affirmed the estimated outcomes. This study suggests the following policy implications for CAREC economies based on the empirical findings.

5.6.1 Policy Implications for RET-led GG

1) The RET is a dynamic process, and to optimize its benefits, long-term and sustainable policies are required for the CAREC region. RET benefits are not realized in a short period; they generate substantial positive spillover effects for GG in the longer term, which require sustainable and long-term integrative policies and plans for RET.

2) Given the favorable potential for the renewable energy sector, particularly in solar and wind energy, CAREC governments should incentivize and support RET developments by expanding credit investments and green financing in the wind and solar energy sectors. Governments should also attract private investors in these sectors by providing lower-cost loans and subsidies. Henceforth, green finance provides a roadmap for RET-led growth in the region.

3) RET is an effective strategy for CAREC economies and a global concern for achieving GG. International assistance and collaboration are required to promote the sharing of expertise and best practices, establishment of joint initiatives, and coordination of the strategies and policies for overcoming the challenges of RET-led GG.

4) Low tariffs and subsidies for conventional energy sources (fossil fuels) are significant obstacles in promoting RET and GG. The lower prices of fossil fuels compared with the international markets discourage RET. Thus, policy support mechanisms are needed to expedite the RET process. In this scenario, the concerned authorities should introduce feed-in tariffs, which are critical to encourage RET at the national level in the initial development stage. After establishing the proper market-based system, auctions may provide the opportunity to purchase renewable energy at lower cost through a market-based mechanism. It is a crucial step in triggering GG in the CAREC region.

5) Governments must modernize the existing energy infrastructure system and develop new and sustainable infrastructure systems that reduce energy costs and improve energy structure efficiency by addressing energy losses during transmissions and distribution. Thus, upgrading the current infrastructure assists in disseminating renewable energy deployment and ensuring SDG 7.

6) Asymmetric information regarding RET and its enhancements restricts RET. Thus, CAREC governments should foster technical awareness and knowledge concerning RET and its future benefits to promote GG. CAREC governments must introduce programs and awareness activities on different platforms, including social media, educational institutes, public meetings, and forums, to disperse the economic, social, and environmental benefits that can be reaped from RET. Sustainable energy utilization improves people’s health conditions, economic and social performance, and environmental sustainability in the long run.

7) Global practices and policy reforms have identified that an independent, credible, and well-functioning regulatory authority or institution overcomes the risks associated with RET, protects private investors’ rights, and boosts their confidence in the renewable energy industry. CAREC countries should establish an independent regulatory institution to facilitate private investors and competition in the renewable energy industry, leading to GG.

8) Moreover, CAREC governments must enhance research and development expenditures, construct green infrastructure developments, and encourage green

innovations in the renewable energy sector. These advancements require enormous investments, which can be fulfilled through international financial institutions, public-private partnership investments, and funding from developed economies.

9) On the demand side, policies must be designed to stimulate energy efficiency in residential, industrial, corporate, and other sectors. It can be done by incentivizing green and energy-efficient buildings and eco-friendly products and equipment. Thus, effective, stringent governance policies transform consumption attitudes toward resource preservation and environmental protection.

10) Regional integration can boost GG growth by increasing the share of sustainable energy trading systems. Through integration policies, one CAREC country can meet the energy demand from the supply of another CAREC economy. For instance, with hydropower, Tajikistan, Georgia, Pakistan, and the Kyrgyz Republic have large shares of renewable energy. These countries can increase the regional energy trading system with countries with a lower share in RET, such as Uzbekistan, Azerbaijan, and Kazakhstan. In this way, the demand and supply gap in renewable energy markets can be filled and countries can move toward reliable and cheaper energy sources, the cornerstone for GG in the entire region.

5.6.2 Policy Implications for DIG-led GG

1) CAREC countries, particularly Pakistan and Tajikistan, must develop the digital infrastructure to disseminate internet coverage and introduce 5G networks. However, such development requires substantial digital investments. Public-private partnerships and international financial institutes are viable funding sources for managing the infrastructure project’s costs and expenses.

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2) Owing to the high cost of internet connections, people cannot access digital services and goods. CAREC governments should review and decrease internet tariffs to encourage internet utilization and increase the number of current internet consumers. Reasonable internet packages and connections should be provided. Moreover, low-cost consumer loans can be used to boost regional digital enhancements. Through these loans, households and individuals can purchase laptops, computers, and other digital devices. Further, CAREC governments should reduce the import duty and taxes on ICT equipment and digital products and services.

3) Excessive use of digital devices and grids can lead to higher electricity consumption, pollution, and e-waste generation. In this aspect, different social awareness programs and campaigns are effective solutions to educate the masses regarding utilizing and disposing of digital instruments and products. Sustainable and eco-friendly digital products must be promoted at different levels through effective social media campaigns and advertisements.

4) For long-term digital developments, consistent and inclusive digital policies must be formulated to regulate digital transactions and establish a legal monitoring framework to increase transparency, accountability, and security associated with the digital economy.

5) CAREC governments should integrate digital advancements with the renewable energy sector to enhance and develop energy-efficient and sustainable technologies and innovations. CAREC governments must elevate cooperation with advanced economies to exchange ideas and knowledge regarding advanced production methods in the industrial and other economic sectors. All these measures promote DIG-led growth in the studied countries.

6) Digital connectivity is necessary for every CAREC economy. Being landlocked economies, they must encourage digital payments and online services in viable sectors, such as trade, health, education, and finance. This digitalized facilitation increases resource efficiency, limits carbon emissions, and leads to GG.

7) A critical concern in the digital economy is data protection and security while using digital apps, websites, and products. Thus, CAREC countries must design inclusive digital security and consumer protection policies that can bolster the security of internet servers, data centers, and consumer property rights. CAREC governments and civil society must raise cybersecurity awareness to impede hacking, digital fraud, and scams.

8) CAREC countries must promote regional digital integration and cooperation. For this purpose, the authorities should establish tax-free zones to develop digital ecosystems across the region. These tax regimes attract private investors, entrepreneurs, and startups in digital advancements and ensure technology inflows in various sectors. At the regional level, digital trade provides a conducive environment for business across borders by reducing transaction costs and time.

5.6.3 Study's Limitations and Directions for Future Research

Although the study elucidates the critical role of RET and DIG in driving GG for CAREC countries, it encompasses certain limitations, which opens new doors for future investigations. Due to data limitations, Turkmenistan and Afghanistan are excluded from the analysis. GG is a multifaceted phenomenon, depending on other pertinent factors, for instance, environmental governance, regional integration, and economic diversification; incorporating these determinants provides deeper insights into the CAREC region. Further, the present study employs a linear estimation technique. However, asymmetric associations may exist stemming from divergent threshold levels, technological revolutions, and potential for renewable energy deployment. In this regard, nonlinear panel estimation yields variant outcomes for policy implications.

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CHAPTER 06

GREEN GROWTH TRIUMPHS OVER BROWN GROWTH DESPITE ENERGY PRICE VOLATILITY

A Paradigm Shift in Sustainable Development

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6.1 INTRODUCTION*

Green growth, as a transformative approach to economic development in the current era, has a profound importance in addressing environmental challenges. Adverse environmental impacts, such as resource depletion, biodiversity loss, deforestation escalation, and the ominous specter of global warming, stem from rapid population growth, high energy-intensive systems, global integration, excessive reliance on finite resources, global rivalries, and technological advancements (Tao et al., 2021). These environmentally destructive practices have given rise to what is known as the "brown economy," referring to systems heavily reliant on factors that relentlessly harm the environment. The excessive consumption of fossil fuels empowers a brown economy and promotes short-term economic growth (Razi et al., 2023). However, not all contributions from brown economies are detrimental to the environment. A delicate balance between economic development and environmental preservation is essential to address the challenges posed by the brown economy and to move towards a more sustainable and greener future (Chen et al., 2022).

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Pursuing a hypercompetitive economy requires a compelling solution that fosters socioeconomic engagement, promotes innovation, and encourages collaborative global efforts (Ramzan et al., 2023). Green growth is a harmonious and sustainable path towards societal progress and economic prosperity. It reshapes economic paradigms through the visionary path of industrial revitalization. This places environmental stewardship at the heart of economic activities (Acosta et al., 2020). Moreover, green growth promotes the development of resilient systems, embraces sustainable practices, drives economic competitiveness, creates economic opportunities, and steers away from the pitfalls of a brown economy (Razzaq & Yang, 2023). The determinants of green growth in developing economies are diverse and interlinked. The efficacy of well-crafted environmental policies, infusion of capital into clean technologies, facilitation of green finance, sustainable infrastructure development, and collaborative endeavors with global partners bolster the capacity for innovation and resource efficiency (OECD, 2021).

With rapid technological advancements and energy-intensive activities, the emergence of Industrial Revolution 4.0 has underscored the increasing significance of energy and energy prices. Numerous studies in the existing literature have highlighted the pivotal role of energy prices in economic growth (Köse & Ünal, 2021). Brown growth, characterized by a heavy reliance on fossil fuels and energy-intensive industries, has a high environmental impact. Brown growth can cause resource depletion, energy inefficiencies, increased energy costs, and greater vulnerability to the volatility of non-renewable energy prices, hindering green growth efforts (Liu et al., 2022). However, brown growth contributes to economic development by creating jobs, advancing technological innovation, and stimulating investment to support green growth initiatives (Kriskkumar et al., 2022).

Sustainable economic and financial growth are intrinsically linked to energy resource availability and efficient utilization. In recent years, crude oil, natural gas, and gasoline have become fundamental catalysts for transportation systems, fueling industrial activities, and overall economic expansion. Access to reliable and affordable energy sources fosters investment, innovation, and technological progress (Moradbeigi & Law, 2017). However, the volatility in energy prices can affect energy consumption and economic efficiency, thereby influencing the growth process. Therefore, a harmonious balance between economic development and environmentally sustainable energy practices ensures resilience and societal well-being (Afshan, Razi, et al., 2023). The country's energy structure shapes its prospects for green growth, a framework with priorities for adopting renewable and clean energy sources, integrating energy-saving technologies, and diversifying the energy mix by reducing vulnerability to global energy market fluctuations and geopolitical uncertainties (Wang et al., 2023). From a green growth perspective, developing economies in the CAREC (Central Asia Regional Economic Cooperation) region are significantly influenced by their energy mix.

Table 6.1 shows the energy profiles of CAREC countries. Their energy mix highlights their varying reliance on fossil fuels and renewable energy sources to meet their demands. Azerbaijan, Kazakhstan, Mongolia, Pakistan, China, Turkmenistan, and Uzbekistan are identified as economies that rely heavily on fossil fuels for energy supply, whereas Georgia, the Kyrgyz Republic, and Tajikistan have a high contribution of renewable energy sources to their energy mix. This disparity in energy sources emphasizes the importance of evaluating the influence of fossil fuel price volatility on green growth prospects in the region. Moreover, according to statistics reported by the Asian Development Bank (2022), the inclusion of Mongolia, China, and Kazakhstan in the top 10 rankings of carbon intensity further emphasizes the critical need to assess the influence of the brown economy in terms of high energy-intensive practices on the

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green economy in the CAREC region. As major regional players, the economic activities and energy usage patterns of these countries substantially affect the region's overall sustainability and environmental health.

Table 6.1: Energy Profile of the CAREC Region

Countries	Energy mix	Energy Exports**	Energy Imports***	Carbon Intensity*	Energy Independence
Azerbaijan	93% natural gas, 7% hydropower	72%		111th	100%
Georgia	83% hydropower, 17% natural gas	-	81%	157th	88%
Kazakhstan	70% coal, 20% natural gas, 10% hydropower	63%	-	4th	100%
Kyrgyz Republic	92% hydropower, 7% coal, 1% natural gas	-	-	158th	100%
Mongolia	88% coal, 5% oil, 7% renewable energy	-		2nd	100%
Pakistan	22% oil, 8% coal, 37% natural gas, and 33% hydropower		32%	95Th	68%
China	67% coal, 3% natural gas, and 30% renewable energy		24%	9th	90%
Tajikistan	93% hydropower, 7% coal			168th	100%
Turkmenistan	100% natural gas	50%		103rd	100%
Uzbekistan	87% natural gas, 3% coal, and 9% hydropower	50%		114th	100%

*out of 172 ** % of total exports, ***% of total imports
Source: Asian Development Bank (2022)

Extant literature has highlighted the benefits of green energy sources in various ways to boost green growth. For example, Han et al. (2023) suggested that green hydrogen energy exhibits a strong potential for synergy with renewable energy sources, in particular because of its inherent characteristics of intermittency and variability. Notably, green hydrogen in this region can serve as a viable means of long-term energy storage, thereby enhancing the efficiency of renewable energy utilization and bolstering the 'reliability of power grids. Similarly, a report by the Asian Development Bank (2023) implies that energy-related initiatives, predominantly financial allocations directed towards green energy undertakings, are channelled into endeavors aimed at enhancing energy provisioning, fostering greater energy efficiency, and ameliorating existing hydropower facilities. Therefore, to formulate effective policies and strategies to promote a more sustainable and balanced approach to economic development, it is essential to assess the sway of brown growth using fossil-fuel-based industries and green growth practices.

The contribution of this study to the existing literature is multifold. For instance, previous studies in the context of CAREC countries have primarily focused on analyzing the impact of oil prices on economic growth and placed limited emphasis on the significant impact of coal and gas prices on the region's energy mix. Reliance on multiple energy sources is a characteristic feature of CAREC countries, and their proper consideration is crucial for a comprehensive understanding of the energy-price-green growth relationship.

However, the literature lacks investigations that simultaneously encompass all three energy sources: oil, gas, and coal. The gap in existing research presents an opportunity for this study to contribute significantly to the understanding of green growth dynamics in CAREC countries. By incorporating all three energy sources, we seek to provide a more holistic and accurate assessment of how these prices influence the region's green growth prospects. In addition, this study employs the Principal Component Analysis (PCA) method to create a composite variable of energy prices to analyze the joint influence of oil, coal, and gas prices on the region's green economy. This approach

improves the comprehensiveness and statistical reliability of the analysis to investigate the intricate relationship between brown growth and the prices of energy (oil, gas, and coal) and their impact on the green growth of CAREC countries.

In addition, given the limited data available from 2000 to 2021, this study employed the nonlinear autoregressive distributed lag (NARDL) method. The NARDL model is particularly useful when the variables under investigation exhibit nonlinearity and asymmetric dynamics, as is often the case in the fields of energy and environmental economics. This novel approach allows for an analysis of the direction and magnitude of asymmetric relationships between variables to fill the existing research gap in understanding the region's complex dynamics between energy prices, brown growth, and green growth. The findings of this study have significant implications for policymakers and stakeholders in CAREC countries. The research outcomes can guide governments in crafting targeted measures to promote green growth, optimize energy utilization, and mitigate environmental impacts.

6.2 CONCEPTUAL FRAMEWORK

It has been widely recognized that unconstrained brown growth can lead to climate change, resource depletion, ecological imbalances, and other environmental challenges that eventually constrain long-term economic prosperity (Khodaparast Shirazi et al., 2020). In contrast, green growth with sustainable economic activities enhances resource availability improves ecological resilience and reduces greenhouse gas emissions. It aims to decouple economic growth from environmental degradation (Garrett-Peltier, 2017). However, the relationship between brown and green growth is complex and interconnected. The theoretical underpinning of the nexus between brown and green growth stems from the "Environmental Kuznets Curve" (EKC) hypothesis, which suggests that in the early stages of development, as economies grow, environmental degradation may increase owing to the greater demand and consumption of natural resources (Kousar et al., 2022). However, with economic advancements, they tend to invest in cleaner technologies, regulations, and sustainable practices, leading to a decline in environmental deterioration. This signifies a potential inverse U-shaped relationship between brown growth and environmental impacts, which aligns with the long-term shift towards green growth (Sharma et al., 2023).

In addition, the "Porter Hypothesis" also provides the base for the brown and green growth relationship. According to this hypothesis, environmental regulations and eco-friendly practices can drive innovation and improve efficiency in supporting green growth (Garrett-Peltier, 2017). The expected association between brown and green growth is positive. However, brown growth can dampen green growth through resource-intensive industries, excessive consumption of finite resources, unsustainable practices, and climate change (Quaas & Smulders, 2018).

In the 19th century, the Industrial Revolution led to remarkable progress in global trade and industry, driven by technological innovations (Kousar et al., 2022). While this growth improved living standards, it relied heavily on energy-based systems, such as crude oil, gas, coal, and petroleum, leading to environmental decline (Khan et al., 2023). Today, energy-dependent advancements persist owing to accessibility, convenience, and cost factors that impact the financial market and various economic sectors. Volatile energy prices also pose uncertainties in economic growth, affecting import- and export-based countries differently (Wang et al., 2023). Green growth, which emphasizes a balance between environmental preservation and economic competitiveness, seeks to improve environmental and economic wellbeing (Moradbeigi & Law, 2017). The transition to ecofriendly energy sources can reduce conventional energy prices and reliance, while creating green job opportunities (Hu et al., 2022). The concepts of energy transition and sustainable development provide a theoretical background for the effects of

energy prices on green growth. Countries that are heavily reliant on oil, gas, and coal are expected to experience higher production and energy consumption costs with an increase in the prices of these energy sources; therefore, they incentivize a shift towards more sustainable and cleaner energy alternatives and promote green growth. However, price volatility in these energy resources hinders green growth by reducing investments in renewable technologies and sustainable development initiatives. Therefore, the expected price elasticity of green growth can be positively or negatively related to countries' policy frameworks, economic structures, and energy mixes.

6.3 METHODOLOGY

6.3.1 Data extraction

This study provides an in-depth analysis of the impact of brown growth and energy prices on the green growth of CAREC countries, focusing on the repercussions on crude oil, natural gas, and coal prices. This investigation spans a comprehensive period of 22 years, from 2000 to 2021, and uses annual data. The NARDL approach was used to facilitate this empirical study. Further, GDP growth rates are employed as a proxy measure to evaluate brown growth, while green growth is assessed through the lens of net adjusted savings (% of GNI), following Afshan, Cheong et al. (2023). According to The World Bank (2023), "Adjusted net savings are equal to net national savings plus education expenditure and minus energy depletion, mineral depletion, net forest depletion, and carbon dioxide and particulate emissions damage." Data were meticulously extracted from the World Development Indicators database. The crude oil, natural gas, and coal datasets were obtained from the Federal Reserve Economic Data and International Energy Agency (IEA) databases. Table 6.2 summarizes these variables.

As this study considers oil, gas, and coal as the major components of the energy mix of the CAREC region, it combines the prices of these three energy sources and, by employing the PCA method, a new composite variable of energy prices that enhances the comprehensiveness and efficiency of analysis was created (Razzaq et al., 2021). This approach has several advantages. It captures the overall variation in energy prices and their joint influence on the green economy, thus providing a more holistic understanding of this relationship (Fu et al., 2022). Moreover, the composite variable helps reduce multicollinearity issues that may arise from separately evaluating individual energy prices, thereby enhancing the statistical reliability of the results (Hu et al., 2022).

Additionally, this novel approach fosters a more concise and efficient representation of the complex interplay between energy prices and the green economy, enabling policymakers to make informed decisions to promote sustainable and environmentally friendly economic growth in the region (Song et al., 2022).

Table 6.2: Variables Summary

Variables	Acronym	Definition/proxy	Data sources
Green growth	GGR	Net adjusted saving (% of GNI)	WDI
Brown Growth	BGR	Real GDP growth rate %	WDI
Crude Oil Prices	OIL	West Texas Intermediate (WTI) benchmark, measured in U.S. Dollars per barrel	FRED
Natural Gas Prices	GAS	Global natural gas prices in U.S. Dollars per cubic meters	IEA
Coal Prices	COAL	Global price of coal, U.S. Dollars per metric ton	FRED
Energy Prices	ENP	The combined form of crude oil, natural gas, and coal prices	The index generated through PCA

WDI: World Development Indicators; IEA: International Energy Agency; FRED: Federal Reserve Economic Data; PCA: Principal Component Analysis

Table 6.3 presents a comprehensive overview of the study variables (e.g., BGR, ENP, COAL, GAS, OIL, and GGR) using descriptive statistics. GGR demonstrates the highest mean value, whereas its median compared to the mean suggests a potential asymmetry in its distribution. Among the variables, ENP exhibits the lowest standard deviation, which is indicative of relatively lower data dispersion, whereas green growth displays the highest volatility. The Jarque-Bera test statistic also underscores the non-normality across variables, substantiated by highly significant p-values. As mentioned in the Data section, the study employs the PCA to create principal components (PCs).

As shown in Table 6.3, the eigenvalue for the first PC is greater than 1, underscoring its significance. Notably, the correlation coefficients between the weighted energy price index and the three energy sources exhibited a strong correlation (>0.50), confirming the reliability of the ENP.

Figure 6.1 shows histograms for a graphical presentation of GGR, BGR, and ENP. This figure accentuates the non-symmetrical nature of the data distribution of these variables. Figure 6.2 depicts the correlations between variables and their distributions. The graph highlights a pronounced positive correlation among GGR BGR, and ENP, whereas the correlation between BGR and ENP was negative. Furthermore, the correlation matrix revealed a potential concern of multicollinearity within the dataset based on the characteristics and strengths of the variables. The coefficients of all independent variables were below 0.6, confirming the absence of potential multicollinearity among the independent variables.

Table 6.3: Descriptive Statistics and Index Construction

Variables	GGR	BGR	COAL	GAS	OIL	ENP
Mean	16.424	16.424	16.424	16.424	16.424	16.424
Median	16.713	16.713	16.713	16.713	16.713	16.713
Maximum	49.500	49.500	49.500	49.500	49.500	49.500
Minimum	-7.554	-7.554	-7.554	-7.554	-7.554	-7.554
Std. Dev.	11.587	11.587	11.587	11.587	11.587	11.587
Jarque-Bera	4.545	4.545	4.545	4.545	4.545	4.545
Probability	0.003	0.003	0.003	0.003	0.003	0.003
Observations	154	154	154	154	154	154

Construction of composite energy price index

PC-1 Eigenval	**Proportion explained by PC-1**	**PC-1 Factor loadings**		
1.541	0.76	Gas	Coal	Oil
Correlation with PCA index		0.623	0.801	0.922

Source: Author Estimation

Figure 6.1: Data Distribution of GGR, BGR, and ENP

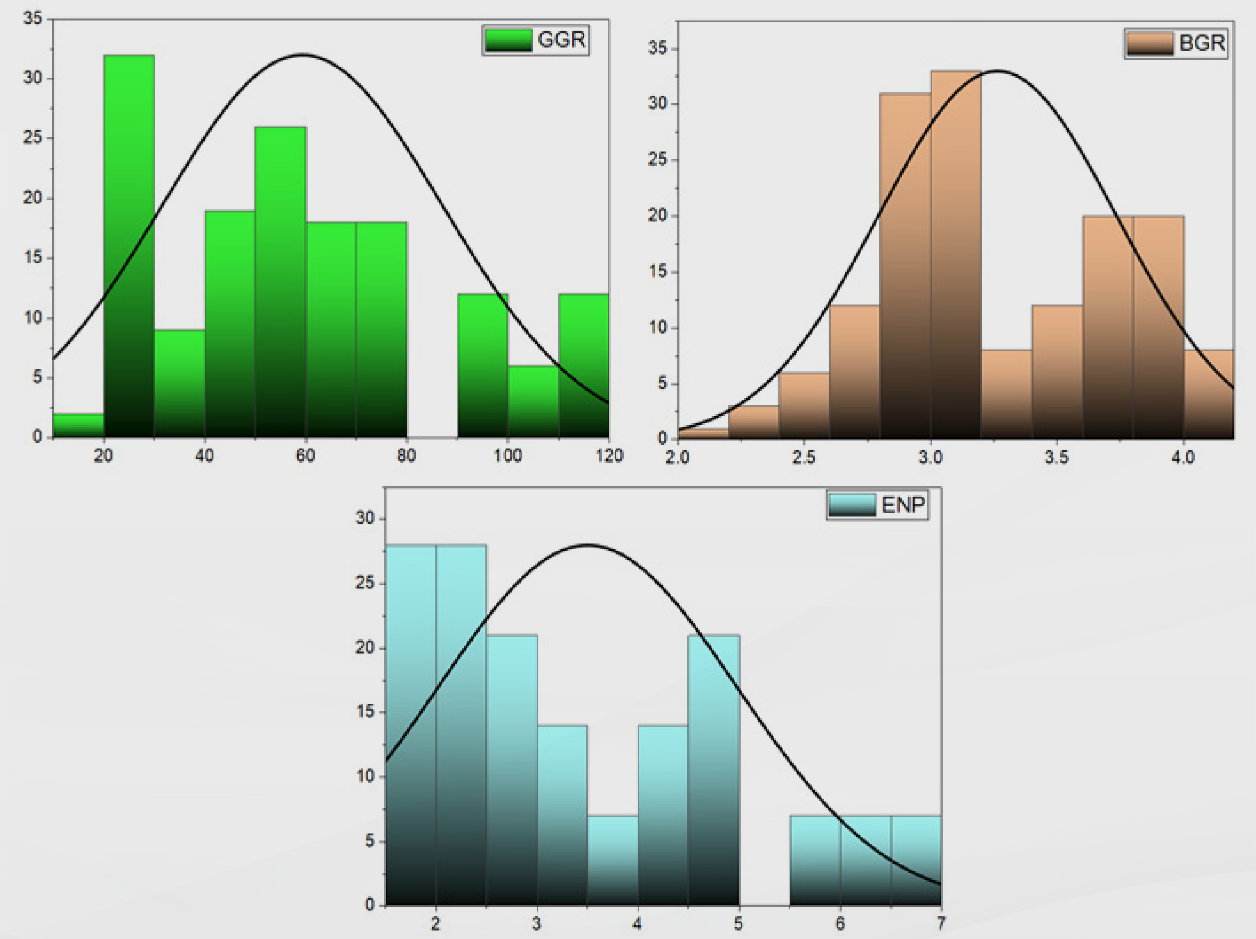
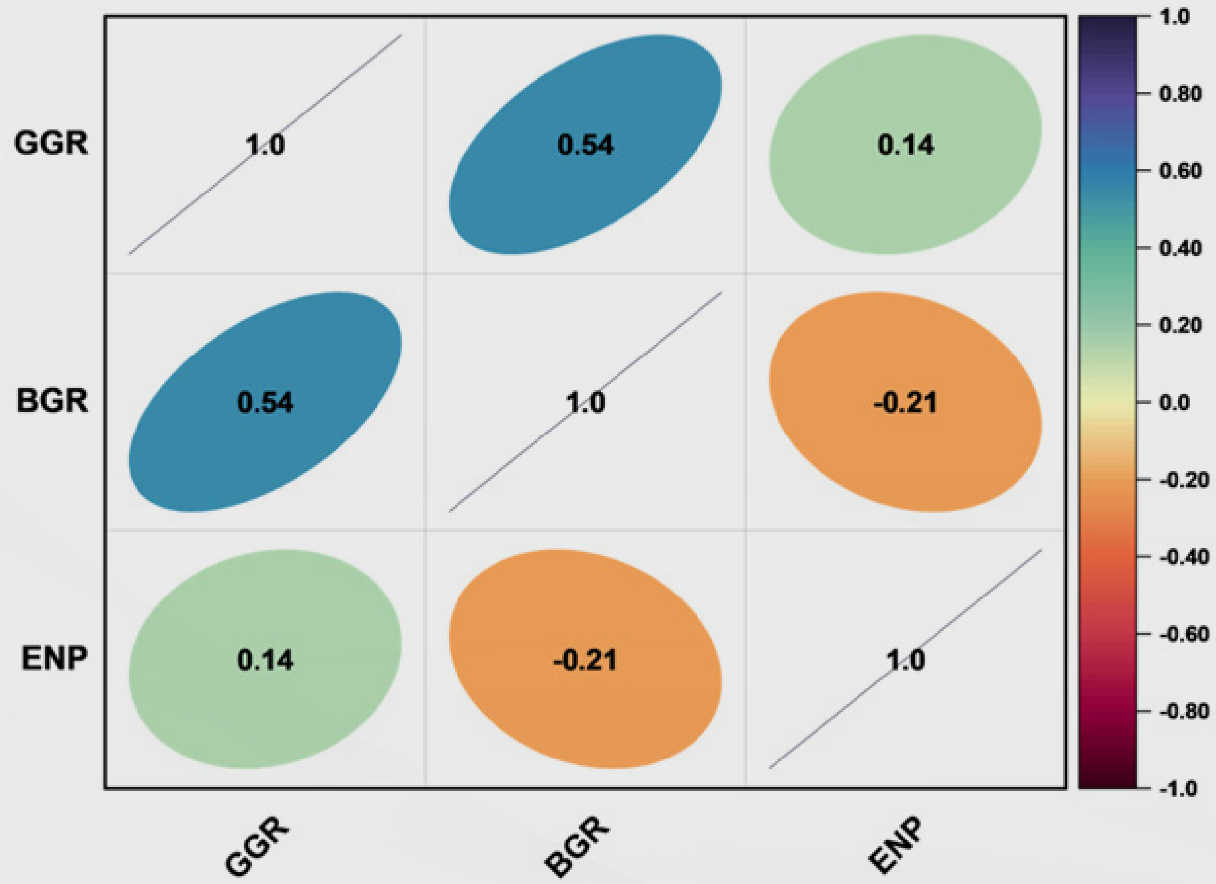


Figure 6.2: Correlation Matrix of GGR, BGR, and ENP



GREEN GROWTH TRIUMPHS OVER BROWN GROWTH DESPITE ENERGY PRICE VOLATILITY
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6.3.2 Model specification

Considering the critical significance of brown growth and energy prices in influencing the green growth trajectory, the model is outlined as follows:

$$GGR_{it} = f(BGR_{it}, ENP_{it}) \qquad (i)$$

The functional form of the model is depicted in Equation (i) and its empirical representation is as follows:

$$GGR_{it} = \delta_0 + \delta_1 \ BGR_{it} + \delta_2 \ ENP_{it} + \varepsilon_{it} \qquad (ii)$$

In Equation (ii), the constant term is represented as δ_0, and the coefficients for brown growth and energy prices are denoted by δ_1 and δ_2, respectively. The letter "i" denoted the CAREC countries (cross-section), while "t" corresponds to the period. The error term is captured by ε_{it} in the regression formulation of the model.

6.3.3 Empirical strategy

Based upon the distinctive attributes of green growth, brown growth, and energy prices (oil, gas, and coal) by employing the NARDL approach, this study explores the intricate non-linear relationship among these variables. This approach was proposed by Shin et al. (2014). The adoption of this methodology is theoretically substantiated owing to its several advantages. For example, it offers robust cointegration estimations that are particularly beneficial for small sample sizes (Sun & Zhang, 2023). Additionally, this method accommodates the integration orders of I(0) and I(1) for the data series, except for the integration order of I(2) (Ali et al., 2022). Notably, the NARDL technique captures nonlinear, asymmetric, and lagged effects, making it suitable for analyzing the intricate volatility of the energy market. Specifically, as the correlation between energy prices and green growth relies on investor sentiment and market dynamics, green growth patterns may exhibit nonlinear trends (Hu et al., 2022). By incorporating distinct coefficients for positive and negative changes in brown growth and energy prices, the NARDL approach facilitates asymmetric estimations and effectively assesses the short- and long-term effects of shifts in these variables (Liu et al., 2022). Furthermore, this method reveals an essential dimension of concealed cointegration inherent in time-series data, enhancing the precision of the estimations (Simran & Sharma, 2023). This framework transforms Equation (ii) into ARDL form as follows:

$$\Delta GGR_{it} = \phi_0 + \sum_{it}^{p} \phi_{1ij} \Delta GGR_{it-j} + \sum_{j=0}^{q} (\phi_{2ij} \Delta BGR_{it-j} + \phi_{3ij} \Delta ENP_{it-j}) + \delta_1 BGR_{it-1} + \delta_2 ENP_{it-1} + \delta_3 GGR_{it-1} + \varepsilon_{it} \quad \text{(iii)}$$

δ_{it} exhibited the long-run coefficient vector, while the short-run exhibited as ϕ_{it} in Equation (iii).

The increasing and decreasing pattern of change in brown growth is separated into BGR^+ and BGR^-, while the increasing and decreasing pattern in energy prices is written as ENP^+ and ENP^-, respectively. The theoretical dissection of the variables is outlined as follows:

$$BGR_{it}^{+} = \sum_{n=l}^{t} \Delta BGR^{+}_{it} = \sum_{n=l}^{t} \max(\Delta BGR_{it}, 0) \quad \text{(iv)}$$
$$BGR_{it}^{+} = \sum_{n=l}^{t} \Delta BGR^{+}_{it} = \sum_{n=l}^{t} \min(\Delta BGR_{it}, 0) \quad \text{(v)}$$
$$ENP_{it}^{+} = \sum_{n=l}^{t} \Delta ENP^{+}_{it} = \sum_{n=l}^{t} \max(\Delta ENP_{it}, 0) \quad \text{(vi)}$$
$$ENP_{it}^{+} = \sum_{n=l}^{t} \Delta ENP^{+}_{it} = \sum_{n=l}^{t} \min(\Delta ENP_{it}, 0) \quad \text{(vii)}$$

Equation (iii) is the ARDL or linear representation of the interrelations among variables. However, in the context of the NARDL, it is necessary to elucidate the non-linear associations. Therefore, the focus variables in Equation (iii) are divided into positive and

negative forms to explain the varying interactions between BGR, ENP, and GGR. Separate factors of these variables can yield dissimilar effects, illustrating asymmetry when they undergo positive or negative alterations. This scenario implies the potential for asymmetric impacts, as shown in the following equation:

$$\Delta GGR_{it} = \phi_0 + \sum_{j=1}^{p} \phi_{1ij} \Delta GGR_{it-j} + \sum_{j=0}^{nq} (\phi_{2ij} \Delta BGR^{+}_{it-j} + \phi_{3ij} \Delta BGR^{-}_{t-j} + \phi_{4ij} \Delta ENP^{+}_{t-j} + \phi_{5ij} \Delta ENP^{-}_{t-j}) + \delta_1 BGR^{+}_{it-1} \delta BGR_{it-1} + \delta_3 ENP^{+}_{it-1} + \delta_4 ENP^{-}_{it-1} + \delta_5 GGR_{it} + \varepsilon \quad \text{(viii)}$$

Equation (viii) outlines "p and q" as the lag orders while the long-run elasticity values for individual variables are denoted by δ_1 to δ_5. The coefficients of the short run in the equation are depicted with the change in variables (Δ). The optimal lag length selection for the regression is based on identifying the minimum Akaike Information Criterion (AIC) value.

6.4 FINDINGS AND DISCUSSION

6.3.1 Data extraction

Before estimating the NARDL technique for the model, it is necessary to identify variables with unit roots to ensure valid results (Hu et al., 2022). However, it is vital to acknowledge that the NARDL approach has some limitations; for example, it requires none of the variable series to possess an integration order of I(2) because the cointegration F-statistics may yield imprecise estimates when the stationarity is obtained at a second difference for the data series (Shin et al., 2014). Therefore, to address this concern of integration order of I(2), this study employed the "augmented Dickey-Fuller" (ADF) and "Phillips-Perron" (PP) unit root tests. The results of these tests are presented in

Table 6.4 for GGR, BGR, and ENP. These tests are used to ascertain the presence of a unit root. The null hypothesis rejection for these tests suggests that the series are stationary at the first difference and none of the variables possess an integration order of I(2). The absence of the I(2) integration order was also confirmed through the Zivot and Andrews (2002) test for structural breaks, affirming the integration order of I(1) for GGR, BGR, and ENP in Table 6.4.

Table 6.4: Unit Root Test Estimates

Variables	GGR	BGR	ENP
ADF (Level)	-1.442	-1.845	-1. 547
ADF (Δ)	-5.326***	-6.745***	-6.802***
	I(1)	I(1)	I(1)
PP (Level)	-0.356	-1.548	-1.214
PP (Δ)	-4.214***	-5.224***	-5.951***
	I(1)	I(1)	I(1)
ZA (Level)	-2.147	-1.749	-1.858
Year	7/21/2015	05/21/2009	10/02/2020
ZA (Δ)	-5.2581**	-7.244***	-6.879***
5Year	06/03/2012	04/28/2020	12/02/2015
	I(1)	I(1)	I(1)

Notes: The values in this matrix specify the ADF and ZA tests' statistics for stationarity property. *** indicates a level of significance at 1%. The critical values for the ZA test are -5.57(1%), -5.08 (5%) and -4.82 (10%).

The preceding examination confirmed that all series exhibit unit roots at the level, thereby indicating that, owing to their stochastic trends, these non-stationary series might display spurious correlations between variables (Ramzan et al., 2023). Thus, validation of long-term correlations is essential. For this purpose, we employed the innovative NARDL bond test. This test accommodates nonlinear relationships among the variables and extends the conventional bond test methodology. The significance of the NARDL bond test is particularly relevant in scenarios involving threshold effects, where the relationship between two variables becomes significant only when one surpasses a certain threshold value (Hu et al., 2022). The findings of the NARDL bond test, as shown in Table 6.5, reveal a significant F-statistic of 12.456, surpassing the upper bound I(1) critical value and affirming the presence of cointegration between GGR, BGR, and ENP.

Table 6.5: NARDL Bond Test: Cointegration Test Estimates

Model	F-Statistics	Upper BondI(1)	Lower BondI(0)
GGR = f (BGR, ENP)	12.456***		
Critical Values			
1%		8.451	6.178
5%		4.347	3.473
10%		3.074	2.703

*** demonstrates a 1% level of significance

Table 6.6 demonstrates the NARDL estimates to provide detailed long- and short-run asymmetric associations between BGR, ENP, and GGR for CAREC countries. Notably, each variable exhibits statistically significant coefficient values, implying an intricate association between these variables. The coefficient of GGRt-1 implies that a one-unit increase in past green growth (a lagged variable) has a positive but relatively modest effect on current green growth. This observation suggests that the influence of past green growth on present growth was attenuated in the long run. Estimates show that in the long run, the variable BGR(+) demonstrates a substantial positive coefficient of 0.432, indicating a robust link between brown and green growth. The positive impact of the BGR on the GGR aligns with the theoretical underpinning of the Environmental Kuznets Curve (EKC) hypothesis, which posits that economic growth initially leads to environmental degradation but eventually results in improved environmental quality because of technological advancements, increased awareness, and policy interventions. The CAREC region strives to balance economic growth with environmental sustainability, emphasizing sustainable development practices with their expansion and development. For instance, in the CAREC region, carbon intensity decreased by 31% between 2000 and 2020, indicating the potential of economic development to drive environmentally friendly practices (Sudan, 2021).

Similarly, the coefficient of BGR(-) also suggests a positive association with GGR. This indicates that even negative changes in brown growth could positively influence green growth over time. This indicates that policy measures aimed at pollution abatement, such as reducing pollution or enhancing resource efficiency, can have lasting effects on the promotion of green growth. For instance, they have implemented stricter emission controls in Kazakhstan, significantly decreasing sulfur dioxide emissions in the last few years (Poberezhskaya & Bychkova, 2022). However, in the short run, the negative and significant coefficients of BGR(+) and BGR(-) solidify the intricate interdependence between brown and green growth over a compressed timeframe.

This signifies that negative economic growth adversely affects overall environmental quality and sustainability. This affects the availability of natural resources and hinders the development of green sectors, renewable energy initiatives, and environmentally friendly technologies that contribute to green growth (Razzaq & Yang, 2023).

The NARDL estimates for ENP(+) in the CAREC region assert a statistically significant negative correlation between energy prices and green growth. This implies that the focus of the CAREC region is on the profound influence of energy prices, such as gas, oil, and coal, on shaping the economic and environmental landscapes. This region relies heavily on gas and coal for its energy production. An increase in energy prices leads to higher costs for energy-intensive industries, which reduces economic activity and potentially stifles green growth initiatives. Higher energy prices can discourage the investment and adoption of green technologies.

Thus, the energy mix, policy environment, economic structure, and investor behavior deter green initiatives in the CAREC region. The continuity of this negative effect, as indicated by the negative coefficient in the short run, highlights the fact that changes in energy prices have immediate repercussions on sustainable economic dimensions. ENP(-) has a negative and significant elasticity value for the short and long run, which implies that with a decrease in energy prices, the cost of fossil fuels and other non-renewable energy sources decreases, disincentivizing investments and advancements in green technologies and renewable energy solutions. This can make traditional, polluting energy sources more economically appealing, slowing down sustainable practices and green growth. These outcomes support the findings of Fu et al. (2022) and Shahbaz et al. (2021), who suggested that a decline in energy prices depresses economic and environmental sustainability. Figure 6.3 presents a graphical illustration of the relationships among the variables, which are supported by the theoretical underpinning.

Table 6.6: NARDL Estimates

Variables	Long run Coeff.	Long run t-stats	Short run Coeff.	Short run t-stats
GGR_{t-1}	0.014*	1.984		
BGR^{+}	0.432***	7.477	-0.369***	3.685
BGR^{-}	0.066**	2.614	-0.021**	2.412
ENP^{+}	-0.174***	5.012	-0.101***	3.989
ENP^{-}	-0.066***	4.235	-0.054**	1.689
Diagnostic tests				
ECM	-0.304***	5.334		
LM test	3.339			
BPG test	5.245			
RESET	6.355			
VIF	3.121			
CUSUM	S			
CUSUM 2	S			
WaldSR	3.919**			
WaldLM	3.212**			
Adjusted R2	0.807			

Note: GGR: dependent variable, "***, **, and * denote 1%, 5%, and 10% levels of significance, LM stands for Lagrange Multiplier, while BPD, RESET, and VIF are referred as Breusch-Pagan-Godfrey, Ramsey Regression Equation Specification Error test , and Variance Inflation Factor, respectively.

Table 6.6 also provides diagnostic tests that provide insight into the validity and fit of the model through diagnostic tests. For instance, the significantly negative "Error Correction Model" (ECM) coefficient of -0.304 indicates dynamic stability and enduring linkages among the variables. The "Lagrange Multiplier" (LM) test value of 3.339, falling below the critical value at the 1% significance level, endorsed that the model is adequate and no residual autocorrelation has been found. Likewise, the "Breusch-Pagan-Godfrey" (BPG) test yielded an insignificant value, signalling the non-existence of heteroscedasticity in the model's residuals. The Ramsey RESET "Regression Equation Specification Error Test" assesses the potential absence of non-linearity.

The insignificant value of 6.355 indicates that the model is suitable for capturing nonlinearity.

However, the "variance inflation factor" (VIF) value is 3.121, which is below 10, indicating that no substantial multicollinearity issues affect the model's reliability. The parameter stability of the model over time was confirmed using the CUSUM and CUSUM square tests, which were within acceptable bounds, confirming stable model parameters. Graphical representations of these tests are shown in Figures 6.4 and 6.5. In addition, the Wald test functions WaldSR and WaldLM measure the overall significance of the respective coefficient groups. In addition, the adjusted R2 value of 0.807 suggests that a substantial percentage of the variance in the dependent variable is explained by independent variables. Thus, the model effectively fits the long- and short-term data dynamics, significantly influencing the GGR.

Figure 6.3: Graphical Representation of NARDL Findings

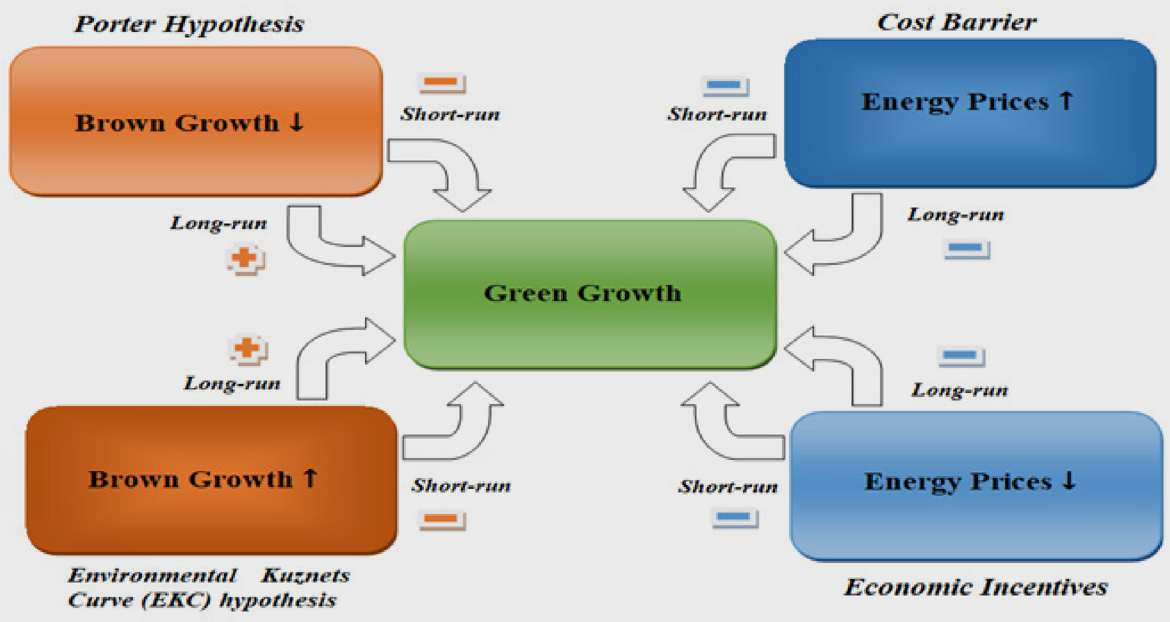


Figure 6.4: CUSUM Test

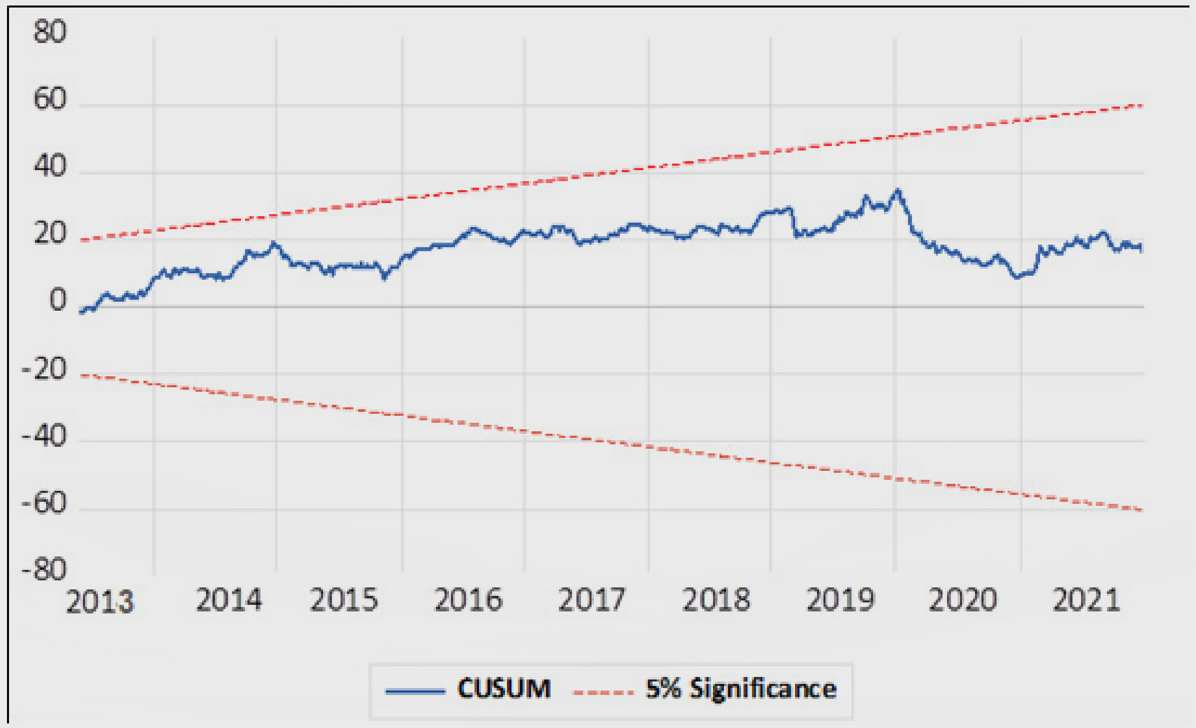
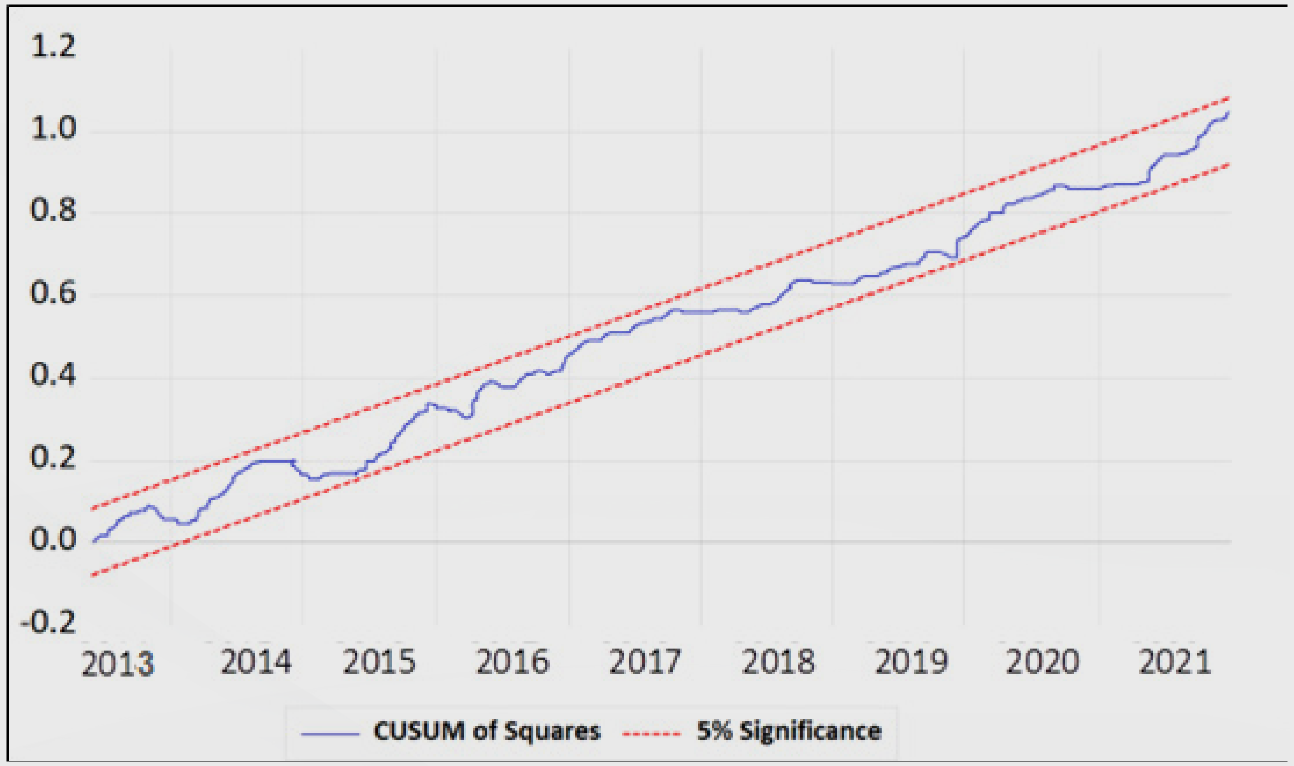


Figure 6.5: CUSUM of Squares Test



6.5 CONCLUSION

This study examined the intricate relationship between brown growth, energy prices, and green growth in the CAREC region. Despite previous explorations, this study examined these variables using the NARDL from 2000 to 2021. These outcomes highlight the distinct roles of brown growth and energy prices in shaping the green sectors of CAREC economies. Notably, a significant positive association between brown and green growth has been observed in the long run, which implies that when brown economic growth enhances an upsurge in financial resources, investment capabilities, and infrastructure development, it facilitates green growth. Similarly, when brown growth declines, economic challenges can prompt resource efficiency and the re-evaluation of development strategies. This can lead to the adoption of sustainable practices and technologies to promote green transitions. In the short term, the BGR and GGR associations are negative, indicating that immediate economic priorities take precedence over long-term environmental considerations, hindering green growth.

During economic downturns, investments in sustainable projects may decrease, and the focus on immediate financial recovery may increase. Similarly, energy price volatility adversely impacts green growth in the short and long run in the CAREC region. Both positive and negative energy price shocks have deleterious effects. For instance, when energy prices increase, there is a sudden increase in energy costs, which leads to higher production expenses for environmentally friendly technologies and renewable energy sources, thereby hindering the adoption of green growth initiatives. Specifically, when energy prices suddenly drop, it discourages investments in renewable energy projects, as they could become less financially viable than conventional energy sources.

6.6 POLICY RECOMMENDATIONS

6.6.1 Energy diversification strategies

These findings have critical implications for policy making. From a holistic perspective, the elimination of brown growth from an economy is unrealistic. Instead, pragmatic approaches such as green growth strategies are necessary for the CAREC region to reduce its dependence on coal, gas, and oil as energy sources. Although green practices involve time-intensive processes, their long-term benefits contribute to environmental sustainability. Hence, transitional methods for cleaner energy production are imperative to mitigate fossil-fuel-based energy emissions. Curbing the consumption of crude oil, natural gas, and coal is vital for global environmental stability. CAREC countries should consider diversifying their energy mix to reduce their dependence on fossil fuels and decrease their vulnerability to energy price volatility. For instance, with its strong reliance on natural gas, Azerbaijan can harness the Caspian Sea wind and solar potential. A strategic roadmap could be established to develop offshore wind energy capabilities and invest in solar farms in the Absheron Peninsula in partnership with European wind energy firms to attract investment by passing legislation to introduce renewable energy credit and share risks. Moreover, the country can create a government-led initiative to map sun-rich zones and develop a phased plan for solar farm construction.

In contrast, Georgia, having a significant hydropower base, could diversify by exploring its geothermal energy prospects, given its location on the tectonically active Eurasian Plate. The country can collaborate with countries experienced in producing geothermal energy, such as Iceland, to conduct exploratory drills and training. Moreover, the implementation of a feed-in tariff (FIT), specifically for solar energy, encourages the installation of private solar panels. There is also a need to establish university programs that focus on renewable energy technologies to foster local expertise. Kazakhstan, the region's largest coal producer, could benefit from a gradual coal phase-out plan while promoting its vast wind and solar resources, particularly in the northern and western steppes. It can establish a fund to phase out coal production and support miners through retraining programs aligned with renewable sector jobs. In addition, the country can identify zone corridors specifically for wind and solar development and streamline approval processes.

Dominated by hydropower, the Kyrgyz Republic Republic must manage its water resources more efficiently and could invest in solar power, given its ample sunshine, to supplement its energy mix. It can start small-scale, community-led solar pilot projects to test the best practices for large-scale implementation. Moreover, the country could study existing hydropower plants to optimize their output and extend their operational lives. It can also seek assistance from international entities such as The World Bank for technical support in renewable projects. Mongolia could leverage its high solar irradiance and potential for wind energy to reduce its heavy coal dependence. The country can use GIS and remote sensing to precisely map its wind and solar resources. It can also designate and develop REZs that are complete with tax incentives and infrastructure readiness. Moreover, the government should issue bonds that specifically fund renewable energy projects, thereby allowing citizens to invest in this transition.

6.6.2 Policy and infrastructure development

To transition from fossil fuels to renewables, Azerbaijan should adopt a strategic approach involving renewable subsidies on a sliding scale that progressively attracts investment as the renewable sector's infrastructure matures. To facilitate grid integration, the government must invest in infrastructure upgrades, particularly in regions with high renewable energy potential. To achieve a significant increase in renewable capacity, Azerbaijan has set a target of 20% renewable energy in the total energy mix by 2030, requiring an investment of approximately $2 billion over the next decade. Additionally, a carbon tax on the natural gas sector with earmarked revenues for renewable energy and energy-efficient projects can generate vital funds.

Georgia's sustainable hydrothermal and geothermal expansion can be achieved by offering tax breaks and feed-in tariffs to small- and medium-scale hydroelectric plants to encourage responsible development without damaging the ecosystem. A well-defined regulatory framework for geothermal exploration and exploitation needs to be established, emphasizing its minimal environmental impact. Furthermore, exploring the establishment of a carbon trading scheme can incentivize a reduction in greenhouse gas emissions. Kazakhstan's transition from coal to clean energy has relied on a robust regulatory framework. A key step is to implement a system of clean energy certificates for companies that invest in renewable energy, which can be traded to help meet emission targets. Introducing a levy on coal production to fund the decommissioning of coal plants and retraining coal workers is essential. Enacting Renewable Portfolio Standards (RPS), which require utilities to source a certain percentage of their energy from renewable sources, further promotes clean energy adoption. Similarly, to enhance hydropower and solar synergy in the Kyrgyz Republic, feed-in tariffs for solar energy should be established to encourage diversification away from hydropower reliance.

Creating a national investment fund that provides low-interest loans for renewable energy projects, particularly in remote regions, can stimulate the development of clean energy. In addition, modernizing energy regulations to facilitate the integration of distributed solar generation into the national grid is essential for grid reliability.

Mongolia's efforts to curb coal dependence require direct subsidies for solar and wind farm construction, particularly in the rural and nomadic communities. Establishing an emissions trading system to cap and reduce greenhouse gas emissions from coal plants is critical. Passing comprehensive renewable energy legislation that provides

a clean and stable legal environment for renewable investments promotes a shift away from coal. Similarly, Tajikistan's hydropower expansion and diversification efforts involve the development of policies that support excess hydropower exports and create new revenue streams for renewable energy expansion. The implementation of strict environmental guidelines for new hydropower projects ensures sustainability. Enacting laws that guarantee the prices of renewable energy fed into the grid, focusing on complementing hydropower with other renewable energy sources, is crucial. In addition to these countries, Turkmenistan and Uzbekistan should pass laws that provide tax credits and import duty exemptions for solar technology components to accelerate solar adoption. Evaluating and piloting carbon pricing mechanisms, such as a carbon tax or cap-and-trade system, focused on the natural gas sector incentivizes a shift towards cleaner energy sources. Introducing mandatory renewable energy targets for energy producers, with penalties for noncompliance, can promote renewable energy adoption.

High oil consumption emphasizes the integral role of crude oil and gasoline in Pakistan's economic activities. Reducing oil dependence could involve revising fuel subsidies, although this may be unpopular because of the population's reliance on motor vehicles. Electromobility and improved public transport offer alternative avenues for reducing gasoline demand. Regionally, the CAREC countries should collaborate on a comprehensive policy framework that aligns renewable energy targets and simplifies cross-border investments. The development of a regional carbon market to trade carbon credits can foster an economy-wide shift towards low-carbon technologies.

Establishing standardized regulations for renewable energy that all CAREC countries can adopt will streamline regional projects and investments.

The primary limitation of this study lies in its regional approach to the CAREC countries, which may not capture the nuances of local policies, regulatory changes, and distinct economic conditions specific to each country. Furthermore, the NARDL methodology utilized in this analysis may not fully account for abrupt and unforeseen external shocks, such as political turmoil or global financial crises, that could substantially influence energy prices and economic growth.

For future research directions, it is recommended to delve into the effects of international trade relationships and agreements on brown growth and the volatility of energy prices. Such research could provide deeper insights into the complexities of economic interdependencies. Additionally, exploring the socio-economic consequences of energy price fluctuations, particularly on diverse population strata within the CAREC countries, would contribute to a more holistic understanding of the region's economic resilience and sustainability.

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GREEN GROWTH TRIUMPHS OVER BROWN GROWTH DESPITE ENERGY PRICE VOLATILITY
CHAPTER 6
A Paradigm Shift in Sustainable Development

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CHAPTER 07

GEOECONOMIC IMPLICATIONS OF A SHIFT TO GREEN ENERGY CARRIERS AND THE ENERGY TRANSITION ON SUSTAINABLE DEVELOPMENT IN CAREC

Dimitris Symeonidis

7.1 INTRODUCTION*

7.1.1 Background

Climate change has been accelerating at an alarming pace, and its effects are evident worldwide, with Central Asia being among the most devastated regions. Glacier melt leads to flooding, while summer water shortages disproportionately impact local populations, exacerbating tensions between the extractive industry, agriculture, and citizens (Sorg et al., 2012). Furthermore, the low availability of water results in reduced hydropower, and combined with extreme cold during winters, inhibits gas production,

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which has resulted in massive power cuts over the past few years (Mideksa & Kalbakken, 2010).

As the energy sector is the primary driver of climate change, contributing to more than two-thirds of carbon emissions, energy transition is deemed the key pathway for mitigating the effects of climate change (Stephenson et al., 2021). However, as the world transitions to cleaner, more inclusive, and financially sustainable energy systems, the increasing need for renewable energy resources has resulted in far-reaching ramifications and transformative changes, underscoring the importance of geoeconomics and its strong correlation with global energy systems (Campos & Fernandes, 2017). In particular, the geoeconomic dimension of the transition to green energy carriers encompasses two main axes. First, the shift from geological dominance to geographical advantages.

This implies that while conventional fuels favored countries and regions endowed with underground riches, a transformation toward renewables benefits nations that can deploy extensive clean energy infrastructure, such as wind farms, solar parks, and other clean energy production units, which require vast land resources (Ioannidis & Koutsoyiannis, 2020). Proximity becomes crucial as transportation costs escalate with distance. Second, demand for energy-related commodities is anticipated to change, leading to an increase in the value of critical raw materials essential for the energy transition (Hache & Carcanague, 2022). Notably, Central Asian and Central Asia Regional Economic Cooperation (CAREC) states possess many of these critical raw materials, including platinum, neodymium, dysprosium, copper, iron ore, and cobalt, as identified in the IRENA report on the geoeconomics of critical raw materials (2023).

The aforesaid transition may alter the geoeconomic dynamics of a heavily politicized sector, such as energy, but does not eliminate the associated risks. Both existing and new risks were identified, which can be divided into the following seven categories (IRENA, 2023):

1) External market shocks: These can include natural disasters, pandemics, or unforeseen events that can create bottlenecks, increase renewable prices, and result in frustration and friction between the supplier and recipients.

2) Resource nationalism: This encompasses measures such as foreign investment screening, tax extortion, and other techniques used by resource- and land-rich countries to exclude foreign firms from their renewable energy sector.

3) Export restrictions: This is similar to resource nationalism and includes export bans and quotas that pose significant challenges in the renewables market.

4) Mineral cartels: This entails a coordinated distortion of the market by cartel-level price-setting, often associated with regionalism.

5) Political instability and social unrest: This can manifest as labor strikes or dissatisfaction among citizens regarding human rights and working conditions violations in mining sites, leading to unrest and destabilization at both national and regional levels.

6) Market manipulation: This is similar to mineral cartels, with the difference being that it may involve insider trading and spoofing.

7) Environmental issues: These range from the environmental degradation of mining sites, which can trigger unrest, as well as lack of resources, such as water, hindering the development of industries including hydrogen production.

7.1.2 Defining Geoeconomics and Why is it Important for the Energy Transition in CAREC?

Geoeconomics has received widespread interest over the past few decades, and various definitions have been provided. The most common is the study of the spatial, temporal, and political aspects of economies and resources (Sparke, 1998). It is currently used to explain a set of economic tools and levers used to advance the geopolitical agendas of different state actors. While conflating geopolitics with geoeconomics is common, the former belongs to the neorealism school of thought on international relations and solely explains how the political decision-making arena is formulated, while the latter utilizes systems thinking to assess how existing economic mechanisms create challenges and identifies alternative economic means to address them (Csurgai, 1998). International institutions have identified geoeconomic implications as key impediments to the energy transition. In the short term, geoeconomic fragmentation poses risks for energy transition for several reasons, which are relevant to the CAREC context (Gardes-Landolfini et al., 2023):

- Legislative constraints, such as the EU CBAM and the US Inflation Reduction Act have become increasingly popular globally. These measures, aimed at reducing carbon footprint and improving labor rights practices, add constraints to supply chains. Similar obstacles emerging in CAREC countries could impede the energy transition for various reasons, the most important of which is the renewable energy industry's high reliance on international supply chains.

- As mentioned above, renewable energy supply chains depend greatly on regional and international collaboration. The absence of such collaboration in critical mineral chains could further fragment CAREC's transition efforts, potentially increasing costs as states rely more on imports to sustain the energy transition.

- Subsidies in the energy transition sector, such as those for electric vehicles or industry support, can have spillover effects on neighboring countries. For instance, Chinese subsidies may dominate regional markets, leading to skepticism from local communities within CAREC.

- Policy diffusion poses another risk, as influential CAREC members disengaging from the energy transition through their economic policies could influence others to follow suit.

These risks underscore the urgent need for geoeconomic alignment among CAREC member states to facilitate an accelerated, sustainable, inclusive, and equitable energy transition for all citizens within the region.

7.1.3 Problem Statement

Reflecting on the two foregoing transformations and the necessity for proximate clean energy sources, Central Asia emerges as occupying a pivotal position in the geoeconomic landscape of the energy transition. Considering the first criterion, Kazakhstan, Turkmenistan, and Uzbekistan possess vast expanses of land, offering ample opportunities for the development of solar parks or wind farms tailored to the region's topography and geomorphological characteristics. Such developments could not only cater to the region's energy needs but also facilitate energy exports (Laldjebaev et al., 2021). Regarding the second criterion, Central Asia can be considered an emerging market for rare earth metals and other critical raw materials. Mongolia, Kazakhstan, and Tajikistan boast considerable copper deposits, positioning them as potential leaders in the copper industry, crucial for electrified infrastructure construction (Seck et al., 2020). Furthermore, Afghanistan reportedly harbors one of the world's largest iron ore deposits, essential for addressing rapid urbanization trends using clean energy sources (Zakirova & Ahmad, 2019).

In addition, geological analysis of rare earth elements (REE) in Central Asia has shown great potential for the extraction of dysprosium, yttrium, and other high-grade REE in Kazakhstan, Kyrgyz Republic, and Tajikistan (Mihalasky et al., 2018).

Considering these facts, most CAREC members are expected to face inherent geoeconomic challenges during the energy transition. Proper management of resources, characterized by a sound regulatory framework, an open market, and a stable political landscape, could position them as frontrunners in the energy transition (Scholten & Bosman, 2018). These elements are crucial for determining the geoeconomic winners in a stable and secure renewable energy supply chain, particularly given the financial challenges faced by several CAREC members. Conversely, a lack of solid geoeconomic strategy could risk exacerbating poor market structures and political instability, leading to regional destabilization and distortions in global energy markets (Malik, 2014). Such outcomes may result in the isolation of CAREC states, perceived more as liabilities than assets in global markets, exacerbating turbulence (Cifuentes-Faura, 2022).

7.1.4 Research Gap

Considering the aforementioned factors, a significant research gap is evident regarding the geoeconomics of the energy transition in Central Asia. Overall, the geoeconomic dimension of renewable energy has been extensively discussed worldwide. However, it has mostly focused on the democratization element of the energy transition, emphasizing decentralized energy production and diminishing the geoeconomic influence of multinational energy corporations (Pastukhova & Westphal, 2020). Other studies have presented several potential ways in which the renewable energy market may be distorted, such as resource nationalism regarding critical raw materials and electricity (Koch & Perreault, 2019). This has been observed at the global level and in regions such as Latin America and Southeast Asia. In addition, research on neocolonialism claims that clean energy business policies are being undertaken in regions such as Sub-Saharan Africa has been conducted (Dorn, 2022). Despite these efforts, a substantial research gap remains. Although possessing all the elements for the development of thriving renewable energy-related industries and active participation as a stakeholder in the geoeconomic decision-making arena, Central Asia has not been extensively studied for the geoeconomic challenges it may face and how to navigate them.

7.1.5 Research Question

Thus, this study sought to address the following question:

"What are the geoeconomics implications of a shift to green energy carriers and the energy transition on the security of energy supply for Central Asia?"

7.1.6 Value Added

This study holds significant value as it explores Central Asia's potential for sustainable development and green growth in the energy sector. However, without addressing geoeconomic pitfalls, the region faces a risk of destabilization or not fully realizing the benefits of this green transformation.

7.1.7 Relevance

This study is highly relevant to the promotion of sustainable development and green growth in the CAREC region. To accelerate sustainable development, three important elements are essential: green skills, renewable energy units, and locally sourced critical raw materials. All these require a strong legal and policy framework, a set of financial incentives, market enablers, and political stability. However, the presence of geoeconomic risks, if left unaddressed, could hinder progress. Therefore, mapping various geoeconomic risks and correlating them with the aforementioned elements

to formulate policies that can stimulate sustainable development while navigating geoeconomic challenges effectively is critical. This aligns with the conference's theme and objectives.

7.2 METHODOLOGY

7.2.1 Qualitative Methodology

Understanding the philosophical underpinnings, approaches, and strategies of each research endeavor is crucial for comprehending its direction. In this study, an inductive approach, which involves collecting data to draw conclusions, is employed. More specifically, data regarding how regional players in the CAREC region operate in both the renewables industry and its critical raw material industries, are gathered. Moreover, data collection encompasses the approaches of external players such as Russia, China, the EU, and the USA in CAREC. Based on this, conclusions on the geoeconomic trajectory of the region in the era of energy transition are drawn. Given that this study attempts to evaluate the geoeconomic challenges anticipated by CAREC countries as they transition toward a sustainable future, an inductive approach is deemed appropriate (Thomas, 2006). Furthermore, the philosophical stance followed in this study will predominantly be interpretive, as it involves the subjective perceptions of different state actors, which aligns with most studies related to international relations, geoeconomics, and power politics. The interpretivist approach is fitting as it seeks to map the different perceptions and interests of each state actor. Therefore, owing to bounded rationality and different national interests, numerous interpretations exist regarding how the energy transition should unfold and what type of strategies each state actor is expected to follow in critical raw materials and renewable energy technologies. This aligns more closely with an interpretivist approach (Scauso, 2020). Finally, grounded theory, which involves collecting data and organizing it into different concepts, categories, and themes, is employed as the methodological strategy. In the final stage, determining the relationships between these themes is attempted (Charmaz, 2012). This strategy is used because this study aims to understand how the behaviors of different CAREC states, as well as their relationships and interactions with external actors and international institutions, can affect the transition to green energy carriers in terms of geoeconomics.

By identifying themes in the behaviors of state actors and international institutions involved and establishing connections, behavioral patterns can be discerned, which can then be translated into driving mechanisms for the energy transition or sources of friction. Both these questions align well with grounded theory, which is considered a suitable approach for analyzing issues in conflict studies (Tucker, 2016).

Drawing from grounded theory, the overall behavior of each state actor involved in the CAREC is categorized into six patterns or themes, developed based on the key elements influencing the energy transition on a global scale. Globally, energy transition is shaped by the following four types of elements (Kamran et al., 2023):

- Environmental elements, such as the extent to which each nation or state actor is devastated by the adverse effects of climate change;

- Economic factors, including the fiscal and monetary status of each state actor, their capacity, and their economic development levels;

- Technological elements, in terms of the level of technological development of each country in the renewable energy sector and digital technologies;

- Societal factors, including societal acceptance, skilled workforce, unemployment, and education level.

Another classification of each country's energy transition policies is based on their proactive and reactive aspects. Some countries focus on climate mitigation measures and become proactive in finding innovative solutions for the future, while others are reactive and promote climate adaptation measures, or in terms of technology, prefer purchasing technologies that are already mainstream (Hashida & Lewis, 2019). Considering these key elements and applying them to the context of the CAREC region, the following themes emerge:

- Resource and energy nationalism (including export restrictions);

- Market manipulations by the private sector;

- Political instability;

- Environmental degradation; and

- Industrial policy development.

Concurrently, external shocks are explored as a theme to understand how the region is expected to respond to them. Considering these themes facilitates an understanding of state actors prone to the geoeconomic implications of the energy transition and how they can effectively address them.

7.2.2 Data Collection

The methods used in this study involved data collection and analysis. Data collection relied on secondary sources, while data we analyzed using qualitative methods instead of quantitative or mixed-method. Qualitative research involves the collection and analysis of non-numerical data, such as texts, videos, or audio, to identify patterns in opinions, concepts, or experiences. Thus, qualitative methodology is useful for cases in which a phenomenon cannot be measured (Aspers & Corte, 2019). The key characteristic of qualitative research is emphasizing cases rather than variables and focusing on meanings, perspectives, and understanding. Moreover, it centers on answering questions related to "why" and "how" a specific phenomenon occurs (Astin & Long, 2014).

The geoeconomic landscape of the energy transition in Central Asia and globally exemplifies the suitability of qualitative research. The geoeconomic implications of the energy transition are complex and depend on national and regional legislations and policies, fiscal, monetary, and regulatory, which are not yet fully in effect. Although renewable energy policies have been implemented to some extent, they have not yet been implemented in a manner that allows the formulation of an entire energy transition system. For example, they only include the deployment of solar, wind, and small hydropower, but not clean energy storage, decarbonization of heavy industry, mining, and extractives, or other sectors such as decentralized energy infrastructure. Future policies and legislation are expected to be passed based on the current state of affairs, existing policies, speculations, and recommendations found in texts, scientific journals, policy reports from think tanks, and articles. All these are materials of a qualitative nature; hence, data are solely qualitative in nature. Qualitative data collection is well-suited for studies on geoeconomics, international relations, and economics as it allows for a nuanced assessment of conflicts or relationships (Kibiswa, 2019). In this study, the meanings and intentions behind each political actor's behavior in the emerging energy transition in CAREC were studied, aligning with the principles of qualitative research.

Quantitative research was not considered either separately or in combination with qualitative research(i.e., a mixed-method approach). Quantitative research typically focuses on numerical data that remains unchanged, yielding objective insights into the "how much/many" of a particular phenomenon (Sukamolson, 2007). This was deemed unsuitable for this analysis because the numerical data relevant to the energy transition would not provide a clear picture of the future geoeconomic landscape of the region.

Data collection includes two types: primary and secondary data. This restudy relies on secondary data, which refers to existing information collected by others for purposes that are different from the current research (Gothe et al., 2021). Secondary data sources include scholarly literature, research databases, or other public resources, and can be journal articles, books, or any type of report (Clark, 2013). With advancements in research technology and the evolution of digital databases over the past decade, secondary data have gained increasing importance in qualitative research and are now considered integral for performing qualitative analysis (Johnston, 2014).

This is in contrast to primary data, defined as data gathered firsthand by researchers through methods such as surveys, questionnaires, interviews, observations, and experiments (Baleiro, 2011). In this study, primary data collection was not pursued because of the scarcity of existing research on the geoeconomic implications of the transition to clean energy, sustainable development, and critical raw materials market in CAREC. In such cases, secondary data research in the form of a literature review and analysis/assessment of this review is highly recommended, before collecting primary data (Hox & Boeije, 2005). Additionally, primary data collection often requires substantial resources and expertise, which were not available for this study (Cheng & Phillips, 2014).

In this study, the main secondary data sources used were scientific journals and books, as well as reports from non-government organizations and international institutions. Data were accessed using digital databases and only valid sources of information, such as NDCs, policy and regulatory reports, and national legislations of all CAREC members (Bocanegra-Valle, 2017). The assessment of articles and their credibility was based on a screening process to determine whether the aforementioned legislations, regulations, or policies stemmed from valid resources such as governmental websites, reputable think tanks, and high-quality consultancies (Cope, 2014). Finally, the reports of international institutions, also underwent a screening process to ensure credibility—only those originating from globally renowned organizations and institutions were chosen, such as IRENA, the EU, the UN, and the CAREC Institute (Chiba et al., 2018).

7.2.3 Methodological Limitations/Caveats

While conducting this study, certain limitations were encountered. First, the absence of primary data, an essential component in most research fields, especially in social sciences, poses a significant constraint. While primary data collection typically offers valuable insights that contribute to knowledge generation, constraints such as time limitations rendered conducting interviews, surveys and questionnaires impractical. Additionally, the preference for secondary data analysis before primary data collection presented a paradoxical situation, as the research gap itself—lack of prior research on the geoeconomic implications of the energy transition in CAREC—can be considered a methodological limitation.

Moreover, the ongoing debate surrounding the energy transition adds complexity to the analysis. The lack of a clear winner in the energy transition, coupled with ongoing discussions about the viability of various clean energy technologies including nuclear energy, hydrogen, and emerging technologies such as geothermal and tidal power, introduces uncertainty into the study. All the aforementioned means of clean power do not necessarily need land, with some of them requiring the power of the sea, available only to CAREC members with access to the Caspian Sea and Pakistan. These pieces of data would result in a whole new framework if taken into consideration. However, These factors require a much broader analysis and access to extensive data, which was beyond the scope of this study.

Finally, language barriers are ubiquitous and create several limitations. While the CAREC region comprises divergent cultures, it is also a mural of different but equally beautiful languages, presenting challenges in accessing resources published solely in national

languages. While the researcher was fluent in English and Russian and could access reports in these languages, national reports, articles, and other resources published solely in the national languages could not be accessed or harnessed for this study. This limitation, particularly concerning regulatory and legal frameworks (which are not all translated into Russian), crucial for understanding the investment environments in critical raw materials and renewables, hindered a comprehensive assessment of the region.

7.3 FINDINGS

7.3.1 Kyrgyz Republic

The Kyrgyz Republic introduced a law and strategy for renewable energy in 2008 but only came into effect in 2019. While comprehensive in setting regulations and creating an investment-friendly environment, as well as incentivizing the uptake of renewables within the country (Mehta et al., 2022), it lacks provisions for reskilling and upskilling workers in the energy sector to support clean energy projects (Safronchuk, 2020). This results in foreign companies bringing their own experts and technicians, creating frustration and social and political instability (Toktomushev, 2021).

Moreover, the outdated nature of the law means that it does not align with the mining laws and regulations of the country, which also require revision to accommodate the progress of the energy transition. The mining laws are also not aligned with the country's industrial policy, making the development of a national renewable technology industry a highly challenging task (Sternberg, 2020). The primary issue, considering only the mining law, concerns environmental regulations. Environmental regulations, particularly, the environmental and socioeconomic impact assessment requirements, are not clear (Tiainen et al., 2014), leading to poor mining practices and potential environmental degradation, exacerbating local community tensions and posing risks of regional destabilization, a major geoeconomic stressor.

7.3.2 Afghanistan

Afghanistan faces numerous geoeconomic risks in the energy transition, primarily driven by political instability following the Taliban regime’s takeover This upheaval has created an unfriendly environment for investment, exacerbated by the nationalization of industries, including energy and mining sectors. Despite a renewable energy strategy laid out in 2015, which planned for grid unbundling and openness to investment in the energy sector (Fahimi & Upham, 2018), all industries have been nationalized since the Taliban regime's ascent to power. This has brought resource nationalism into the agenda as, apart from the energy sector, the mining sector has also been nationalized (Afzal, 2022). Furthermore, the lack of alignment between industrial policy and renewable energy goals, coupled with underutilized iron and copper deposits, impedes the country's ability to develop its renewable energy sector.

One of the successes of the existing policies has been the rollout of solar photovoltaic units in rural areas, helping scale renewable decentralized solutions, although the lack of coordination hampers broader adoption(Jahangiri et al., 2019). Despite the potential for iron and copper deposits to support industrial policy for electricity infrastructure (Hale & Ali, 2023), the prevailing humanitarian crisis and adverse investment climate pose significant barriers. The only positive trait is the absence of environmental degradation specifically related to the energy sector, with agricultural activities bearing the brunt of environmental impact in Afghanistan.

7.3.3 Pakistan

Pakistan is currently facing a predicament that presents conflicting signals regarding its robustness and resilience to potential geoeconomic ramifications arising from the energy transition. Before the political conundrum following the army crackdown in Islamabad, Pakistan’s national laws and regulations were on a promising trajectory toward establishing a resilient national renewable energy system and potentially formulating an industrial policy around it. The NDC of Pakistan outlined clear goals for increasing renewable energy adoption and electromobility, supported by incentives such as feed-in tariffs to its prosumers (Zafar et al., 2018). In addition, business and investment laws facilitated foreign firms’ incorporation and exploration of critical raw materials, resembling the oil and gas exploration laws in the Gulf States. However, provincial-level taxation regulations increased complexity and created market-related barriers, consequently increasing geoeconomic risks for Pakistan (Lodhi, 2017). Amid this uncertainty, political instability has been exacerbated by the tumultuous events following the military crackdown. This instability adds another layer of geoeconomic risk, as social and political unrest could have far-reaching consequences, potentially surpassing those experienced in neighboring Afghanistan.

7.3.4 Kazakhstan

Kazakhstan stands out among the CAREC states for its relatively clear regulatory framework concerning renewable energy. It has set specific targets for renewable energy adoption, aiming for 15% by 2030 and 50% by 2050, supported by clear subsidizing policies (Guliyev, 2023). Moreover, it has been the first country in the region to develop a green hydrogen policy. However, the green skills training component is absent even in the case of Kazakhstan. It is also the only country with an industrial policy that considers the valorization of copper and iron ore for energy transition purposes, such as manufacturing cables and transmission lines (Bozhko, 2017). However, the industrial policy remains relatively unclear and tends to favor statism, as evidenced by the emphasis on protective measures to safeguard the national production sector from "external threats" (Nem Singh, 2023). While the risk of social unrest in Kazakhstan is considerably low, it cannot be disregarded entirely. The nationwide protests in 2020, sparked by soaring fuel prices, underscore the potential for energy-related issues to incite public discontent and unrest, as demonstrated by the protests that originated in the city of Mangystau.

7.3.5 Mongolia

Mongolia has also developed a comprehensive renewable energy plan, with a clear regulatory framework and targets that include a 22.7% reduction in greenhouse gas emissions (Myangmarsuren, 2020). The national government also has developed an enabling investment framework for national and international investors for renewable energy projects, such as wind and solar energy. However, the mining sector presents a contrasting environment. In 2019, the country introduced a mining law allowing the state to claim 50% ownership of any mining company operating within its jurisdiction, indicating a statist approach, which may deter investments in the sector (Lander, 2019). On the industrial policy front, Mongolia has set ambitious targets, pledging to develop its own green energy industry and recognizing skills as its critical component, paving the way for green skills programs (Miller, 2019). Additionally, relative political stability provides a conducive environment for investment and helps mitigate geoeconomic risks, particularly when accompanied by supportive investment policies.

7.3.6 Tajikistan

Tajikistan faces geoeconomic risks similar to Kyrgyz Republic. Despite already having a high proportion of renewable energy in its mix, predominantly from hydro sources, which account for 90% of the electricity generated, Tajikistan aims to diversify by incentivizing investments in solar and wind (Akkermans et al., 2023). The primary challenge is the lack of financing tools because of limited state financial liquidity

and reluctance to open and unbundle the energy market. As with other CAREC nations, Tajikistan's mining regulations are not aligned with its renewable energy policy. Although it has a mining law that allows foreign investments, in practice, it has witnessed minimal engagement from foreign investors, primarily Chinese firms operating in Tajik mines (van der Kley, 2020). In addition, environmental regulations regarding mining are either non-existent or very challenging for foreign investors to navigate, leading to a surge in environmental pollution, particularly air pollution (Aleinikova et al., 2021). This has resulted in unrest at mining sites on numerous occasions, thereby posing a political instability risk. Moreover, the mining landscape exhibits characteristics of a mineral cartel, adding market-related geoeconomic risks (van der Kley, 2020).

7.3.7 Turkmenistan

Turkmenistan presents a unique case within CAREC, with the lowest probability of experiencing political instability or social unrest, as evidenced by its track record. Consequently, it offers an investment environment that can be considered safe. However, the country lacks specific targets for the renewable energy sector and has no provision for developing an industrial policy and green skills based on renewable energy. The energy sector, apart from being state-owned, is heavily subsidized (Ioannis, 2022). In terms of mining laws and regulations, notable is the absence of consideration for resources beyond hydrocarbons, indicating a current lack of interest in diversifying investments. Nevertheless, the lack of frameworks and interaction with the renewable energy sector does not constitute a geoeconomic risk by itself (Horak, 2023).

7.3.8 Uzbekistan

Uzbekistan, together with Kazakhstan, is among the most progressive countries in CAREC in terms of renewable energy adoption. It has already set a clear renewable energy policy of developing 7GW of solar and 5GW of wind power (Allaev et al., 2023).

However, unlike Kazakhstan, it has yet to implement a hydrogen strategy. Despite being mainly invested in by Masdar, Uzbekistan is offering financial and regulatory incentives and actively coordinating with international institutions such as the European Bank for Reconstruction and Development, demonstrating a willingness for openness (Lazizakhon, 2023). Correspondingly, the mining law in Uzbekistan is conducive to investments and fosters a friendly environment for their deployment. Nonetheless, the lack of sufficient environmental regulations has led to instances of environmental degradation and has caused frustration among local citizens. In addition, Uzbekistan has not aligned its mineral law and policy with either its industrial or renewable energy policies (Rustambekov, 2022). Finally, Uzbekistan stands out in CAREC as the only country whose Ministry of Labor has developed a clear plan for training skills in the green and digital economy, collaborating with international institutions such as the World Bank on this initiative.

7.3.9 China

China also stands out as a unique case within CAREC because of its distinct approach to the energy transition, influenced by both internal and external factors. Internally, China's substantial energy demand has driven the development of its capacity to mine and refine the majority of critical raw materials, supported by abundant resources and industrial policies (Zhang et al., 2017). Furthermore, its mining policy is closely linked to its industrial policy, as China is a major manufacturer of solar and wind power producing units. Ambitious targets have been set, aiming for 1200GW of solar and wind power by 2030, with projections suggesting these targets may be reached even 5 years ahead of schedule (Lin et al., 2023). Political stability is also deemed to be the highest among all CAREC members. Regarding external factors, China's policy is driven by its motivation to become the innovation leader in the renewable energy sector and a key player in global markets, offering high-quality products at competitive prices, as well as critical minerals and metals (Andrews-Speed & Zhang, 2019). With a stable political environment, China is expected to maintain and potentially expand its dominance in

the global green energy market. However, external factors such as resource nationalism pose a potential geoeconomic risk, as all mining and renewable energy companies in China are state-owned, which could increase the risk of disruption among global supply chains (Yang et al., 2022).

7.3.10 Azerbaijan

Azerbaijan's policy approach differs somewhat from that of the other CAREC states because of its geographical location and unique circumstances. Despite being a significant player in the oil and gas industry, Azerbaijan has set ambitious renewable energy targets, aiming for a 30% penetration of renewables by 2030 (Mustafayev, 2022). Moreover, its engagement with the EU under the neighborhood policy framework has facilitated collaboration with Brussels on green skills development, promising inclusive sustainable development opportunities. However, the outreach to local communities offers room for improvement (Kakachia et al., 2022). The main challenge facing Azerbaijan is its geopolitical tensions with both Yerevan and Tehran, which contribute to an unstable landscape and pose a significant geoeconomic risk. Nonetheless, Azerbaijan offers favorable investment laws in both mining and renewable energy sectors, providing opportunities for foreign investors without the threat of nationalization (Aydin, 2019).

The aforementioned analysis can be succinctly presented in Table 7.1, which outlines the risks related to the energy transition for all CAREC member states. To gauge the risk concerning each set of policies for every country, the presence and implementation status of relevant strategies were assessed. Specifically, if a strategy was absent, the country was classified as high risk in that area. For example, if a strategy on green skills is absent, the country under study is considered to be at high risk concerning green skills. If a strategy exists but has not been implemented in the form of legislation or financial support, the country is deemed to have medium risk. Finally, if a strategy has already been deployed and materialized, low risk is attributed.

Table 7.1: Assessment of risks for all CAREC member states in sectors relevant to the energy transition. Color significance: Green—Low risk; Yellow—Medium risk; Red-High risk

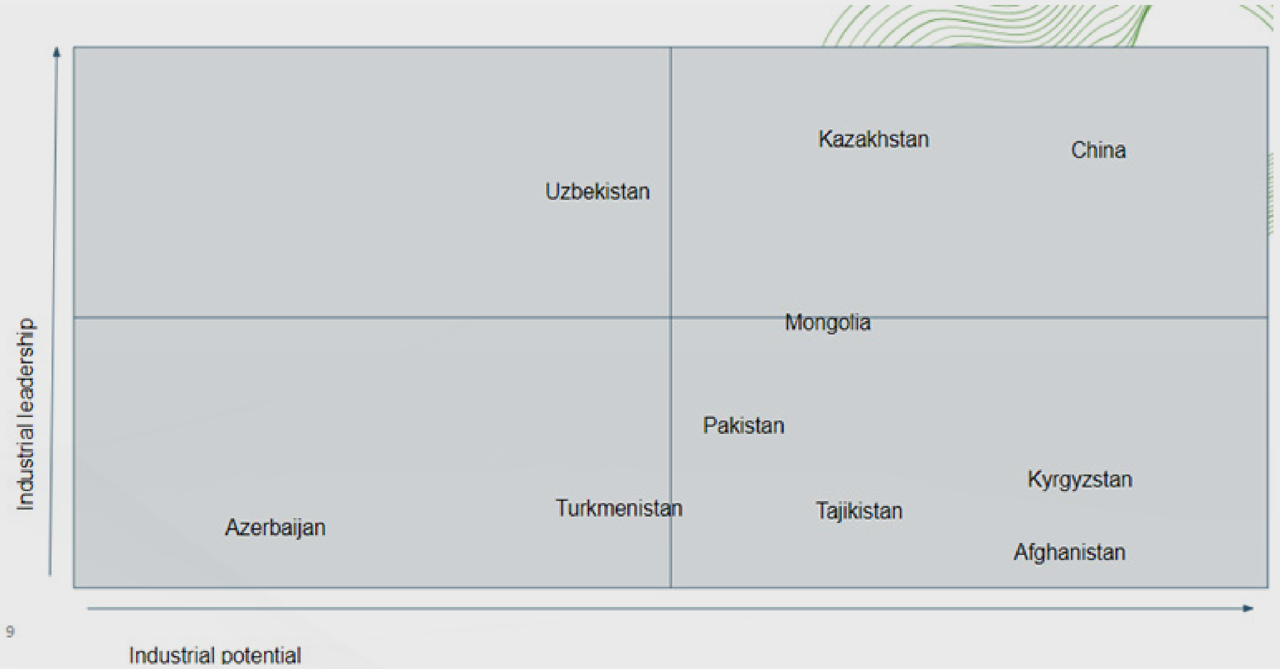
	Skills	Industrial	Mining	Renewable Energy	Environment	Political Stability
Afghanistan	Yellow	Red	Red	Red	Green	Red
Azerbaijan	Red	Yellow	Green	Green	Yellow	Yellow
China	Green	Green	Green	Green	Yellow	Green
Kazakhstan	Yellow	Red	Green	Green	Yellow	Yellow
Kyrgyzstan	Red	Green	Yellow	Green	Red	Yellow
Mongolia	Yellow	Green	Red	Yellow	Red	Green
Pakistan	Red	Yellow	Yellow	Green	Yellow	Red
Tajikistan	Red	Red	Yellow	Green	Red	Yellow
Turkmenistan	Red	Yellow	Red	Yellow	Yellow	Green
Uzbekistan	Green	Green	Yellow	Green	Red	Yellow

7.4 CONCLUSIONS

Based on the major stressors identified to increase the geoeconomic risks of the energy transition, and the policies being implemented by CAREC member states, several conclusions can be drawn.

A notable trend observed is the lack of connection between mining policies and industrial and renewable energy strategies. Figure 7.1 presents an overview of the industrial policy landscape. Apart from China, and partly Kazakhstan, none of the CAREC members have begun valorizing critical raw materials or establishing refining facilities for such minerals. The reasons for this vary. Some countries (Kyrgyz Republic, Tajikistan) do not have the financial capacity to develop such an industrial policy, while others (Turkmenistan) have yet to establish clear renewable energy targets, or have revised them due to political instability (Afghanistan, Pakistan). Figure 7.1 further illustrates this, depicting that countries with a high percentage of youth and unemployment possess significant industrial potential, while industrial leadership is underpinned by existing industrial policy initiatives, legislation, regulations, and financial support.

Figure 7.1: Industrial policy landscape in CAREC member states



Another virtually ubiquitous element, corresponding to the previous trend, is the lack of green skills training. Figure 7.2 provides an overview of the green skills landscape. This aspect could be considered complementary to the previous one, as skilled personnel are essential for industries developed through robust industrial policies. As noted earlier, the lack of green skills training poses an even higher geoeconomic risk for Central Asia and several CAREC states. Some of them (Tajikistan and Kyrgyz Republic) rely on remittances from workers in Russia, which has been disrupted due to the conflict in Ukraine. These workers, primarily in blue-collar occupations and already earning low incomes, contribute to a heightened risk of social unrest and political instability. Addressing this issue through low-cost reforms would be particularly suitable for these countries. By contrast, other countries (Afghanistan and Pakistan) have not yet developed these policies. Political instability has resulted in mass emigration, posing a challenge in engaging young people in green skills training initiatives.

Developing an effective policy for green skills is considerably more difficult for these nations. These challenges are all also illustrated in Figure 7.2. Similar to the industrial policy landscape, green skills potential is bolstered by the presence of a strong youth workforce, whereas green skills leadership indicates countries that have already developed and implemented initiatives and policies in this area.

Figure 7.2: Green skills landscape for all CAREC member states

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Environmental regulations and their relationship with social unrest, and thus, political instability, are also major issues that should be analyzed separately in the context of geoeconomics. In most CAREC countries, gaps have been noted in the environmental regulations of mining activities as well as in their environmental and socioeconomic impact assessments. However, not all cases can be linked to political instability. This has only been the case for Kazakhstan, Kyrgyz Republic, and Uzbekistan, whereas Afghanistan and Pakistan have not faced destabilization due to environmental regulations.

Similar to other regional blocs, such as the EU, the CAREC region is also characterized by dissimilar security perceptions and priorities of its member states, leading to the development of two clusters of countries. The first supports the development of the renewable energy industry and views it as an opportunity to further progress its industrial policy agenda, increase its energy independence, and lower import dependence. The second group focuses on reliable supplies and perceives renewables as a risky and volatile market, resorting to traditional fossil fuel imports and electricity from fossil fuels.

Finally, a sector in which a diverse set of behavioral patterns is observed is the tax and market regulation system. In most CAREC countries, the market, both in the mining and renewable energy sectors, is challenging to penetrate. While Kazakhstan experiences fewer challenges in market penetration, most others face difficulties. In countries where the market and tax system seem to malfunction, reasons vary. For example, in Pakistan, differences in business law between provinces contribute to the challenges. Meanwhile, in Uzbekistan and Tajikistan, despite mining and energy legislations fostering market openness, carteling behaviors are the norm.

7.5 POLICY RECOMMENDATIONS

Based on the aforementioned analysis and conclusions, the following policy recommendations aim to reduce the geoeconomic risks of Central Asia's renewable energy deployment:

- Develop rare earth exploration: Focus on exploring rare earth and other critical raw materials, especially in resource-rich countries, such as Kazakhstan, Turkmenistan, and Kyrgyz Republic. Collaborate with experienced countries such as China to share best practices.

- Strengthen environmental regulations: Improve mining regulations and link them to renewable energy policies. This should be developed in two parts. First, establish clear requirements for environmental and socioeconomic impact assessments, with specific indicators that need to be achieved by the operating company, and ensure inclusive practices. Second, develop a regional renewable energy credit market, which would function as a financial incentive for companies to operate in a green manner or to invest in sustainable energy projects in CAREC. These credits could either be modeled by the voluntary carbon credit market or be formulated in a revolutionary manner to include the introduction of cryptocurrencies as an incentive.

- Simplify tax and market entry: Streamline tax and market regulations to attract investment. The renewable energy landscape is characterized by pluralism, and unless embraced by all CAREC states, it can result in serious geoeconomics stressors. For countries such as Pakistan, harmonize all regional policies regarding renewable energy and mining, while for Mongolia, remove the clause regarding 50% ownership by the state. Finally, Turkmenistan should embrace public-private partnerships in the extraction and valorization of critical raw materials.

- Establish a CAREC fund: Create a fund for industrial policy development and/or green skills training across CAREC. One key issue that poses challenges for sustainable development in many CAREC states is access to finance. This fund could be modeled after the EU's just transition mechanism, where states with skilled personnel and industrial policy (e.g., China, Kazakhstan) can assist other members. This can be in the form of either funding or sharing best practices and training support. In these efforts, the role of educational institutes such as the Confucius Institute can be of great value, as they can provide the space for vocational training to reskill and upskill the local population.

- Liberalize energy markets: Unbundle grid operators and electricity and energy companies and promote competition for cheaper and innovative solutions. Liberalization of the market can have positive effects, especially for countries that face serious economic problems. They can increase the cash flows from taxation, and by increasing competition, provide cheaper electricity and innovative solutions. Successful practices from countries such as Kyrgyz Republic and Tajikistan should be followed. This can alleviate societal stress, not only reducing the risk of social unrest but also creating favorable market conditions, thereby reducing geoeconomic risks even further.

- Promote integration and mediation: Encourage unity among countries with differing perceptions on renewable energy within CAREC, so that solutions on green energy can emerge with long-term political stability. Advocate for a regional policy for a just, inclusive, and long-term energy transition, led by a leading nation such as China or any neutral external country.

- Support local civil society: Empower civil society actors to provide green skills training and environmental/climate education to increase transparency among the local communities regarding the government's renewable energy policies. The latter, especially, has a strong potential to increase the level of trust between the government and the local communities, particularly near mining sites.

Laws and policies play a crucial role in facilitating a rapid, seamless, inclusive, and sustainable energy transition. However, geoeconomic fragmentation can impede this process. Therefore, aligning legislative and policy frameworks, as suggested in the policy recommendations and articulated in the explanation of the geoeconomics definitions, is vital. This alignment can promote regional integration toward sustainable development, ultimately fostering long-term regional stability and peace, a fundamental objective for CAREC.

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CHAPTER 08

HOW DO GSCM PRACTICES AFFECT SUSTAINABLE ORGANIZATIONAL PERFORMANCE

Circular Economy Practices in Selected CAREC Economies

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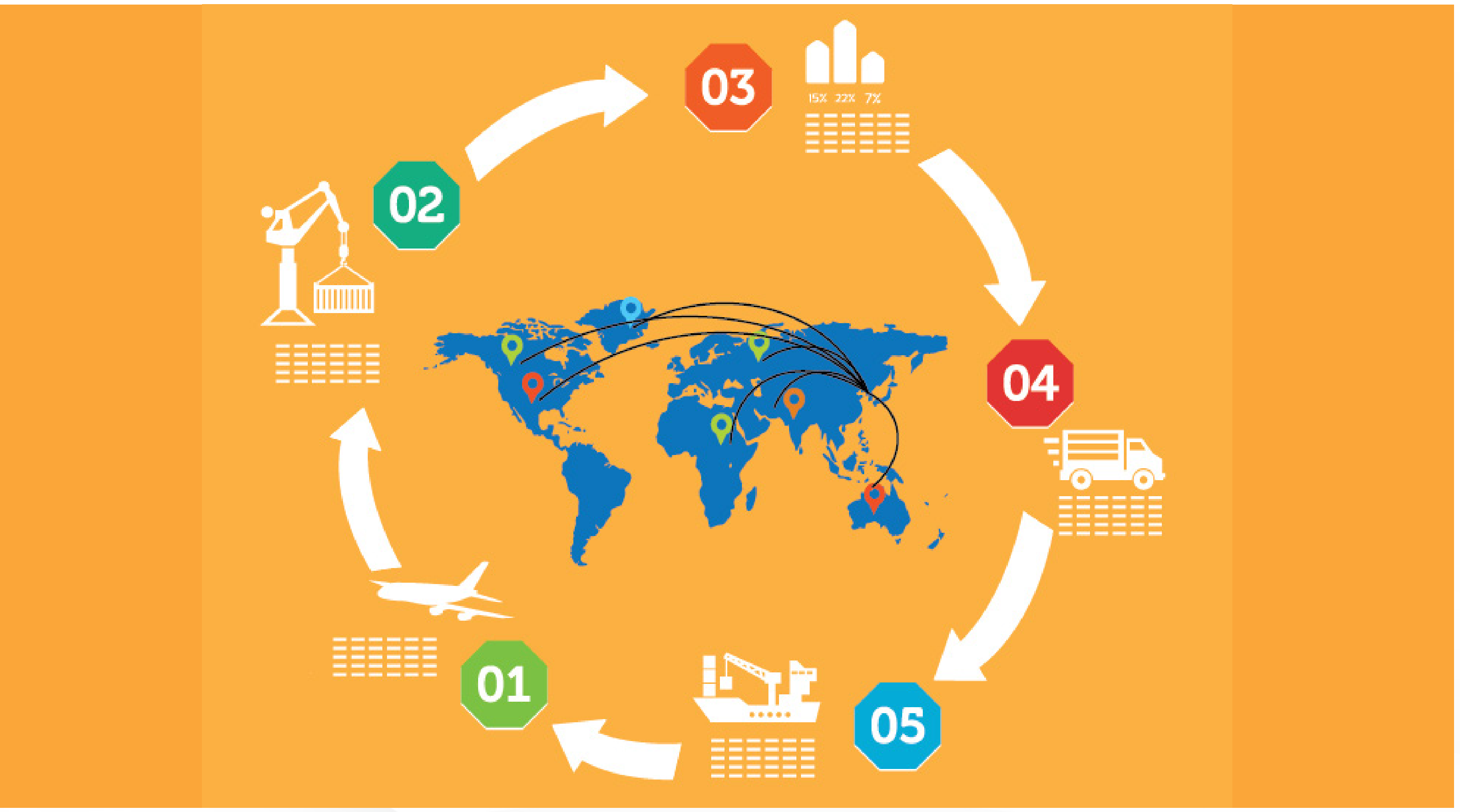
8.1 INTRODUCTION



In recent years, sustainability has become increasingly well-known across various global enterprises (Del Giudice et al., 2020). Organizations are becoming cognizant of the importance of incorporating sustainable practices into their daily operations to reduce adverse effects on the environment and promote long-term resilience (Rahman et al., 2023). The significance of sustainability and prudent resource management has become increasingly apparent in the face of rising global environmental issues (Bai & Sarkis, 2018). Currently, businesses in all sectors must adopt environmentally friendly procedures to solve ecological problems and improve their performance and

competitiveness. Organizations worldwide are under growing pressure to integrate sustainability as a key component of their operations when environmental issues and resource constraints become more critical (Shahzad et al., 2022). Green supply chain management (GSCM) is a strategic policy that incorporates ecological concerns into conventional supply chain procedures. Organizations may reduce their environmental impact, maximize resource use, and enhance performance by implementing green and sustainable practices across the supply chain (Del Giudice et al., 2020). By aligning GSCM practices with sustainability goals, a sustainable supply chain offers a pathway for organizations to reduce their environmental footprint, optimize resource usage, and bolster overall performance (Qu et al., 2022; Rahman et al., 2023).

According to Bové and Swartz (2016), global supply chains are responsible for over 80% of enterprises' greenhouse gas emissions and 90% of their total detrimental environmental effects (water, air, land, biodiversity, and geological resources). Similarly, 50% of resources worth USD 475 billion worldwide are reusable (Rahman et al., 2023). These factors put businesses under enormous pressure to decrease emissions, hazardous contamination, and chemical spills by implementing eco-friendly practices, particularly in supply chain operations (Rogetzer et al., 2018). Further, GSCM practices help companies do this by enhancing their sustainable (social, environmental, and economic) performance in all their downstream and upstream supply chain operations, from purchasing raw materials to disposing of products (Rehman et al., 2023; Shahzad et al., 2019).

Moreover, GSCM practices encourage businesses to buy and employ environmentally efficient transportation, friendly materials, and cleaner energy in all stages of the product life cycle (Antwi et al., 2022; Sun et al., 2022). Additionally, GSCM practices attempt to mitigate the detrimental effects of business operations on society and the environment by reducing resource waste, emissions, consumption, and pollution; this benefits overall sustainable performance. Interface Inc., a global manufacturer of commercial flooring, launched a project known as Mission Zero in 1994 (UNCC, 2022).

It pays attention to lowering its carbon footprint by 74%, converting 75% of its energy consumption to renewable sources, using 100% renewable electricity, and expanding its use of recycled or bio-based materials to 60% in 2019.

The pursuit of sustainability and responsible resource management goes beyond GSCM, highlighting the need for a comprehensive and regenerative strategy (Del Giudice et al., 2020). The concept of circular economic practices (CEPs) has recently received considerable attention. CEPs seek to establish a closed-loop system that maximizes resource consumption and reduces waste output (Ripanti & Tjahjono, 2019). CEPs are based on waste reduction, resource efficiency, and the extension of a product's life (Chowdhury et al., 2022); they have enormous potential to enhance the effects of GSCM techniques on sustainable organizational performance (SOP) (Shahzad et al., 2019; Sun et al., 2022). Additional focus is being placed on CEPs, which enable the reduction of resource utilization and waste generation to achieve sustainable development (Gupta et al., 2019). This necessitates the fusion of economic activity and environmental well-being (Jabbour et al., 2019) as well as the fusion of new business models that result in improved environmental, social, and financial performance (Del Giudice et al., 2020; Ripanti & Tjahjono, 2019). However, circular economy (CE) and supply chain management techniques are closely related because they are built on the efficient management of business processes.

Firms have traditionally concentrated on vertically integrated structures in their supply chains to achieve sustainability (Chowdhury et al., 2022). By contrast, from a CE perspective, businesses are creating sustainable, cross-industry networks that enable the creation of integrated supply chains that utilize resources per the 3R strategy: recycling, reduction, and reuse (Tseng et al., 2018, 2019). Although prior research has advocated for combining supply chain management and the CE, empirical studies are still lacking. Recent academic literature has also emphasized incorporating CE concepts into SOP; however, Geissdoerfer et al. (2018) found that the circular supply chain is still a relatively unexplored field of study.

Furthermore, the economies of member states of the CAREC Institute represent a diversified, vibrant area with specific problems and possibilities amid the growing understanding of the critical need for sustainability (Asian Development Bank [ADB], 2022). The CAREC region, which includes Central Asian nations and their surrounding territories, covers a vast area; it is distinguished by different topographies, abundant natural resources, and levels of economic development. CAREC has grown to 11 members and now covers diverse topics such as agriculture, education, health, water, tourism, gender, and information and communications technology / digital technology.

By December 2021, member governments and development partners invested USD 41 billion in infrastructure, capacity building, and policy reforms. Although this variety of initiatives offers unique opportunities for sustainable development, it also presents a challenging environment for successfully integrating and implementing GSCM. The use of renewable energy in CAREC countries rose from 1% to 6% (ADB, 2022). Table 8.1 shows countrywide gross domestic product (GDP) growth as a percentage of CAREC members from 2017 to 2022 (ADB, 2022).

Table 8.1: GDP Contribution of CAREC Members (2017-2022)

Country	2017	2018	2019	2020	2021	2022
Afghanistan	2.7	1.2	3.9	-1.9	3.0	4.0
Azerbaijan	0.2	1.5	2.5	-4.3	2.2	2.5
People's Republic of China	6.9	6.7	6.0	2.3	8.1	5.5
Georgia	4.8	4.8	5.0	-6.2	8.5	6.5
Kazakhstan	4.1	4.1	4.5	-2.6	3.4	3.7
Kyrgyz Republic	4.7	3.8	4.6	-8.6	3.5	5.0
Mongolia	5.3	7.2	5.2	-5.3	4.6	6.0
Pakistan	5.2	5.5	2.1	-0.5	3.9	4.0
Tajikistan	7.1	7.3	7.5	4.5	5.0	5.5
Turkmenistan	6.5	6.2	6.3	1.6	4.8	4.9
Uzbekistan	4.5	5.4	5.8	1.6	5.0	5.5
Middle East and Central Asia			1.4	-2.6	4.0	3.7
Emerging markets and developing economies			3.7	-2.1	6.3	5.2
Low-income developing countries			5.3	0.2	3.9	5.5
Global			2.8	-3.2	6.0	4.9

Source report: CAREC 2030 Development Effectiveness Review by the ADB (2017-2020)

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Although the CAREC Institute provides financial and other types of assistance to member countries in diverse sectors such as energy, transport, and trade, policymakers, companies, and stakeholders, they must comprehend the complex link between GSCM practices and sustainable organizational performance in the context of CAREC economies. The efficiency of GSCM techniques in these economies and their impact on SOP may significantly influence sustainable social, economic, and environmental development (Rahman et al., 2023; Shahzad et al., 2019).

Despite their significance, to date, no empirical study has examined the effects of GSCM practices and CEPs on SOP. Earlier studies have only partially addressed this topic. Rahman et al. (2023) highlighted that GSCM practices significantly impact sustainable performance in Pakistani manufacturing firms. Sun et al. (2022) indicated that supply chain visibility significantly affects sustainable performance in China. Del Giudice et al.

(2020) underscored that CEPs significantly affect firm performance in the CE of Italian firms. Similarly, Jinru et al. (2021) found that sustainable logistics positively influences CEPs in Chinese manufacturing firms. Furthermore, Antwi et al. (2022) revealed that GSCM practices strongly impact SOP, including economic, environmental, and social performance in mining firms in Ghana.

However, GSCM practices are still in their infancy, with a combination of CEPs and SOP in developing countries in the CAREC region. Hence, an in-depth study on applying CEPs supported by GSCM methods is urgently needed to ensure SOP. Therefore, this study focuses on how GSCM practices and CEPs affect SOP, and the mediating role that CEPs play in these connections shed light on sustainable development. Using an all-encompassing model that incorporates the following research topics, this study seeks to clarify these interactions.

- Do GSCM practices improve CEPs and further enhance SOP?
- How do CEPs mediate the relationship between GSCM practices and SOP?

Exploring these research questions contributes to the literature in several ways. The proposed theoretical model examines how GSCM practices directly affect CEPs and SOP. The mediation of CEPs between GSCM practices and SOP was also evaluated using a novel structural equation modeling (SEM) approach. Second, this study clarifies a crucial CEP notion raised by SOP but which is currently understudied in this context. To improve SOP over time, this study may also assist managers and policymakers in implementing CEP measures backed by GSCM practices in organizational processes. This study has various implications for the selected CAREC countries. A review of relevant literature is presented below. A description of the methodology, findings, and conclusions follows. Finally, the paper presents recommendations for future research.

8.2 REVIEW OF LITERATURE AND HYPOTHESES DEVELOPMENT

8.2.1 Theoretical Foundation: (Stakeholder Theory and Resource-based View)

Stakeholder theory highlights the relevance of every group or individual agent that can impact or be impacted by pursuing an enterprise's goals. Groups or individual agents might influence the company's goals or put more pressure on the company to minimize harmful effects and increase favorable ones through business management procedures. According to Freeman (1984), stakeholders that can generate organizational change can be internal actors who have relatively more comfortable relationships with the enterprise; external relations may be characterized by uncertainty and discomfort. Stakeholder theory has been frequently used in many studies (Bouzon et al., 2018; Sarkis et al., 2011; Waheed & Zhang, 2020) to explain how internal and external impediments may affect GSCM implementation (Rahman et al., 2023; Walker et al., 2008). The importance of stakeholder theory is demonstrated by the fact that

stakeholders' aims might not coincide with those of the business as it pursues its GSCM strategy. Barriers to GSCM and the adoption of associated practices may be recognized from the perspective of the roles and functions of different supply chain stakeholders; this is implicitly taken from stakeholder theory, the prevailing theoretical framework.

Stakeholder theory cannot fully explain the competitiveness of enterprises with different degrees of organizational capacity. Hence, stakeholder theory is considered beneficial in the theoretical framework as a complementary approach.

Furthermore, this study employs RBV theory to examine resource allocation concerning internal organizational aspects while considering external and internal factors.

According to its resources and capacity, a business can gain a competitive edge by organizing itself based on the RBV (Barney et al., 2001; Wernerfelt, 1995). After a period where many studies concentrated almost entirely on industry factors of enterprise performance, the RBV was first established in strategic management to comprehend organizational internal strengths and weaknesses and their association with performance and competitiveness (Barrutia & Echebarria, 2015). According to proponents of RBV, an enterprise's competitive position is determined by its overall resource allocation rather than its use of a specific product (Savino & Shafiq, 2018; Sun et al., 2022). These resources (which the company may own, control, or have access to) may take the shape of tangible assets, such as physical properties; intangible assets, such as a brand image; or a combination of both (Andersén, 2021). This idea emphasizes how crucial it is for a company to have the right structure of resources and to methodically gather valuable, imitable, uncommon, and incomparable resources because they are the core assets that set the company apart from its competitors. The RBV has been developed and improved as a leading theory in strategic management since the 1990s, resulting in multiple branches with varied underlying assumptions and perspectives (Peteraf, 1993).

For example, several studies have emphasized the fundamental relational premise of the RBV viewpoint to support the claim that resources providing a competitive advantage can cross organizational borders and be entrenched in inter-firm ties (Barney et al., 2011). According to GSCM researchers who have adopted the RBV, while GSCM methods can increase an enterprise's performance and competitiveness, they rely on essential and pertinent organizational resources (Gueler & Schneider, 2021).

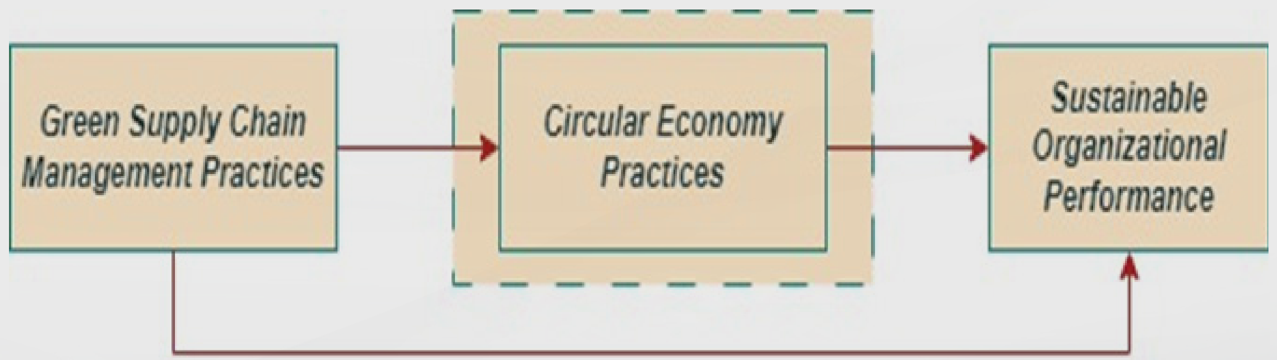
According to Gavronski et al. (2011), based on RBV, top management commitment and environmental investment play significant roles in the GSCM process of manufacturing enterprises. Jabbour et al. (2019) examined the link between important success factors and the adoption of GSCM methods; this was done to bridge the gap observed by Sarkis et al. (2011) regarding how crucial variables and resources may promote the greening of the supply chain process. They asserted that businesses could implement GSCM more successfully if they had a defined green human resources strategy. The RBV in GSCM calls attention to the reasons why businesses in a certain sector can use various tactics or procedures like improve their use of resources, reduce waste and pollution, enhance recycling procedures (Lee et al., 2013; Shahzad et al., 2022). Table 8.2 presents a detailed literature review of these core constructs, while Figure 1 depicts the study's framework.

Table 8.2: Literature Review

Authors	Methods/theory	Integrated constructs /measures	Findings
Zhou et al. (2023)	211 Survey Natural Resource-Based View, Resource Dependence Theory: Structural Equation Modeling	Green Logistics Management, Circular Economy Practices, Supply Chain Traceability, and Sustainability Performances	Organizational circular economy practices and sustainability performance are favorably impacted by green logistics management. Supply chain traceability and circular economy practice both mediate the targeted relationship.
Shahzad et al. (2022)	308 Survey Stakeholder Theory: Structural Equation Modeling	Stakeholder Pressure (Primary and Secondary), Green Management Practices, Organizational Motives (Instrumental, Relational, and Moral)	Green management practices are significantly impacted by corporate goals as well as primary and secondary stakeholder demand.
Hassan and Jaaron (2021)	250 Survey Stakeholder Theory: Structural Equation Modeling	Total Quality Management Practices, Green Management Practices, and Organizational Performance (Operational, Financial, and Employee)	Green management practices considerably moderate the linkages between total quality management practices, green management practices, and organizational performance.
Baah et al. (2021)	210 Survey Stakeholder theory, Natural Resource-Based View, Institutional Theory: Structural Equation Modeling	Stakeholder Pressure (Regulatory and Organizational), Firm Reputation, Green Production Practices, Environmental and Financial Performance.	Green production practices are influenced by stakeholder (regulatory and organizational) pressure, which improves the firm's reputation as well as its environmental and financial performance.

Kitsis and Chen (2021)	206 Survey Stakeholder Theory: Structural Equation Modeling	Stakeholder Pressure, Green Operations (Product and Process), Top Management Commitment, Economic and Environmental Performance	Stakeholder Pressure significantly impacts green operations by highlighting the vital mediating channel of commitment by senior management.
Rui and Lu (2020)	278 Survey Institutional Theory: Structural Equation Modeling	Stakeholder Pressure (Regulatory, Normative, and Imitative Pressure), Corporate Ethics, Responsible Leadership, Environmental Awareness, and Green Innovation	By identifying the crucial mediation channel of corporate ethics between pressure and green innovation, it is possible to understand how stakeholder demands substantially impact business ethics. Responsible leadership also controls specific connections.
Shahzad et al. (2020b)	318 Survey Stakeholder Theory: Structural Equation Modeling	Primary Stakeholders' Pressure (employees, customers, and government). Secondary Stakeholders' Pressure (media and NGOs). Organizational Learning and Human Development.	Primary and secondary stakeholder pressure improves environmental practices, including corporate social responsibility and green innovation.
Baah et al. (2020)	132 Survey Stakeholder Theory: Structural Equation Modeling	Stakeholder Pressure (Regulatory and Organizational), Green Logistics Practices, Social Reputation, Environmental Reputation, and Financial Performance.	Green logistics practices are influenced by stakeholder (organizational and regulatory) demand, strengthening organizational their environmental reputation and financial performance.
(Zhang & Zhu, 2019)	259 Survey Stakeholder theory; Organizational Learning theory; Structural Equation Modeling	Stakeholder Pressure (Regulatory and Consumer), Organizational Learning (Exploitation and Exploration), and Green Innovation (Process and Product)	Consumer and regulatory pressure impact the development of green products, with regulatory pressure having a more significant favorable effect. Organizational learning also positively mediates these associations.
Foo et al. (2018)	178 Survey Resource-Based View: Structural Equation Modeling	Green Supply Chain Management Practices (Internal environmental management, Investment recovery, Cooperation with Customers, Eco-Design, Supplier Selection, Supplier Evaluation, Environmental Collaboration, and Sustainable Organizational Performance)	Except for supplier selection and assessment, all green supply chain management techniques significantly and favorably influence long-term organizational performance (social, economic, and environmental).

Figure 8.1: The study's framework



8.2.2 Green Supply Chain Management and Sustainable Organizational Performance

GSCM is a developing concept that integrates environmental awareness into conventional supply chain procedures. Businesses are adopting environmentally friendly practices and exploring ways to reduce their ecological impacts owing to the growing awareness of environmental issues and sustainability concerns (Del Giudice et al., 2020; Rahman et al., 2023). Organizations that embrace and effectively implement GSCM practices are likely to have a positive impact on their SOP, leading to enhanced environmental, economic, and social outcomes. Although sustainable development (SD) is a popular topic in the literature, analysts and researchers have not yet come to a consensus on its definition (Gordon et al., 2011; Hahn et al., 2015). The description of SD embraced globally is provided by the World Commission on Environment and Development (WCED, 1987): "Development that meets the needs of the present without compromising the ability of future generations to meet their needs." The WCED includes environmental, economic, and social concerns. These three elements, acknowledged as the triple bottom line (TBL), affect present and future generations (Elkington, 1998). Each pillar (environmental, economic, and social) of sustainability in this approach is equally important; thus, it is an integrative theory of sustainability.

In line with Abdallah and Al-Ghwayeen (2020), the four most crucial GSCM components were chosen: Green Purchasing (GP), Internal Environmental Management (IEM), Eco-design (ED), and Collaboration with Suppliers and Customers (CSC). According to Cosimato and Troisi (2015), these dimensions are also thought to enhance organizational reputation and competitive edge. For instance, IEM establishes various ecological aims and standards for businesses, helps them allocate resources wisely, and designs and implements strategies for effective completion (Shah & Soomro, 2021; Zhu et al., 2008). GP also supports the substitution of dirty and riskier alternatives with harmful materials and dirty energy, discouraging businesses from purchasing and using them. Additionally, this motivates businesses to demand environmentally friendly and clean manufacturing from their suppliers, which has little to no detrimental consequences for society and the environment (Amjad et al., 2022; Namagembe et al., 2018). Similarly, ED seeks to improve the ecological effectiveness and quality of items. ED mandates reducing resource consumption, waste, emissions, and pollutants during manufacturing and promoting the potential of goods to be recycled and biodegraded (Abdallah & Al-Ghwayeen, 2020; Amjad et al., 2022). Businesses' partnerships with suppliers help them with GP, and their partnerships with consumers keep them informed about purchasers' environmental sensitivity (Amjad et al., 2022; Zhu et al., 2008). Furthermore, GSCM and CEPs share a symbiotic relationship as both focus on sustainability and resource efficiency. GSCM emphasizes eco-friendly practices throughout the supply chain, whereas CEPs promote the regenerative use of resources, and their integration ensures a holistic approach to sustainability, fostering long-term environmental and economic benefits (Chowdhury et al., 2022; Ripanti & Tjahjono, 2019). The CE and sustainable supply chains are combined to create a circular supply chain, including the management and design of the circular supply chain relationship (Del Giudice et al., 2020; Jinru et al., 2021). Therefore, following the above argument, a connection between GSCM, CEPs, and SOP was postulated.

This implies that companies are more likely to achieve sustainable outcomes in various areas of their operations when environmentally friendly practices are included in their supply chain activities (Bag et al., 2020), for instance, minimizing adverse environmental effects, enhancing resource efficiency, encouraging social responsibility, and realizing financial gains.

A green supply chain results in the investment of resources in reverse logistics, which is closely tied to the performance of reverse logistics and remanufacturing (Bag & Pretorius, 2021). Furthermore, a rapid customs clearance procedure may be a component of the green supply chain. As reducing wait times saves fuel and reduces emissions, it has a major impact on environmental quality (An et al., 2021).

This hypothesis posits that firms may significantly improve their sustainability performance by implementing GSCM practices, such as green procurement, eco-friendly transportation, waste reduction, and energy efficiency. Consequently, consumer loyalty, cost savings, brand reputation, and market competitiveness may improve.

H1: GSCM practices significantly and positively affect CEPs.
H2: GSCM practices significantly and positively affect SOP.

8.2.3 Circular Economy Practices and Sustainable Organizational Performance

A CE is an economic model designed to exploit resource efficiency by promoting the continual use, refurbishment, remanufacturing, and recycling of products and materials (Chowdhury et al., 2022; Ripanti & Tjahjono, 2019). It aims to move away from the traditional linear "take-make-dispose" model and create a closed-loop system that minimizes waste and conserves resources (Del Giudice et al., 2020). A circular supply chain includes the management and design of the circular supply chain relationship, where ideas about the CE and sustainable supply chains are integrated (Zeng et al., 2017). The Ellen MacArthur Foundation (2015) first described the CE as "a new method to design, create, and utilize things within planetary boundaries before expanding it to include an industrial system that is restorative or regenerative by intention and design." Thus, CEPs have changed the conventional linear manufacturing process in which raw materials are input into a circular manufacturing process, in which the input is the output of previously used materials (Dieckmann et al., 2020). Businesses that actively apply CEPs are more likely to see improvements in their SOP, which will boost resource efficiency, reduce environmental impact, and improve economic performance.

Green raw materials are essential for green growth and CE goals and are supported by green sourcing. Green raw materials are required to produce sustainable products. Previous studies have acknowledged the advantages of green sourcing in increasing green and sustainable production, thereby enhancing the CE (Tseng et al., 2020).

According to research, CE supply chain practices, particularly those related to design and relationship management, have a long-lasting favorable effect on company outcomes (Zeng et al., 2017). To increase competitiveness, businesses can use management of the circular supply chain relationship (Sun et al., 2022). This ensures the sustainable creation of economic possibilities and provides societal and environmental advantages (Ripanti & Tjahjono, 2019; Shahzad et al., 2019). According to Schroeder et al. (2019), a significant number of sustainable development goals can be attained using CEPs. Previous studies have also highlighted that green logistics and financing for raw materials acquisition directly affect CEPs (Jinru et al., 2021). Sustainable production methods play a significant role in the adoption of CEPs. Green operations aim to effectively manage businesses that are part of the CE, simplify manufacturing logistics, and streamline logistics processes in the production systems of firms involved in product delivery (Seroka-Stolka & Ociepa-Kubicka, 2019). In addition, the CE focuses on recycling trash and renewable resources without negative external influences. The following hypotheses are proposed in response to this debate:

H3: CEPs significantly positively affect SOP.
H4: CEPs mediate the relationship between GSCM practices and SOP.

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8.3 METHODOLOGY

Using convenience sampling, a questionnaire was developed and sent to small to medium-sized enterprises (SMEs) in the manufacturing sector in Pakistan and China. Chinese SMEs are defined as businesses with 999 (or more) employees and a yearly revenue of at least RMB 300 million. SMEs in Pakistan are classified as businesses with up to 250 workers and an annual revenue of at least 250 million rupees (Waheed & Zhang, 2020). The ultimate objective of SMEs is to improve the national economy, and experts have demonstrated the significance of SMEs in economic progress. SMEs are a large contributor to GDP, comprising approximately 30% of it and providing a sizable portion of the country's employment (Shahzad et al., 2019; Waheed & Zhang, 2020). A total of 1,000 surveys were distributed between March and July 2023 using online tools and in-person visits. Subsequently, 301 questionnaires from China and 287 questionnaires from Pakistan were collected. These were the final sample sizes used for data analysis. After carefully reviewing each response, surveys that were filled out erroneously were excluded. Colleagues and students from Pakistan and China were also requested to assist with data collection. Most respondents (approximately 40% in each sample) held high-level positions with master's degrees and were in charge of carrying out organizational procedures and policies. Men accounted for over 60% of the respondents. Table 8.4 presents comprehensive demographic information. This study used the 10 times rule for the sample size, which is "10 times the largest number of structural paths directed at a particular latent construct in a structural model" (Hair et al., 2017). Additionally, this study verified the sample's suitability by performing several power assessments using the G*Power program, as suggested by Prajapati et al. (2010). The overview of the study was divided into two parts. Data on demographic traits were collected in the first segment. In the second section, 15 items were adapted for GSCM and divided into four major elements: IEM, GP, ED, and CSC (Rahman et al., 2023). Furthermore, 15 items were adopted for SOP and divided into three major components: environmental, social, and economic performance (Shahzad et al., 2019; Zhu & Sarkis, 2004). Furthermore, four items related to CEPs were employed based on the work of Chowdhury et al. (2022). Table 8.3 outlines the questionnaire and its items. A 7-point Likert scale was used to evaluate each item, with seven representing strong agreement and one indicating strong disagreement. In accordance with Hinkin (1998), I carried out pilot research to confirm the validity and reliability of the recognized constructs in the context of the study.

Table 8.3: Measurement and Items Details

Description	No. of Measuring Items	Reference(s)
Green Supply Chain Management (GSCM	15	(Rahman et al., 2023)
Green Purchasing	3	
Internal Environmental Management	3	
Eco Design	4	
Collaboration with Suppliers and Customers	5	
Circular Economy Practices (CEP)	4	(Chowdhury et al., 2022)
Sustainable Organizational Performance (SOP)	15	(Shahzad et al., 2019; Zhu & Sarkis, 2004)
Environmental Sustainability	5	
Economic Sustainability	5	
Social Sustainability	5	

Table 8.4: Demographic Information

Respondents' information		China (n=301)		Pakistan (n=287)	
Attributes	**Spreading**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Gender					
	Male	178	59.14	59.14	59.14
	Female	123	40.86	40.86	40.86
Education level					
	Bachelor's Degree	77	25.58	81	28.22
	Master's Degree	122	40.53	109	37.98
	Technical Degree	59	19.60	65	22.65
	Other	43	14.29	32	11.15
Age					
	18 - 24 Years	98	32.56	83	28.92
	25 - 32 Years	111	36.88	90	31.36
	33 - 40 Years	65	21.59	66	23.00
	Above 40 Years	27	8.97	48	16.72
Job experience					
	0 - 10 Years	158	52.49	123	42.86
	11 - 20 Years	91	30.23	89	31.01
	Above 20 Years	52	17.28	75	26.13
Job Title					
	Officer / Executive	124	41.20	109	37.98
	Supervisor/ Manager	83	27.57	73	25.44
	Senior Manager	55	18.27	63	21.95
	CEO / Director	39	12.96	42	14.63

8.4 ANALYSIS TOOLS

This study employed partial least squares SEM (PLS-SEM) using SmartPLS version 3.3.9. PLS-SEM is an effective method for examining intricate models. It aimed to identify endogenous variables that contributed the least to the model. PLS-SEM can simultaneously manage both structural and measurement models (Hair et al., 2017). As stated by Hair et al. (2017), the measurement and structural models were explicitly approximated to provide reliable results. Validity and reliability tests were applied, as suggested by Hair et al. (2017), to evaluate the measurement model. The results were above the 0.70 threshold obtained when Cronbach's alpha (CA) and composite reliability (CR) were used to evaluate the reliability of all constructs (Cohen, 1988). The outcomes of convergent validity showed that all items' standardized factor loading values were higher than 0.70, and the values of the average variance extracted (AVE) were higher than 0.50 (Sarstedt et al. 2017). In this study, the values were above the threshold limits. Additionally, GSCM and SOP are second-order formative constructs. According to Petter et al. (2007), construct validity is ensured by computing the outer weight values of the first-order constructs. These values were also within good range and met Petter's criteria. Table 8.5 presents the complete results of the CA, CR, and AVE values.

Table 8.5: Construct Reliability

	China			Pakistan		
	CA	CR	AVE	CA	CR	AVE
CEP	0.858	0.905	0.705	0.856	0.902	0.698
CSC	0.859	0.898	0.639	0.868	0.904	0.653
ED	0.830	0.887	0.663	0.796	0.881	0.714
ESOP	0.801	0.868	0.576	0.856	0.897	0.636
EnSOP	0.916	0.937	0.748	0.845	0.889	0.618
GP	0.801	0.883	0.716	0.852	0.909	0.769
IEM	0.731	0.796	0.566	0.728	0.846	0.647
SSOP	0.874	0.897	0.832	0.904	0.918	0.428

Discriminant validity (DV) was evaluated to determine whether the constructs differed from one another. The Fornell-Larcker criteria were employed to evaluate DV (Hair et al., 2017). The relationship between the AVE values and shared variance was examined among the constructs. Table 8.6 shows that the roots of the AVE values are more significant than the correlational values. Since all items' adjusted total item correlation values were above the cutoff point of 0.5, the measurement model did not have a DV issue (Fornell & Larcker, 1981).

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Table 8.6: Discriminant Validity

China

	CEP	CSC	ED	ESOP	EnSOP	GP	IEM	SSOP
CEP	**0.840**							
CSC	0.209	**0.799**						
ED	0.374	0.389	**0.814**					
ESOP	0.396	0.291	0.487	**0.759**				
EnSOP	0.528	0.211	0.317	0.386	**0.865**			
GP	0.299	0.249	0.598	0.549	0.260	**0.846**		
IEM	0.507	0.442	0.441	0.363	0.444	0.288	**0.752**	
SSOP	0.227	0.271	0.510	0.745	0.171	0.575	0.247	**0.812**

Pakistan

	CEP	CSC	ED	ESOP	EnSOP	GP	IEM	SSOP
CEP	**0.836**							
CSC	0.269	**0.808**						
ED	0.401	0.332	**0.845**					
ESOP	0.356	0.162	0.376	**0.798**				
EnSOP	0.322	0.136	0.399	0.548	**0.786**			
GP	0.217	0.158	0.212	0.553	0.304	**0.877**		
IEM	0.447	0.378	0.492	0.441	0.431	0.250	**0.804**	
SSOP	0.330	0.261	0.277	0.588	0.427	0.576	0.405	**0.797**

Diagonal bold and italic values are the AVE values.

The bootstrapping technique used 5,000 subsamples to determine the significance of the hypothesis. The findings showed a significant and positive correlation between GSCM and CEP, with beta values of 0.538 and 0.317 for China and Pakistan, respectively. Consequently, H1 was supported. Furthermore, the second hypothesis, GSCM to SOP, also revealed a positive and significant result with beta values of 0.217 and 0.213, respectively, which aligns with H2. Moreover, the relationship between CEPs and SOP demonstrated significant and positive outcomes with beta values of 0.170 and 0.113, respectively; this is in line with H3. In addition, the mediating relationship of CEPs between GSCM and SOP was evaluated in H4. The results indicated that CEPs mediated the relationship between GSCM and SOP in China, thus enabling the acceptance of H4; however, H4 was not supported in the case of Pakistan. In this study, the model fit was also high and acceptable. Table 8.7 displays the results.

Table 8.7: Results of Hypothesis Testing

Hypotheses	Proposed relationships	β-value	t-value	p-value	Decision
	China				
H1	GSCMP – > CEP	0.538	7.602	0.000	Supported
H2	GSCMP – > SOP	0.217	6.973	0.000	Supported
H3	CEP – > SOP	0.170	5.242	0.000	Supported
H4	GSCMP – > CEP – > SOP	0.147	6.235	0.000	Supported
	Pakistan				
H1	GSCMP – > CEP	0.317	7.086	0.000	Supported
H2	GSCMP – > SOP	0.213	4.35	0.000	Supported
H3	CEP – > SOP	0.113	3.329	0.001	Supported
H4	GSCMP – > CEP – > SOP	0.026	1.302	0.194	Un-Supported

t-value above 2.58 at p<0.000; t-value: 1.97 - 2.57 at p<0.001; t-value: 1.68 - 1.96 at p<0.050

8.5 CONCLUSION AND POLICY RECOMMENDATIONS

Research on the impact of GSCM practices on SOP, focusing on the key role of CEPs in China and Pakistan within selected CAREC economies, contributes significantly to theoretical knowledge and practical applications. GSCM practices have immense potential in China and Pakistan and are essential for companies operating in both countries to achieve green, sustainable competitiveness. This enriches the understanding of the relationship of GSCM practices with sustainability and the CE.

It provides valuable insights for businesses and policymakers seeking to promote sustainable practices in their supply chains, which equips stakeholders with the necessary knowledge and tools to promote sustainability and enhance overall regional organizational growth.

Focusing on the crucial importance of CEPs in selected CAREC economies (China and Pakistan), research on how GSCM practices impact SOP has provided numerous critical theoretical advances. Investigating the connection between GSCM practices and SOP adds to the body of knowledge in the developing field of GSCM. First, it closes the gap between CE concepts and GSCM practices by highlighting the vital importance of CEPs.

This integration clarifies any potential overlap between these two frameworks and aids in comprehending how their combined impact on performance might be sustained. This study showed that CEPs are the most important motivator, offering solutions for ecological degradation and economic effectiveness. As evidenced by the widespread adoption of hybrid and electric cars, green technologies have the potential to transform an industry with a high carbon footprint into one that is profitable, sustainable, and cost-efficient. This example and the findings indicate that environmental protection strategies assist organizations and stakeholders in pursuing SOP by boosting CEPs. Second, this study enhances the contextual understanding of CAREC economies (China and Pakistan). The comparative analysis between China and Pakistan contextualizes GSCM adoption and its impact on sustainable performance in different economic settings, both directly and through CEPs. This analysis can reveal country-specific challenges and opportunities, in addition to offering valuable lessons for businesses and policymakers in similar economies. The findings of the present study identified the best practices for GSCM and CE implementation in both China and Pakistan. Such insights can serve as benchmarks for businesses to enhance their sustainability and performance. Furthermore, this study contributes to the refinement of existing theoretical frameworks related to targeted constructs. By incorporating empirical evidence from CAREC economies, this study strengthens and updates these frameworks to better reflect real-world dynamics.

Practically, this study guides businesses operating in China, Pakistan, and other CAREC economies to implement GSCM practices. By understanding the impact of CEPs on SOP, companies can identify specific strategies and actions to enhance their environmental and social obligations in the supply chain. Through a comparative analysis of China and Pakistan, this study identified best practices in GSCM and CE adoption against industry peers and competitors in China and Pakistan. Businesses can learn from successful case studies in each country and replicate practical approaches to improve their supply chain sustainability. This comparison highlights areas for improvement and helps set realistic sustainability goals aligned with regional standards and practices. This study also provides deep evidence-based insights for policymakers in CAREC economies. Policymakers can use the results to design and implement supportive regulations, incentives, and frameworks to encourage businesses to adopt sustainable practices and contribute to national as well as regional sustainability goals. Furthermore, investors and development partners in CAREC economies can leverage the findings to make

informed decisions regarding investments in infrastructure, capacity building, and policy reforms that promote GSCM practices. This can lead to targeted and effective investments that support sustainable development. Adopting green and sustainable technologies is one way to address the mounting demand for these nations to invest in green technology. Emergency efforts to reduce environmental effects are already placing a heavy load on organizations. There is a chance for emerging countries such as Pakistan to learn from the methods used by wealthy nations for environmental protection. To help organizations lessen their reliance on fossil fuels and increase their use of renewable energy, governments should actively endeavor to promote the "Punjab Green Development Program" or to create a "green business climate" (World Bank, 2018). This raises the industry's ecological consciousness and encourages economic growth. Public-private partnerships will also help deliver cost-effective solutions for cutting-edge green technologies.

Furthermore, this study can foster opportunities for collaboration among businesses, government entities, and development partners in CAREC economies. By recognizing the benefits of GSCM practices and CEPs on SOP, stakeholders can collaborate to generate shared value and address common sustainability challenges. However, given the current climate of energy crises and resource shortages, governments should provide tax exemptions and incentives for the limited use of natural and energy resources. Finally, businesses can use research insights to better assess and mitigate environmental and social risks within their supply chains. Understanding the impact of GSCM practices on SOP can help identify vulnerabilities and implement risk management strategies.

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PART THREE

SUPPLY CHAIN, ESG MARKETS, TRADE AND AGRICULTURE SUSTAINABILITY IN CAREC REGION

PART THREE

CHAPTER 09

THE DEVELOPMENT OF ESG IN CAREC COUNTRIES

Evidence from the Capital Markets in China and Kazakhstan

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9.1 INTRODUCTION

9.1.1 Background

The world is becoming increasingly interconnected and interdependent. Global challenges such as climate change, social inequality, and governance issues necessitate a unified approach to ensure sustainable development. The Central Asia Regional Economic Cooperation (CAREC) 2030 strategy exemplifies this collaborative approach by fostering economic cooperation among countries in the region and connecting people, policies, and projects for shared and sustainable growth. The CAREC 2030 strategy is a comprehensive long-term framework that encourages regional cooperation among 11 countries in Central Asia and its neighboring regions. It focuses on five operational clusters: economic and financial stability; trade, tourism and economic corridors; infrastructure and economic connectivity; agriculture and water; and human development. In addition, it emphasizes the importance of regional cooperation in increasing the region's resilience and embracing the developments of the modern era (Holzhacker, Lu, & Yazyyev, 2023).

Environmental, social, and governance (ESG) factors are crucial in promoting sustainable development in the CAREC region. ESG factors reflect the environmental and social impacts of an organization and its governance practices, which ensure its ethical and responsible operations. Integrating ESG factors into business and investment decisions allows for a more comprehensive understanding of an organization's performance, risks, and opportunities. This is vital for companies in CAREC countries, which face challenges such as water scarcity, high energy consumption, and labor shortages that can significantly impact their long-term sustainability and value creation. For instance, the CAREC region's largest importers are the EU, China, Russia, and Turkey.

The IMF's April 2023 World Economic Outlook predicts that EU would only have a real GDP growth rate of 0.8% in 2023 and 1.4% in 2024. Meanwhile, Russia is expected to have a real GDP growth rate of by 0.7% in 2023 and 1.3% in 2024, and Turkey is expected to grow by 2.7% in 2023 and 3.6% in 2024. In contrast, China and the CAREC region are expected to have substantially higher growth rates in 2023 and 2024 (Holzhacker, Lu, & Yazyyev, 2023).

Focusing on ESG issues can help companies manage risks more effectively, paving the way for sustainable development and long-term growth. Moreover, ESG can significantly enhance companies' ability to manage resources and boost brand value, making them more attractive to both domestic and international investors. A strong commitment to ESG is essential for businesses to gain a competitive advantage and create sustainable value, as global awareness of environmental and social issues continues to increase. However, ESG development in the CAREC region is still in its early stages compared to developed countries. Several challenges, including the lack of unified disclosure standards for ESG information, low quality and transparency of information, limited comparability of data, and insufficient awareness of ESG concepts among CAREC member countries must still be overcome. Concerted efforts at national and regional levels are needed to address these challenges.

This study examines the ESG development in two CAREC countries: China and Kazakhstan. Both countries have made noticeable strides in integrating ESG into their business practices, as reflected by their increasing ESG disclosures and public fund growth. We provide a comparative analysis of their ESG development as a foundation for supporting the CAREC 2030 strategic framework and promoting sustainable development in all CAREC countries. By examining their ESG journey, we uncover insights that can help foster good ESG practices, encourage regional companies to become more sustainable, and improve organizational resilience in the face of unstable factors such as resource shortages, severe climate change, anti-globalization movements, disease pandemics, and financial crises. Thus, we contribute to the CAREC 2030 strategy by underlining the significance of regional cooperation and sustainable development in an increasingly interconnected world.

In the following sections, we delve into the importance of ESG for sustainable development, examine the current status and challenges of ESG development in CAREC countries, and present detailed case studies of China and Kazakhstan. We shed light on the way forward, proposing potential solutions and recommendations to strengthen ESG practices in the CAREC region and thus contribute to sustainable economic cooperation.

9.1.2 The Importance of ESG for Sustainable Development

9.1.2.1 ESG Factors and Sustainable Development: An Integrated Perspective

Understanding the intrinsic value of ESG factors in the context of sustainable development is crucial in the contemporary global economic landscape. Lokuwaduge and Heenetigala (2017) suggest that integrating ESG disclosures can be a significant benchmark for a country's journey towards sustainable development. This is particularly relevant for rapidly developing economies China and Kazakhstan. Both countries are key players in the CAREC initiative and are at crucial stages of their ESG adoption and sustainability journey. The integration of ESG factors has become the cornerstone of policy decisions and investment strategies in both countries. This interconnectedness with the global sustainability agenda, coupled with their economic potential, shapes emerging markets, influences corporate behavior, and redefines the investment landscape. The transparent reporting of ESG metrics is a critical component of these strategies, serving as a communication bridge with stakeholders. These reports enhance stakeholder understanding, enabling informed decision-making and facilitating better management of ESG risks and opportunities. They promote accountability, foster a culture of transparency, and are instrumental for long-term sustainability (Zhou, Liu, & Luo, 2022).

9.1.2.2 The Multifaceted Impacts of ESG Factors

ESG factors represent a holistic approach for evaluating a company's performance and impact, linking with its long-term viability and growth. The environmental dimension of ESG captures a company's interactions with the natural environment, such as efforts to curb pollution, reduce carbon footprint, and promote efficient resource usage.

These aspects have gained significant attention in light of global climate change and are particularly pertinent in countries such as China, which has a vast industrial base, and Kazakhstan, which has abundant natural resources. Meanwhile, the social element of ESG revolves around a company's relationships with its employees, suppliers, customers, and communities. Addressing issues such as labor rights, supply chain ethics, and community relations is central to a company's social responsibility and reputation (Lokuwaduge and Heenetigala, 2017). As societies become more interconnected, the social performance of companies increasingly shapes their success. Lastly, governance concerns a company's leadership, executive pay, audits, internal controls, and shareholder rights. China and Kazakhstan are steadily progressing in these areas, albeit at different paces and with varying degrees of convergence with international standards. Good corporate governance promotes accountability, enhances corporate performance, and builds investor trust, thereby supporting sustainable growth (Zhou, Liu, & Luo, 2022).

9.1.2.3 ESG Factors: Catalysts for Financial Performance and Sustainable Investment

Robust ESG performance is integral to a company's financial health and long-term competitiveness. ESG factors can enhance operational efficiency, spur innovation, mitigate risks, and unlock new market opportunities. Therefore, companies that proactively manage ESG issues may gain a competitive edge, facilitating increased profitability and shareholder value over time (Zhou, Liu, & Luo, 2022). The integration of ESG factors also shapes the investment landscape and underpins sustainable investment strategies (Folqué, Escrig-Olmedo, & Corzo Santamaria, 2021). Investors are increasingly considering ESG risks and opportunities in their decision making, aligning financial returns with environmental, social, and governance outcomes. These strategies promote the adoption of better ESG practices by companies, contribute to mitigating climate change, and support the transition to a more sustainable economy, thus aligning with the CAREC 2030 strategy. Therefore, the importance of ESG for sustainable development is significant and multi-dimensional. By embracing ESG factors, companies not only enhance their financial performance, but also contribute to broader

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societal and environmental outcomes. Simultaneously, the rise in ESG investment signifies a shift towards a more sustainable financial system, underpinning the interconnectedness of economic growth, social equity, and environmental protection.

9.2 CURRENT STATUS AND CHALLENGES OF ESG DEVELOPMENT IN CAREC COUNTRIES

CAREC includes Afghanistan, Azerbaijan, China, Georgia, Kazakhstan, Kyrgyz Republic, Mongolia, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan. The socioeconomic and political landscapes of the member countries are distinct and significantly influence their ESG development. The integration of ESG principles into their growth strategies is paramount for building resilient economies, promoting sustainable development, and improving international economic standings (Ng et al, 2020).

9.2.1 Capital Markets for ESG development in CAREC region

Capital markets play a crucial role in supporting ESG practices in the CAREC region. The CAREC 2030 strategy’s economic and financial sustainability cluster aims to support macroeconomic and financial stability and enhance the region’s economic resilience. The CAREC capital market regulatory forum is part of the economic and financial stability cluster and aims to accelerate capital market development and promote innovation.

Furthermore, the economic and financial sustainability cluster collaborates with the Asian Development Bank (ADB) to support CAREC capital market regulators and promote the exchange of product innovation experience. The ADB supports the regulators by providing knowledge products, capacity building, and organizing activities to promote the exchange of product innovation experiences.

Calls for the regulation of ESG data and rating providers have increased, standards for bond issuers have been debated, and developments in the carbon market have been closely monitored. Asset owners, asset managers, banks, and insurers have embedded ESG factors, especially climate change, into their risk-management frameworks and stress tests. In China, the Shanghai Stock Exchange launched the SSE STAR Market in 2019, which focuses on high-tech and innovative companies committed to sustainable development. The SSE STAR market has attracted many companies dedicated to ESG practices. Moreover, the China Securities Regulatory Commission (CSRC) promotes ESG disclosure and reporting in the Chinese capital market. In 2020, the CSRC issued guidelines on ESG disclosures for listed companies. These guidelines require listed companies to disclose information on environmental protection, social responsibility, and corporate governance. The CSRC also encourages the development of green finance and sustainable investment in the Chinese capital market.

9.2.2 Strategies for ESG Progress in CAREC Region

Environmental regulations in CAREC countries present unique challenges, in contrast to their counterparts in the Organization for Economic Co-operation and Development (OECD). CAREC countries are rich in natural resources, have energy-intensive industries, and experience rapid economic growth, leading to significant pollution and environmental degradation. With less stringent environmental regulations than OECD countries, they risk becoming "pollution havens," attracting pollutive industrial trade and exacerbating environmental concerns (Irfan, 2021).

To address these issues, several CAREC countries have undertaken initiatives to stimulate sustainable energy investments. For instance, China has embarked on substantial renewable energy projects, while Kazakhstan has leveraged its potential for renewable resources. Qu and Xu (2023) emphasize strategies encouraging private sector participation, developing conducive regulatory and policy environments, and strengthening utility operations and management. However, successfully transitioning to sustainable energy utilities requires broader systemic changes including improved regional cooperation and infrastructure development.

CAREC countries also face various social issues, such as labor rights, poverty, education, and healthcare. For example, China is undergoing significant healthcare reform, while Kazakhstan is enhancing its education system. These complex issues require multifaceted solutions including policy reforms, targeted investments, and social sector innovations. Advocating socially responsible business practices is crucial to achieving broader social sustainability goals. In the governance domain, the role of monetary policy is significant. This policy affects several economic variables which in turn, influencing ESG performance (Mehar, 2022).

9.2.3 Challenges of ESG Development in CAREC Countries

ESG development in CAREC nations is hindered by issues such as the lack of unified disclosure standards for ESG information, low quality of data, lack of transparency and comparability of data, and insufficient awareness of ESG concepts. For instance, companies in China and Kazakhstan often face challenges in reporting ESG activities because of the absence of a standardized disclosure format, leading to inconsistent and non-comparable data. Moreover, the quality of disclosed information often varies significantly, thereby affecting investors' ability to accurately assess ESG risks and opportunities. This lack of uniformity and transparency hinders the development and adoption of ESG standards, underscoring the need for regulatory interventions and educational campaigns to increase the awareness and understanding of ESG concepts.

Developed and developing economies significantly influence the economic growth of CAREC countries (Jumayev, 2021). External investments, knowledge transfer, and technological innovation significantly enhance ESG performance in CAREC countries. However, this relationship underscores the necessity for robust regulatory frameworks in CAREC countries to ensure that external influences align with the countries' sustainability goals. Therefore, the current status of ESG development in CAREC countries presents a complex picture of progress and challenges. Although strides have been made in areas such as sustainable energy and monetary policy reform, significant hurdles have remained, particularly regarding environmental regulations, social equity, and ESG disclosure standards. In the face of these challenges, collaboration, knowledge exchange, and a shared commitment to sustainable development are crucial for advancing ESG performance across the region. The success of these efforts is not only critical for individual countries but also for broader global sustainability initiatives.

9.3 RESEARCH FRAMEWORK

9.3.1 Theoretical Framework

This study's theoretical framework provides a comprehensive understanding of the intersection between ESG practices and sustainable economic development within the CAREC region. It establishes the importance of ESG in achieving the CAREC 2030 agenda and outlines the potential for ESG to serve as a catalyst for sustainable development. This study is grounded in sustainability theory, which posits that long-term economic growth must align with environmental stewardship and social well-being. By examining ESG factors through this lens, we seek to uncover their multidimensional impact on sustainable development.

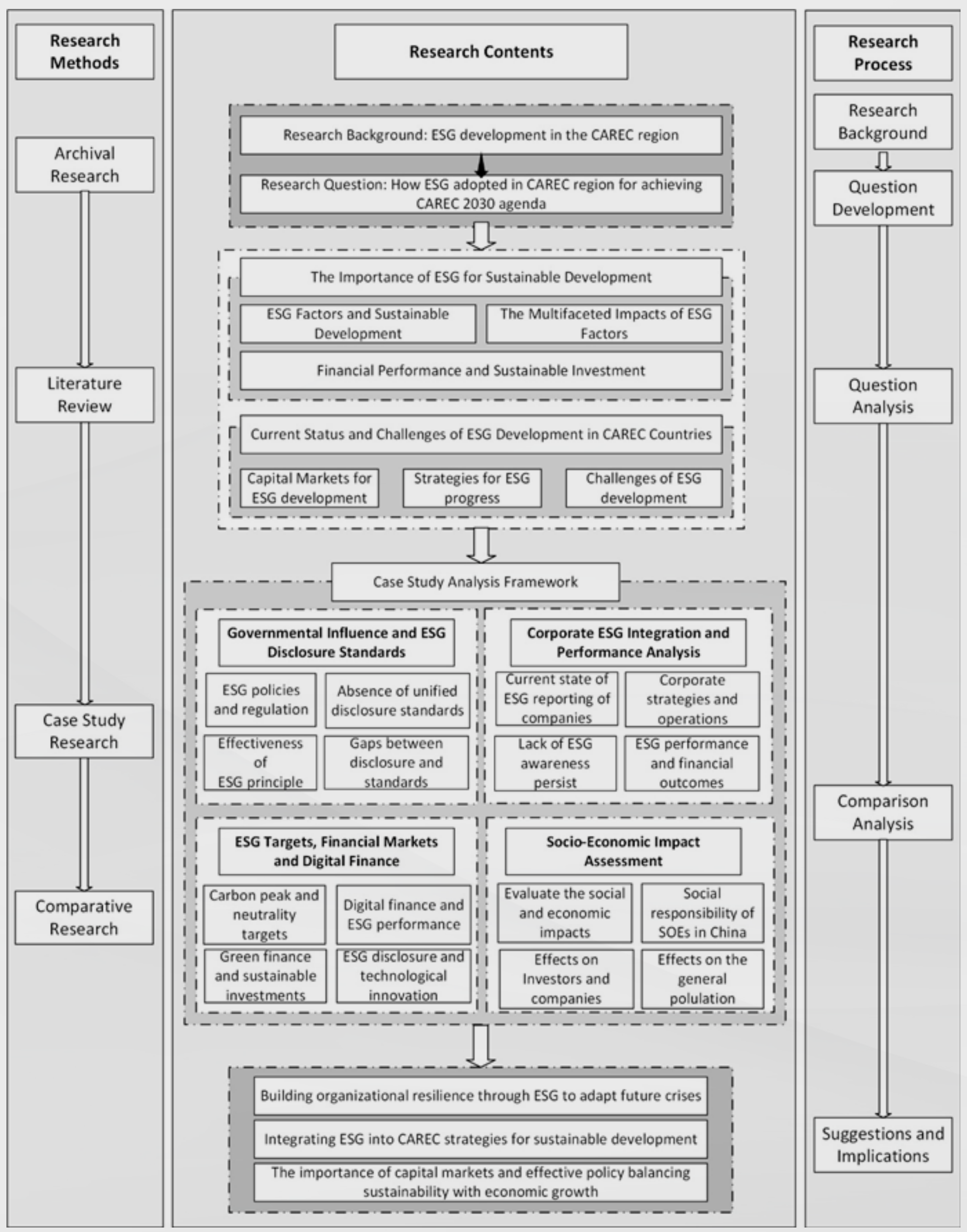
Furthermore, institutional theory is incorporated to understand how norms, values, and regulations influence corporate behavior and governance practices. This theory helps explain the role of governmental influence and the absence of unified disclosure standards in shaping the ESG landscape. Financial theories related to sustainable investment and performance provide insights into how financial markets act as levers for progress by incentivizing ESG integration and assessing the financial implications of ESG reporting. The ability of ESG practices to mitigate risk and contribute to recovery efforts is a crucial aspect of this study, aligning with the broader theoretical understanding that sustainability is essential for long-term organizational and economic resilience. By combining these theoretical strands, this study provides a logical and coherent analysis of the ESG's role in the CAREC region's quest for sustainable development and suggests strategic implications for policy and practice.

9.3.2 Methodological Framework

The study's methodological framework is rooted in a multipronged approach that integrates archival research, a literature review, case study research, and comparative analysis to investigate the adoption and integration of ESG practices within the CAREC region. Archival Research involves the systematic examination of existing data, reports, and publications from credible sources, including institutional archives, to establish a historical context for ESG development in the CAREC region. This will help to identify the evolution of ESG standards and the current status of member countries. This literature review critically analyzes the existing academic and industry literature to gauge the importance of ESG for sustainable development. By synthesizing various perspectives on ESG factors, sustainable development, financial performance, and investment, we lay the groundwork for understanding the multifaceted impacts of ESG.

Further, this study delves into detailed case study analyses to explore the effectiveness of ESG policies, the role of government influence, corporate integration of ESG within performance analytics, and the socioeconomic impacts of these practices. We employ comparative research to evaluate ESG targets, digital finance, and green technology initiatives across different jurisdictions and sectors. By choosing China and Kazakhstan, this comparative perspective seeks to identify best practices, assess the socioeconomic impacts of ESG, and understand the nuances of ESG adoption in varying contexts within the CAREC region. Figure 9.1 shows the study's theoretical and methodological research framework, including the contents, processes, and methods used.

Figure 9.1: Theoretical and Methodological Research Framework



9.4 CASE STUDY: ESG DEVELOPMENT IN CHINA

China has been rapidly integrating ESG considerations into its economic fabric, and the Chinese government has played a pivotal role in this commitment. Thus, we examine ESG development in China. Specifically, we analyze how government measures foster ESG development in China and their impacts, scrutinize the ESG report disclosures of A-share listed companies, and investigate the implications of the carbon peak and carbon neutrality targets on ESG public funds.

9.4.1 Analysis of the Development and Importance of ESG in China

China's exceptional economic growth has engendered widespread admiration globally. Nonetheless, this remarkable growth trajectory comes with the responsibility of addressing critical ESG issues, given their significance in sustainable economic advancement. In the past decade, China has noticeably embraced ESG principles, with progressive inclusion in its policy frameworks, industrial guidelines, and corporate strategies, signifying a strong commitment to sustainable growth (Broadstock et al, 2021).

Several factors underlie the growing importance of ESG in China. First, knowledge on the interaction between ESG metrics and financial performance has grown. This knowledge has sparked interest among institutional investors who have acknowledged that companies with robust ESG performance often encounter fewer financial constraints, indicating a positive relationship between ESG performance and access to finance (Bai et al, 2022). Consequently, Chinese firms have focused on enhancing their ESG performance to attract investment and financing opportunities. Corporate scandals in recent years have exposed severe ethical and governance deficiencies in the country, bringing the 'G' in ESG into sharper focus. He et al (2022) show that firms with higher ESG performance have lower incidences of managerial misconduct, reinforcing the argument for comprehensive ESG implementation. Furthermore, the Ministry of Finance and CSRC have been proactively enhancing corporate governance standards. Through stringent regulations and oversight mechanisms, they have mandated greater transparency and accountability among companies, particularly regarding ESG disclosures. The heightened regulatory environment has catalyzed improvements in corporate governance, ensuring that companies adhere to legal and ethical standards.

Second, the Chinese government has become a strong advocate of green growth and the concept of an "Ecological Civilization." Such a policy stance encourages companies to not only adhere to environmental regulations but also make meaningful contributions to wider sustainability goals. The targets of the Chinese government to reach peak carbon emissions by 2030 and achieve carbon neutrality by 2060 further underscore the importance of integrating ESG factors into corporate strategies. To promote the societal perspective of ESG, the Chinese government has introduced measures that state-owned enterprises (SOEs) must follow. Chinese SOEs play a unique role, often serving as trend setters in the adoption of governmental policies. Thus, the Chinese government mandates that these entities comply with social responsibilities as part of their operational framework. This mandate is crucial, as SOEs set precedents for private-sector companies, demonstrating the practicality and importance of integrating social responsibility into corporate strategies.

Recent studies show a positive correlation between government policies and corporate ESG performance. According to Zhang et al (2023), companies that improve their ESG performance are more likely to receive government subsidies, suggesting a reward-based system to incentivize ESG adherence. Conversely, Nie et al (2023) highlight the challenges faced by firms in regions where local governments are under high debt pressure, leading to a decline in corporate ESG performance. These studies underscore

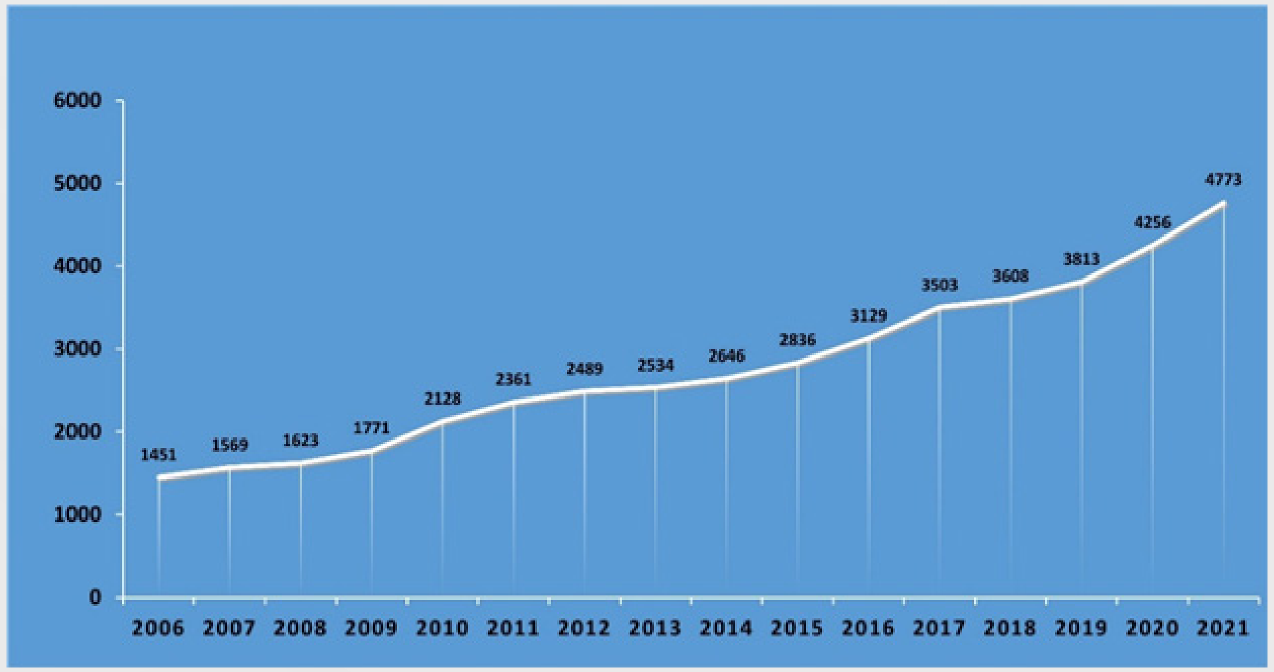
the significant impact of government policies and fiscal health on corporate ESG practices. Thus, the Chinese government's robust and multifaceted approach to ESG development, spanning environmental policy, corporate governance reform, and SOEs' compliance, is central to the integration of ESG principles into China's corporate landscape. This approach not only addresses existing ESG challenges but also paves the way for sustainable economic growth aligned with global sustainability goals.

9.4.2 ESG Report Disclosure among A-share Listed Companies in China

Figure 9.2 shows that ESG disclosures among Chinese A-share listed companies is increasing, and the increase is driven by regulatory changes coupled with a stronger emphasis on corporate transparency. Despite this positive momentum, the quality of ESG reports varies substantially, indicating inconsistencies in disclosure practices.

Notably, companies with higher ESG ratings demonstrate a reduced risk of stock price crashes, reflecting the protective function of ESG performance in financial markets (Feng, Goodell, & Shen, 2022). This underlies the importance of ESG disclosure in risk management and highlights the strategic value of transparency for investors and stakeholders.

Figure 9.2: Trend in the Number of ESG Reports from 2006 to 2021



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However, pressing challenges remain unaddressed. The absence of unified disclosure standards for ESG information in China might lead to the disclosure of low-quality information and inhibit data comparability. Combined with the existing lack of awareness and understanding of ESG concepts among Chinese firms, this issue can severely compromise the effectiveness of ESG disclosures in enhancing market transparency and efficiency (Chen & Xie, 2022).

In-depth research on the conditions of ESG disclosure in China further elaborates this predicament. According to Meng-tao et al (2023), ESG disclosure improves stock liquidity for enterprises, showcasing the financial benefits and market necessity of comprehensive ESG reporting. They suggest that improvements in ESG disclosures may increase in a company's stock trading volume and decrease stock price spread, making the stock more liquid and attractive to investors. Moreover, Chen et al (2023) scrutinize the interplay between ESG disclosures and the technological innovation capabilities of listed Chinese companies. They posit that ESG disclosures enhance a companies' technological innovation capabilities by fostering stakeholder trust and attracting more investment in research and development. This suggests that ESG disclosures directly and indirectly contribute to companies' economic growth and sustainability.

9.4.3 Carbon Peak and Carbon Neutrality Targets' Impact on ESG Public Funds in China

China's pledge to reach peak carbon emissions by 2030 and carbon neutrality by 2060 has far-reaching implications for the country's ESG landscape. These ambitious targets necessitate a large-scale shift towards low-carbon industries and technologies, thrusting ESG to the forefront of public fund investment strategies. ESG public funds play a crucial role in mobilizing the immense capital required for this transition. The carbon neutrality target has magnified the importance of green finance, prompting a substantial flow of investment into ESG-aligned projects. ESG investing is found to deliver comparable, if not superior, financial performance when juxtaposed with traditional investing, further stimulating the growth of ESG public funds in China (Zhang, Zhao, & He, 2022).

Digital finance has also begun to influence ESG financing in China. Digital finance platforms can augment ESG performance by improving access to financing, enhancing transparency, and offering innovative solutions to sustainability challenges. Chang et al (2023) show that companies with strong ESG performance and a high level of digital finance can achieve more efficient corporate financing. Thus, ESG development in China is a dynamic and multifaceted process that has become an integral component of the strategic planning of corporations, financial institutions, and governments. However, significant strides must be made to enhance ESG disclosure practices, increase ESG awareness, and nurture the growth of ESG investment. The commitment to achieve carbon neutrality presents both formidable challenges and exciting opportunities for ESG development in China, emphasizing the critical role of ESG in shaping the country's sustainable future.

9.5 CASE STUDY: ESG DEVELOPMENT IN KAZAKHSTAN

9.5.1 Steps Towards Sustainable Development and ESG Reporting in Kazakhstan

Over the past few years, Kazakhstan has made significant strides towards achieving sustainable development and enhancing its ESG reporting framework. The Kazakhstan Stock Exchange's (KASE) move to join the United Nations Sustainable Stock Exchanges (UN SSE) initiative underscores the nation's commitment to creating sustainable and transparent markets (Азретбергенова, Есымханова, & Есенали, 2023). The UN SSE initiative is a peer-to-peer learning platform for exploring how exchanges can collaborate with investors, regulators, and companies to enhance corporate transparency regarding ESG issues and encourage sustainable investments. By joining this initiative, KASE shows its intent to foster corporate transparency and contribute to creating a sustainable global financial system. Participation in the initiative not only sets the stage for the promotion of sustainable business practices, but also provides opportunities for Kazakhstan to learn from the experiences of other countries and adopt internationally recognized best practices.

Simultaneously the methodology for ESG report preparation in Kazakhstan is progressing towards alignment with international standards. This alignment, which often encompasses adopting standardized reporting formats and adhering to globally recognized disclosure guidelines, not only enhances transparency, but also facilitates comparisons across companies and countries, thus promoting fairness and boosting investor confidence. According to PwC Kazakhstan (2023), the quality of ESG information disclosure in Kazakhstani company reports is improving. The average score for the top 50 reports at the end of 2020 is 5.1 points, up from 4.6 points at the end of 2019. This growth is facilitated by the support of regulators, primarily exchange regulators, and the efforts of individual companies. The most noticeable improvement in disclosure quality is observed in the "Sustainable Development Management" block, where the description of ESG policies, approaches, and disclosure of a strategy regarding sustainable development is evaluated (PwC Kazakhstan, 2023).

However, achieving ESG compliance has been a challenge. As Barkemeyer, Revelli, and Douaud (2023) argue, selection bias in ESG controversies pose a significant risk to sustainable investors. The crux of this argument is that investors, often guided by the information disclosed in ESG reports, may inadvertently support companies involved in controversial activities if they are not sufficiently covered in the reports. This underscores the need for complete transparency in ESG reporting and highlights the potential consequences of bias or omissions.

9.5.1.1 ESG Report Preparation Methodology in Kazakhstan

In Kazakhstan, the methodology for preparing ESG reports is developed by KASE, with the support of the International Finance Corporation (IFC). This initiative is part of KASE's accession to the UN SSE initiative, which aims to strengthen cooperation between exchanges, investors, and regulators (Karassaeyev, 2018). This methodology provides guidance on preparing ESG reports and aims to help form appropriate corporate governance and risk management systems in companies. It also aims to improve Kazakhstan's investment climate by enhancing the attractiveness of companies to foreign investors, ensuring long-term sustainable investment, and raising the level of disclosure. Furthermore, this methodology is expected to contribute to the implementation of the UN Sustainable Development Goals in Kazakhstan (Karassaeyev, 2018) and supplements KASE's requirement for the disclosure of information in the annual report of a listed company. It guides joint-stock companies and limited liability companies in preparing ESG reports. It is intended for listed companies regardless of their size, industry, or location, as well as for members of the exchange of all membership categories. However, other stakeholders may also use this methodology to prepare their respective reports (Karassaeyev, 2018).

The methodology, which is based on IFC standards for ESG practices (Karassaeyev, 2018), follows the model Guidance for the UN SSE initiative to present ESG Reports to investors and contains the international best practices for preparing ESG Reports. It includes the global reporting initiative, International Integrated Reporting Council, Sustainability Accounting Standards Board, and other similar initiatives among stock exchanges within the framework of UN SSE Initiative, including those in Malaysia, Brazil, Singapore, and Hong Kong.

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9.5.1.2 Compliance with International Standards

The ESG report preparation methodology in Kazakhstan is designed to comply with international standards and provides guidance on the disclosure of ESG information along with financial information. The use of integrated reports allows for an adequate assessment of a company's future performance and effectiveness, enabling more informed decisions in the long run (Karassaeyev, 2018). The methodology provides guidance on the content of ESG reports, which should include the company's overall vision and strategy regarding the management of significant environmental and social impacts of the company or those that can be linked to its operations because of its relations with third parties (suppliers, population, and various organizations) (Karassaeyev, 2018). Furthermore, ESG reports should disclose the operations and performance indicators of the company and of any entity in which the company owns at least 50% of the total outstanding shares or the paid authorized capital of such an entity. The results of operations, expressed in quantitative terms, should include information on the controlled companies that do not consider minority interests. Information on affiliated, but not consolidated companies, should be provided in the volume necessary to explain the ESG strategy and performance of the company (Karassaeyev, 2018).

This methodology emphasizes the importance of compliance with environmental requirements. The company provides information on its compliance with environmental legislation requirements, the total amount of fines, and the number of cases of non-financial sanctions, including the limited sanctions applied to the company during the reporting year for violating environmental requirements, the number of claims submitted against the company during the reporting year for environmental impact, the nature of such violations, sanctions, and claims, and information on their settlement (Karassaeyev, 2018).

9.5.2 ESG Disclosures and Corporate Social Responsibility

Growth in ESG disclosures is closely linked to the rise of corporate social responsibility (CSR) in Kazakhstan. Companies are increasingly realizing the importance of engaging in socially responsible activities and incorporating ESG factors into their annual reports (Азретбергenova et al, 2023). The integration of ESG factors into annual reports demonstrates the growing awareness and application of ESG criteria, signaling a shift towards sustainable business models. This practice also sends a strong message to stakeholders, including investors, about the company's commitment to sustainability. The increase in CSR in Kazakhstan’s business landscape has several potential benefits. Beyond contributing to sustainable development, CSR enhances a company's reputation, helps manage risks, and strengthens relationships with stakeholders (Serikakhmetova & Adambekova, 2022). Kenzhebulatov (2022) finds a positive correlation between CSR and the financial wealth of Kazakhstani companies. Thus, adopting CSR practices not only supports sustainability but also contributes to economic success.

9.5.3 Quality Assurance and Future Trends

As ESG reporting evolves, quality assurance and robust regulatory mechanisms become crucial to further ESG development. Reflecting on Omirbayev et al’s (2021) study on the national model of quality assurance of education in Kazakhstan, we can apply a similar approach to ESG practices. Assuring the quality of ESG reports requires a comprehensive and transparent framework, clear guidelines, and robust monitoring mechanisms. By aligning with international standards, Kazakhstan can instill confidence among investors and stakeholders while also promoting ESG compliance among local companies.

PwC Kazakhstan (2023) has a series of evaluation criteria that focus on the quality and availability of ESG information in reports of Kazakhstani companies. The analysis is based on annual reports and sustainability reports (or their equivalents, including integrated reports and sustainability and social responsibility reports), collectively referred to as “Reports.” The reports prepared by companies based on the results of their activities in 2021 are evaluated. The evaluation criteria include four main disclosure pieces, collectively referred to as the “Analysis of the Four”: sustainable development management, social policy, environmental impacts, and corporate governance.

Additional scores are awarded for the clarity and quality of information. This approach includes an analysis of the availability of quantitative indicators that reflect the impact of an organization's activities on social and environmental aspects. We also focus on the disclosure of strategies policies, and the integration of sustainable development issues into the corporate governance system. Any Kazakhstani company with a suitable report can participate in this project. The sample, which comprises 98 companies operating in Kazakhstan includes companies that submitted official applications, and the ratings are taken from public reports in the year 2021. Tables 9.1 and 9.2 show companies rated “B” or higher with regards to their ESG disclosure level (PwC Kazakhstan, 2023).

Table 9.1: Top non-financial companies by ESG disclosure level

Position	In overall ranking	Company	Rating
1	1	NAC Kazatomprom	A
2	2	NC KazMunayGas	B+
3	3	KazTransOil	B+
4	4	Kazakhtelecom	B+
5	5	AC Altynalmas	B+
6	6	Samruk-Energy	B+
7	7	Joint venture Inkai	B
8	8	Karachaganak Petroleum Operating B.V.	B
9	9	KEGOC	B
10	10	NOSTRUM OIL & GAS PLC	B
11	11	CAEP	B
12	12	NC Kazakhstan Temir Zholy	B

Table 9.2: Top financial companies by ESG disclosure level

Position	In overall ranking	Company	Rating
1	5	KazAgroFinance	B+
2	10	Halyk Bank of Kazakhstan	B
3	11	NMH Baiterek	B
4	13	Kazakhstan Housing Company	B

Although Kazakhstan has made significant strides through the enhancement of ESG reporting, adoption of CSR practices, and the establishment of quality assurance measures, ESG development clearly remains in its early stages. To drive sustainable growth and align with global best practices, Kazakhstan needs to make continuous efforts and remain committed to ESG principles. Economic growth and sustainability need to be balanced to ensure that future development is inclusive, environmentally friendly, and economically viable.

9.6 IMPLICATIONS FOR THE CAREC 2030 STRATEGIC FRAMEWORK

Given the evaluation of the ESG principles' evolution and impact in China and Kazakhstan, we investigate the implications for the CAREC 2030 strategic framework. We examine how our findings bolster the framework, outline pathways to endorse strong ESG practices, highlight the significance of organizational resilience, and proffer tangible measures for realizing CAREC 2030 goals.

9.6.1 Insights from China and Kazakhstan's ESG Landscape

China and Kazakhstan’s ESG landscapes offer valuable insights into the CAREC 2030 strategic framework. By further analyzing the cultural, historical, and geographical reasons why China and Kazakhstan adopt different ESG methods, we provide a detailed basis for countries to learn from and develop their own ESG methods according to local conditions. An in-depth understanding of these landscapes not only elucidates the potential for ESG practices to drive economic resilience and growth but also provides practical examples to guide future development.

Xue et al (2023) highlight how local government centralization under China's county-to-district reform positively influences corporate ESG performance, suggesting a strong link between governance structure and ESG effectiveness. He et al (2022) illustrate the governmental focus on curbing managerial misconduct, which is critical for reinforcing the governance aspect of ESG. Moreover, the Chinese model underscores the value of public-private partnerships in fostering ESG compliance. Government initiatives, such as the green finance Initiative, are complemented by corporate efforts to achieve sustainability targets. China's progress in integrating ESG factors into its economic fabric, bolstered by strong regulatory support and oversight, showcases the merits of adopting a policy-backed ESG model. Culturally, China's ESG implementation reflects Confucian values of harmony and collective welfare (Liu et al, 2023). These values underpin the social dimension of ESG and encourage companies to align their strategies with broader societal goals. Geographically, China's diverse landscape, ranging from industrial hubs to rural areas, necessitates region-specific ESG approaches, especially in environmental management (Liu et al, 2023).

Kazakhstan's ESG journey reveals how a resource-rich country can address unique ESG-related challenges while striving for sustainable development. Kazakhstan, with its post-Soviet transformation and rich natural resources, has a contrasting ESG narrative. Geographically, Kazakhstan's vast terrain and resource richness pose unique environmental challenges and opportunities, necessitating tailored ESG strategies that balance economic growth with ecological preservation (Serikakhmetova & Adambekova, 2022). Furthermore, Kazakhstan's historical trajectory influences its current ESG practices, with significant emphasis on evolving from resource dependence to a more diversified and sustainable economy (Serikakhmetova & Adambekova, 2022).

Traditional norms and a growing global outlook shape Kazakhstan's ESG approaches, particularly in social governance and corporate responsibility. As Kazakhstan works towards improving its governance structures, promoting social equality, and preserving the environment, its situation provides a distinct viewpoint on the synergies between sustainability and economic growth. Kazakhstan's progress in ESG reporting and corporate governance highlights the value of transparency and accountability for enhancing ESG practices. Learning from Kazakhstan's experience, CAREC countries can tailor their approaches to unique economic and social contexts to foster sustainable economic integration.

9.6.2 Strengthening ESG Practices and Corporate Sustainability

A critical pathway to realizing the goals of the CAREC 2030 Strategic Framework is to amplify the adoption and practice of ESG principles within the regional bloc. This enhancement requires the coordinated efforts of various stakeholders, including governments, businesses, and financial institutions. We explore strategies to cultivate these practices, from the development of policy incentives and public awareness to the sophistication of ESG reporting standards, with a specific focus on the experiences and lessons learned in China and Kazakhstan.

9.6.2.1 The Interplay of Government Policies and Corporate Strategies in Promoting ESG

Governments and corporations play crucial roles in advancing ESG practices. While government policies create a legal and regulatory environment for ESG integration, corporate strategies determine how these principles are actualized in business operations.

9.6.2.1.1 Role of Government Policies

Governments drive ESG adoption. They create enabling environments through regulatory measures, promote transparency, and monitor ESG compliance. The lessons learned in China and Kazakhstan underscore the effectiveness of government policies in shaping ESG practices. On the one hand, China's approach to ESG integration is instructive. The Chinese government provides economic incentives for ESG compliance through policy initiatives such as the green finance initiative. For example, the government supports corporations in adopting green technologies and practices through subsidies, tax benefits, and loans at lower interest rates. This approach fosters an environment in which corporations view ESG practices not just as regulatory requirements but also as strategic opportunities for long-term growth. The government also penalizes firms that fail to adhere to ESG standards. This underscores the need for strong regulatory frameworks that punish noncompliance, thereby reinforcing the economic consequences of ignoring ESG considerations.

On the other hand, Kazakhstan's experience also offers insightful lessons. Despite being resource rich, the government is diversifying its economy and promoting sustainable development. The government has formulated policies to improve corporate governance, promote transparency, and encourage the adoption of sustainable practices. For example, Kazakhstan's government has introduced regulations requiring companies, particularly in extractive industries, to disclose their ESG performance. This requirement encourages companies to implement sustainable practices and provide investors with the necessary information to make informed decisions.

9.6.2.1.2 ESG Integration in Corporate Strategy

The corporate sector is pivotal in actualizing ESG principles. Companies must understand that ESG strategic value extends beyond regulatory compliance. They create long-term value for all stakeholders by integrating ESG considerations into strategic planning and daily operations. Many Chinese companies have integrated ESG principles into their strategies and have aligned them with the national agenda. They have created sustainability departments, invested in green technologies, and actively sought to reduce their environmental footprints. Businesses also engage with various stakeholders, including employees, customers, and communities to address ESG-related issues effectively. For instance, Chinese companies have programs to improve worker

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welfare, initiate community development projects, and responsibly source materials. Meanwhile, Kazakhstani companies, particularly those in extractive industries, face challenges related to environmental preservation and social inequality; although, many are integrating ESG principles into their strategies. For example, Kazakhstani companies have introduced measures to reduce emissions, manage waste responsibly, and improve worker safety. They have also sought to improve their corporate governance structures and foster transparency.

9.6.2.2 Financial Institutions as a Catalyst for ESG Integration

Financial institutions can significantly influence the ESG landscape. They can promote sustainable business models and direct capital towards sustainable projects. Thus, we elucidate the role of financial institutions in China and Kazakhstan in advancing ESG integration. The Chinese financial sector plays a crucial role in promoting ESG principles. Financial institutions are increasingly integrating ESG considerations into their lending and investment decisions. For example, some banks offer lower interest rates to businesses that demonstrate robust ESG performance. Similarly, investment firms actively invest in companies committed to ESG principles. Meanwhile, the role of Kazakhstani financial institutions in ESG integration is still evolving; although, the importance of sustainable finance is increasingly being recognized. Some banks have started offering green loans to businesses implementing environment-friendly projects, whereas investment firms have considered ESG factors in their investment decisions.

Moreover, Chinese and Kazakhstani financial institutions can leverage their financial clout and encourage corporations to comply with the ESG standards by introducing stricter lending criteria or preferentially investing in businesses that adhere to robust ESG standards. Overall, the promotion of ESG practices and corporate sustainability is a complex and multifaceted endeavor that requires the concerted efforts of governments, corporations, and financial institutions. The experiences and lessons from China and Kazakhstan provide valuable insights that can inform and guide other CAREC countries during their journey towards ESG integration. By strengthening ESG practices, CAREC countries can foster sustainable development and build resilience against social, environmental, and economic challenges.

9.6.3 Building Resilience in the Face of Global Challenges

Organizational resilience-the ability of a business to adapt, recover, and grow in the face of stressors and shocks-has gained significant importance against the backdrop of escalating global crises. Organizations worldwide are confronting issues of unprecedented complexity and scale—from the COVID-19 pandemic to the urgent challenges posed by climate change. ESG principles play a crucial role in enhancing organizational resilience by promoting sustainability. Organizations that incorporate strong ESG practices often demonstrate a superior ability to withstand and adapt to crises. Their proactive risk management, inclusive decision-making, and significant investment in human and environmental capital prepare them to face both predictable and unpredictable challenges. In the context of the CAREC 2030 strategic framework, building resilience through ESG principles can lead to sustainable economic growth. Thus, we focus on the experiences and lessons from China and Kazakhstan in bolstering organizational resilience through ESG principles and discuss potential strategies to achieve the CAREC 2030 objectives.

9.6.3.1 Organizational Resilience and ESG: Lessons from China and Kazakhstan

9.6.3.1.1 China: Building Resilience through Policy-Driven ESG Practices

In China, ESG integration is an effective strategy for building organizational resilience. Policy initiatives, such as the green finance Initiative and mandatory ESG disclosures, create an environment that encourages and rewards the adoption of ESG practices. This approach not only fosters a more sustainable economy but also equips businesses to navigate challenges effectively. For example, Chinese companies that prioritize environmental sustainability are better prepared to manage the regulatory risks associated with China’s increasingly stringent environmental regulations. By proactively reducing their carbon footprint, these companies benefit from cost savings in energy consumption, enhanced reputation, and increased competitiveness, which contribute to organizational resilience. Additionally, Chinese companies with robust social practices have demonstrated resilience during crises. Those with good labor practices and strong community ties have been better equipped to manage workforce disruptions during the COVID-19 pandemic. They have maintained operations and recovered faster, illustrating how the social aspects of ESG contribute to resilience.

9.6.3.1.2 Kazakhstan: Overcoming Challenges through ESG Integration

In Kazakhstan, ESG principles have been progressively incorporated into organizational strategies, aiding in building resilience. Despite being a resource-rich country, Kazakhstan faces challenges in economic diversification, governance, social equality, and environmental preservation. Kazakhstani companies, particularly those in the oil and gas sector, have begun to realize that ignoring ESG risks can lead to reputational damage, legal liabilities, and financial losses. By adopting ESG practices, they have taken proactive steps to manage these risks. For example, several mining and oil companies have introduced measures to reduce their environmental impact and improve worker safety, effectively managing potential environmental and social risks. Moreover, the country's introduction of ESG reporting standards has encouraged companies to improve their governance structures, enhancing their resilience. Companies with good governance practices tend to have better risk management, decision-making processes, and stakeholder relationships, which are all critical for enhancing resilience.

9.6.3.2 Strategies for CAREC 2030: Enhancing Resilience through ESG Integration

China and Kazakhstan's experiences provide valuable insights for other CAREC countries to enhance their resilience through ESG integration, including promoting ESG practices through policy measures, integrating ESG into corporate strategies, and leveraging the role of financial institutions. CAREC countries can introduce policy measures to encourage ESG integration. Mandatory ESG disclosures, tax incentives for sustainable practices, and penalties for noncompliance can foster a region-wide shift towards sustainable development. These policies not only promote ESG practices, but also prepare businesses to manage regulatory and other related risks, thereby enhancing resilience. Furthermore, businesses in other CAREC countries can integrate ESG principles into their corporate strategies. They can invest in green technologies, improve labor practices, enhance governance structures, and engage with communities. These practices not only contribute to sustainable development but also enable businesses to anticipate and manage a wide array of risks, boosting resilience. Moreover, following the example of financial institutions in China, financial institutions in other CAREC countries can help promote ESG practices. By integrating ESG considerations into lending and investment decisions, these institutions can push businesses towards sustainable practices and enhance their resilience.

Therefore, the incorporation of ESG principles helps build organizational resilience and achieve the objectives of the CAREC 2030 strategic framework. The experiences and lessons learned from China and Kazakhstan underscore the importance of ESG integration in fostering resilience and offer valuable insights for other CAREC countries. CAREC nations can achieve a shared vision of sustainable economic integration and ensure resilience in the face of global challenges.

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9.6.4 Recommendations for CAREC 2030

Drawing on ESG developments in China and Kazakhstan, several recommendations have emerged for the CAREC 2030 strategic framework such as bolstering policy frameworks, promoting ESG education, and enhancing cross-border collaborations. Building on China's success, other CAREC countries should consider developing robust ESG policy frameworks. Regulations mandating ESG disclosures, fiscal incentives for sustainable practices, and penalties for non-compliance can encourage a region-wide shift towards ESG integration. This approach, coupled with strong governance and monitoring mechanisms, can ensure accountability and facilitate successful implementation of ESG principles.

As such, the importance of education and awareness cannot be overstated. Providing regular training for business leaders and employees, launching public awareness campaigns, and integrating ESG principles into educational curricula foster a sustainable corporate culture. Additionally, increased awareness stimulates public demand for more sustainable products and services, thus reinforcing the business cases for ESG integration. Cross-border collaboration between CAREC countries allows them to learn from each other's experiences, share best practices, and align strategies to address common challenges. Moreover, joint research initiatives, technological exchanges, and investor dialogue provide forums for exploring novel solutions and fostering a collective approach to ESG integration. Therefore, the integration of ESG principles in China and Kazakhstan has substantial implications for the CAREC 2030 strategic framework. By promoting effective ESG practices and corporate sustainability, CAREC countries can achieve economic integration and sustainable development. Furthermore, the importance of organizational resilience underscores the pivotal role of ESG principles in ensuring economic stability in an increasingly volatile world.

9.7 CONCLUSION

This study examines the ESG principles in China and Kazakhstan and their implications for the CAREC 2030 strategic framework. It explores strategies to foster effective ESG practices, enhance organizational resilience, and provide specific recommendations to achieve the CAREC 2030 objectives.

9.7.1 Summary of Main Findings and Their Implications

The analysis of ESG practices in China and Kazakhstan sheds light on how they have incorporated ESG principles into their economic strategies, revealing distinct patterns and critical insights. In China, the government plays a significant role in propelling ESG practices through policy initiatives. Stringent regulatory frameworks and mandatory ESG disclosures have driven Chinese corporations to adopt ESG principles, fostering economic growth and sustainability. Thus, we find that Government incentives clearly motivate corporations to integrate ESG principles into their strategies, thereby demonstrating the power of effective policies. Meanwhile, Kazakhstan offers a unique perspective for addressing ESG-related challenges. The country's efforts towards ESG integration, while addressing governance, social equality, and environmental preservation issues, provide a practical framework for balancing sustainability with economic growth. The introduction of ESG reporting standards and efforts to improve corporate governance are critical steps towards fostering sustainable economic integration in the region. Our findings indicate that the effective integration of ESG principles into governmental policies and corporate strategies creates a resilient and sustainable economic environment. They also underscore the pivotal roles of governments, corporations, and financial institutions in advancing ESG practices and driving economic growth and sustainability.

9.7.2 Possible Solutions for Identified Issues

This study provides solutions to several issues through examining the experiences of China and Kazakhstan. We find that government policies are significant in driving ESG practices. Governments can incentivize businesses to integrate ESG principles into their strategies through tax benefits, subsidies, and efficient monitoring systems. In contrast, penalties could be levied on corporations that fail to meet ESG standards. Additionally, governments could foster an ESG-friendly environment by enhancing transparency and implementing mandatory ESG reporting and further expand the number of companies adopting ESG through government policy measures and monitoring ESG compliance. CAREC can build a platform for member countries to learn from each other's experiences, share best practices, and cooperate to address common challenges.

Additionally, the role of financial institutions in endorsing ESG investing and adjusting their lending practices in line with ESG principles cannot be overlooked. Investment decisions can influence corporate behavior and direct capital towards sustainable projects. Companies should recognize the strategic value of ESG principles in creating long-term value for all stakeholders. They can integrate ESG principles into their strategic planning and operations, thus actively identifying and addressing ESG-related issues through stakeholder engagement.

9.7.3 Future Research Directions

This study uncovers several promising avenues for future research. In the future, a comparative study of ESG practices in other CAREC countries could be conducted to provide a more comprehensive understanding of ESG integration in this region. This might uncover unique challenges and opportunities for ESG integration and contribute to a broader strategy for achieving the CAREC 2030 goals. Furthermore, future studies could comprehensively examine the specific mechanisms through which government policies foster ESG practices. They could help identify the most effective policy measures for promoting ESG integration and sustainable economic growth. Lastly, future research could investigate the impact of corporate culture and leadership on ESG integration. A closer examination of how corporate leaders can drive ESG practices could yield valuable insights into promoting sustainable corporate cultures.

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CHAPTER 10

SUSTAINABLE TRADE BRIDGES

Potential Prosperity for Pakistan and Uzbekistan in the CAREC Region

Adeel Kadri and Muhammad Musa

10.1 INTRODUCTION

Pakistan's economy has witnessed a number of golden days and dark nights since its independence in 1947. The country's rapid economic progress in the 1960s was appreciated worldwide. Many countries used the example of Pakistan's economic progress to guide their own development. Subsequently however, Pakistan faced a series of setbacks that diminished its pace of economic development. Despite its high geographic potential, the country's economic growth rate has stagnated. Pakistan is richly endowed with natural resources that have unfortunately remained largely untapped.

One of the biggest obstacles to realising the country's potential has been its security situation. However, the country's economy has shown great resilience, and has demonstrated the ability to bounce back after each setback. Foreign investors have regained their faith in the country's potential, and investment capital has begun to reenter the country. Pakistan's allies have demonstrated satisfaction and ease in collaborating with the country, and the process of development has been restarted. Another serious issue faced by Pakistan is climate change. Pakistan has proved to be extremely vulnerable to climate change. This has caused extreme weather events to occur regularly in the country, resulting in severe economic losses and loss of life. Pakistan is actively seeking sustainable green trade partnerships, while focusing intently on carbon emissions during production and trade transit.

Uzbekistan is similar to Pakistan in many respects. Uzbekistan is a relatively younger state than Pakistan, as it regained its independence after the dissolution of the USSR in 1991. Uzbekistan continues to explore various avenues for sustainable economic development through regional trade. Similar to Pakistan, Uzbekistan is also vulnerable to climate change. Consequently, the country faces the threat of recurring droughts, high temperatures, heat waves, heavy precipitation, mudflows, floods, and avalanches. Pakistan was among the first states to recognise Uzbekistan as an independent state in 1991. The first state visit from the Prime Minister Mian Muhammad Nawaz Sharif, and the subsequent return visit of Uzbekistan's president, Islam Karimov in 1992 laid the foundation for harmonious bilateral relations between the two countries (PBC, 2017).

There is considerable untapped potential for bilateral trade between Pakistan and Uzbekistan, and it is imperative for both countries to realise it sustainably. If prioritised, the products traded globally by Uzbekistan and Pakistan can have significant potential for bilateral trade. There is also need for genuine steps to be taken towards a greener route to bilateral trade development. Both countries need to prioritise ground-based routes for trade that are both environmentally friendly and sustainable.

10.2 ISLAMIC REPUBLIC OF PAKISTAN

Surrounded by Iran in the west, Afghanistan in the northwest, India in the east, and China in the north, Pakistan is located in the heart of South Asia. The country was founded on 14th August 1947, following the exit of the British from the Indian Subcontinent. Its southern border touches the Arabian Sea that provides it access to numerous seaports. The geographical location of the country is ideal for the enhancement of trade in the region.

Pakistan faced a deteriorating state of national security that hindered its economic growth for more than a decade. Despite success in tackling economic threats, the country continues to face the threat of climate change-induced extreme weather events due to increased carbon emissions in the region. Pakistan is not a significant contributor to global warming, but is on a high-growth trajectory of carbon emissions linked to high fossil fuel use (WorldBank, 2022). Pakistan is making efforts to reduce its carbon emissions and is actively seeking sustainable trade partnerships. Pakistan offers the shortest land route to the Central Asian Republics (CARs) to access the Arabian Sea for trade: 2600 km via Afghanistan compared to Iran (4500 km) and Turkey (5000 km) (TDAP, 2021).

Pakistan has a coastline of 1046 km along the Arabian Sea with several large and small ports. The most notable seaports in Pakistan are the Karachi, Bin Qasim, and Gwadar seaports, shown in Figure 10.1.

Figure 10.1: Pakistan's Major Ports

Source: Nations Online Project

Karachi Port is a large-scale deep-seaport operating along Pakistan's Arabian Sea coastline. The port handles nearly 60% of all national shipments. It has been in operation since the early 18th century. Presently, the port comprises 32 km of wharves and docks. The anchorage depth is 16 m, with 41 berths and 8 wharves available for commercial vessels. Karachi also hosts another major seaport, Bin Qasim Port. The Bin Qasim port is the second largest port in Pakistan and one of the top 150 ports in the world. It is a 50 square kilometer wide, deep-seaport constructed in an artificial harbour in the Sindh Province. It handles approximately 35% of the total maritime trade through Pakistan. Another prominent seaport in Pakistan is Gwadar port, situated in Balochistan Province and in close proximity to Iran's Chahbahar port. Gwadar is key to the trade transit of Pakistan-Afghanistan, and is a hub in the proposed China-Pakistan Economic Corridor (CPEC). The port is linked to the Maritime Silk Road and Belt & Road Projects (MarineInsight, 2021).

10.2.1 China-Pakistan Economic Corridor (CPEC)

Over the past decade, Pakistan has accelerated its diplomatic activities and achieved several remarkable milestones deemed essential to the development of the country's economy. The biggest feat of the previous decade is the CPEC, which is a framework of regional connectivity. This development project aims to connect the Gwadar Port of Pakistan to China's northwestern region of Xinjiang via a network of highways, railways, and pipelines. The economic corridor is projected to run approximately 2700 km from Gwadar to Kashghar. With further expansion, the corridor will provide access to Pakistani seaports to other countries in the region. The CPEC will not only benefit China and Pakistan, but will also have a positive impact on the economies of Iran, Afghanistan, the CARs, and the region in general. The enhancement of geographical linkages requires improved road, rail, and air transportation systems with frequent and free exchanges of growth stimuli. This will promote people-to-people contact and enhance understanding

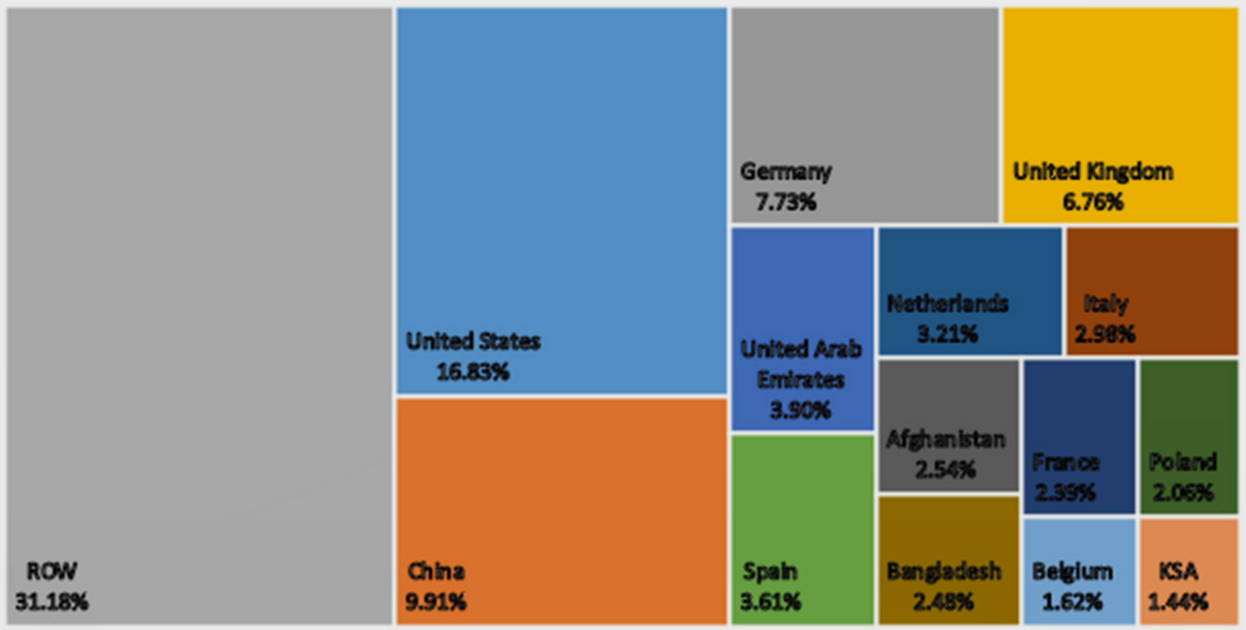
through the exchange of academic, cultural, and regional knowledge. It will eventually lead to higher volumes of flow of trade and business, and enhancement of cooperation by win-win model resulting in well connected, integrated region of shared development. The CPEC is a significant part of the journey towards economic regionalisation in a globalised world. Pakistan has been actively striving to establish a diplomatic front to attract more countries to join the corridor. The CARs have always been on Pakistan's radar, and in the last few years, Pakistan's interest in coordinating with CARs has risen significantly. The CARs have considerable untapped potential because of their landlocked positioning. Their access to the sea is limited, compelling them to use ports situated in, and managed by other countries. Doing so adds to the cost of their products and harms the country in competitive markets. In its search for perfect partners, the government of Pakistan has shown increased interest in collaborating with the Republic of Uzbekistan.

10.2.2 Pakistan's Trade

Over the years, Pakistan has reached a number of bilateral and mulilateral trade agreements that have proven to be beneficial to the country's trade and economy (See Table 10.1). Pakistan's exports were worth USD 32.7 billion in 2021, ranking it at 66th position among global exporters. Between 2016 and 2021, Pakistan's exports increased by USD 7.11 billion from USD 25.6 billion to USD 32.7 billion.

In declining order, the topmost export categories in 2021 were: House Linen (USD 4.63 billion), Rice (USD 2.26 billion), Non-Knit Men's Suits (USD 2.03 billion), Knit Sweaters (USD 1.5 billion), and Non-Knit Women's Suits (USD 1.37 billion). The most common destination for Pakistan's exports in 2021 were the United States (USD 5.51 billion), China (USD 3.25 billion), Germany (USD 2.53 billion), United Kingdom (USD 2.21 billion), and United Arab Emirates (1.28 billion). Please see Figure 10.2 below.

Figure 10.2: Pakistan’s Export Partners 2021 (%)

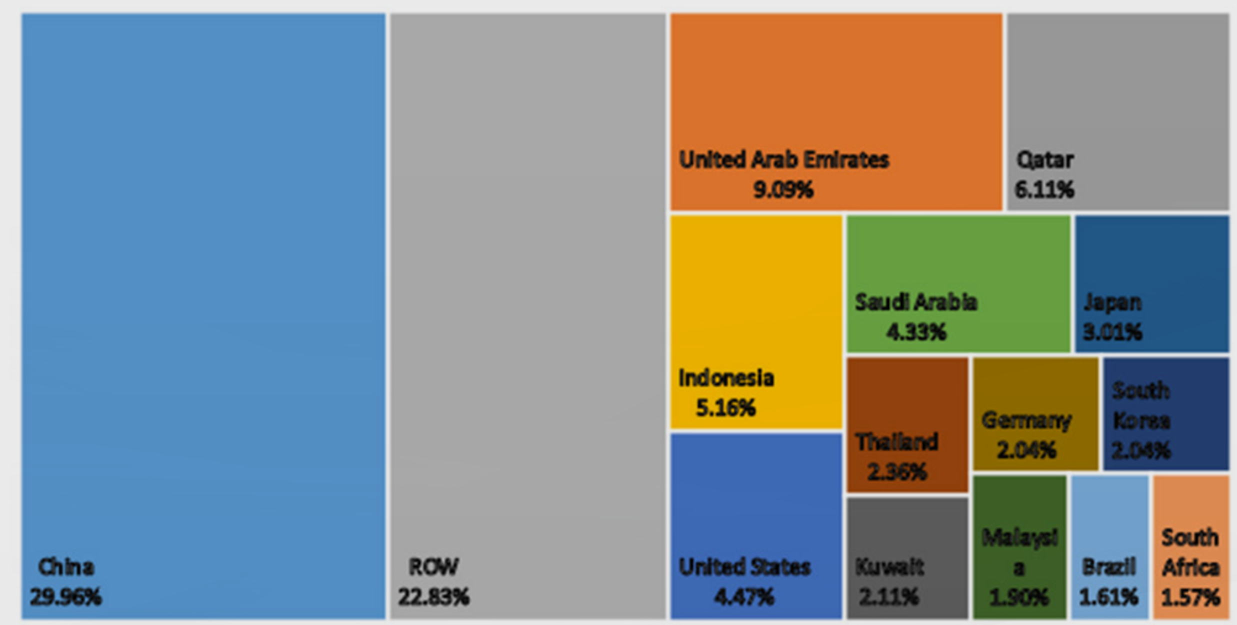


Source: (OEC, 2021)

Pakistan imported goods and services worth USD 78.5 billion in 2021, ranking it as 47th among the world’s import destinations. Pakistan’s imports were enhanced by USD 26 billion from USD 52.5 billion in 2016 to USD 78.5 billion in 2021.

In 2021, Pakistan’s imports were led by Refined Petroleum (USD 6.58 billion), Petroleum Gas (USD 6.41 billion), Crude Petroleum (USD 3.53 billion), Palm Oil (USD 3.36 billion), and Vaccines, blood, antisera, toxins and cultures (USD 3.06 billion). The most common import partners for Pakistan in the year 2021 were China (USD 23.5 billion), United Arab Emirates (USD 7.13 billion), Qatar (USD 4.8 billion), Indonesia (USD 4.05 billion), and the United States (USD 3.51 billion). Please refer to Figure 10.3.

Figure 10.3: Pakistan’s Import Partners 2021 (%)



Source: (OEC, 2021)

Table 10.1: Trade Agreements of Pakistan

Title	Year Signed
Pak-Sri Lanka Free Trade Agreement	2002
Trade & Investment Framework Agreement (TIFA)between Pakistan and USA	2003
Pak-Iran Preferential Trade Agreement	2004
Agreement on South Asian Free Trade Area	2004
Pak-China Free Trade Agreement in Goods and Investment	2006
Pakistan Malaysia Free Trade Agreement (FTA)	2007
Pak-Mauritius Preferential Trade Agreement	2007
Pak-Afghanistan Transit Trade Agreement	2010
Pak-Indonesia Preferential Trade Agreement	2012
Pakistan-Tajikistan Transit Trade Agreement	2022
Pakistan-Türkiye Trade in Goods Agreement	2023
Pakistan-Uzbekistan Preferential Trade Agreement (PTA)	2023

Source: (MOC, 2023)

10.3 REPUBLIC OF UZBEKISTAN

Uzbekistan is one of the only two double landlocked countries in the world. The only other country is Liechtenstein in Western Europe. A country is considered double landlocked when all its neighbouring countries are also landlocked. In case of Uzbekistan, it is surrounded by Afghanistan, Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan.

Being surrounded by landlocked countries means that any transit shipment must cross at least two countries to reach its destination. Together with its four other 'stan' neighbouring countries, Uzbekistan is referred as the 'Central Asian Region', which is of high geostrategic importance in terms of trade, politics and abundant natural resources. Uzbekistan needs sustainable green trade partnerships that will help reduce its carbon emissions during production and trade transit. The country is vulnerable to climate change and faces threats of drought, high temperatures, heat waves, heavy precipitation, mudflows, floods, and avalanches. Uzbekistan is vulnerable to water shortages that are worsened by climate change, as 80% of its water comes from sources outside the country. It also faces threats of land degradation, soil salinization, reduced water quality, wind and water erosion, and decreased productivity of arable land (UNDP, 2023). For initiating private infrastructure investments in Uzbekistan, legal, regulatory, and institutional assessments of the climate are often recommended (WorldBank, 2020).

The only port available to the Republic of Uzbekistan is the river port of Port Termiz (Amu Darya). The Termiz River port is located on the right bank of the Amu Darya River on the border between Uzbekistan and Afghanistan. The port has a developed network of 4 km long railway sidings, which allows the simultaneous supply of 100 railway cars/ platforms. It is a customs control zone that can simultaneously store up to 30,000 tons of cargo and 3,000 large-capacity containers (TDP, 2023).

To gain access to Central Asian (CA) markets, countries are signing various transit, bilateral, and multilateral agreements, where CA countries benefit from access to seaports, and the other partner countries benefit from cheaper imports. Following this practice, Uzbekistan is also making efforts to enter into transit agreements with countries with cheaper and more accessible routes to ports. In the absence of sustainable trade agreements, CAR countries, including Uzbekistan, will be forced to use longer routes for trade transit that will increase carbon emissions and adversely affect the region.

10.3.1 Uzbekistan: Pre and Post 2016

Islam Karimov remained President of Uzbekistan from its independence until his death in 2016. During his rule, Uzbekistan became an economically and politically isolated country with minimal foreign trade and low foreign direct investments. The violent suppression of protests in 2005 damaged the country's international image in terms of human rights protection. Since independence, the country has had tense relations with its small neighbours, Tajikistan and Kyrgyzstan (Schiek, 2018).

After Karimov's death in 2016, Uzbekistan was compelled to hold elections. Shavkat Mirziyoyev won the elections with an overwhelming majority of votes (89%). He then became the president of the country. Mirziyoyev's policies have been more inclusive than those of Karimov. Mirziyoyev decided that Uzbekistan should seek a place in the international community in accordance with universal principles, norms and laws. He vowed that Uzbekistan would be a reliable partner and good neighbour, and pledged to change the closed image of the country. He declared that the 'New Uzbekistan' was committed to reforming the image of the country; wherein close attention would be paid to the country's growth potential, and to remedy its past failures and mistakes (Imamova, 2018).

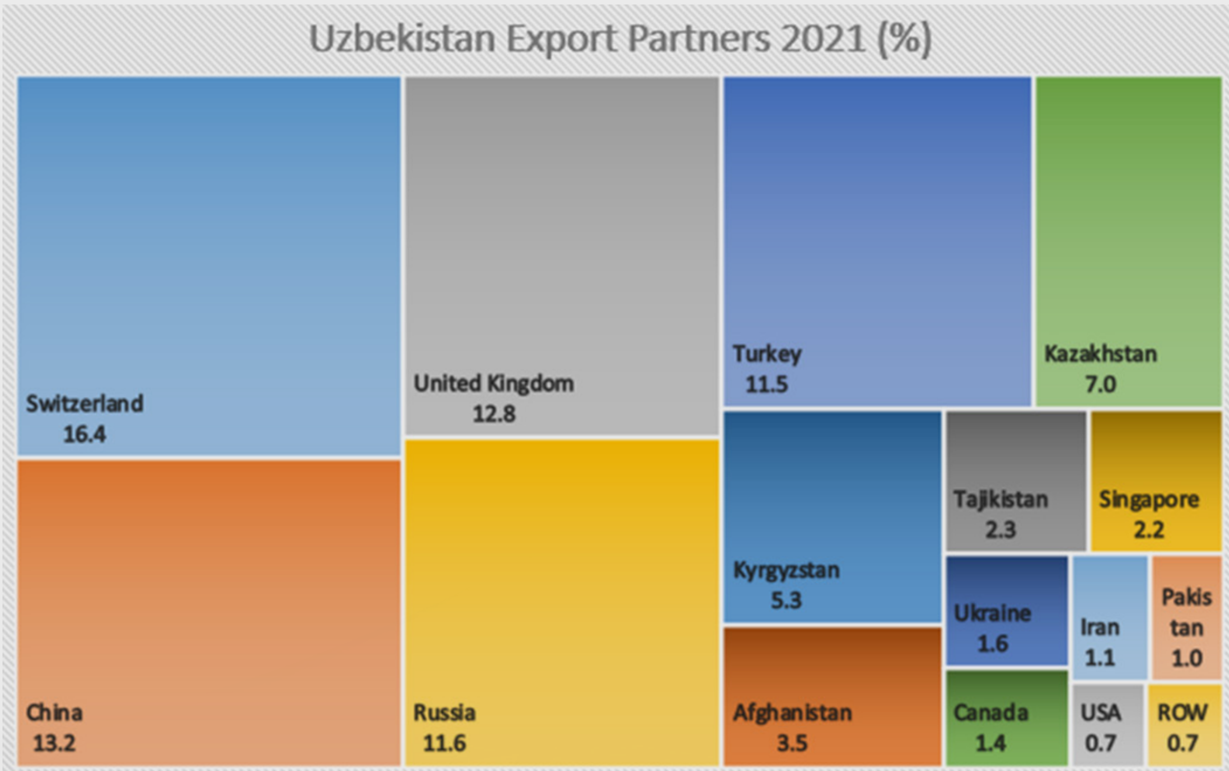
Mirziyoyev served as Prime Minister of Uzbekistan from 2003 until his election as president in 2016; thus, he was aware of the challenges confronting the country and the potential solutions to those problems. Under his rule, Uzbekistan adopted a reform manifesto called the National Development Strategy 2017–2021 that identified five areas that needed to be prioritised for sustainable economic and social development. The five priority areas were public administration, the judiciary, the rule of law, economic development and liberalisation, the social area, and security and foreign policy (Tsereteli, 2018).

The implementation of this strategy has been a fruitful for the country, as it has resulted in improvements in different spheres, including justice, law, economy, and religious harmony. It has also proved to be beneficial in the development of foreign relations between the country and its neighbours. Uzbekistan moved to delimit its borders with its neighbours, and by 2021, 95.5% of the total border, more than 99% of the Uzbek-Tajik border, and more than 80% of the Uzbek-Kyrgyz state border had been delimited. Uzbekistan also witnessed radically increased trade volumes with its neighbours. Furthermore, relations with partner countries such as Russia, China, the United States, Turkey, Europe, the Middle East, Southeast Asia, and other regions have significantly strengthened in almost all fields (Tulyakov, 2022).

10.3.2 Uzbekistan's Trade

Uzbekistan exported USD 14.7 billion in 2021, ranking it as 81st among global exporters. Uzbekistan's exports increased by USD 7.31 billion from USD 7.37 billion in 2016 to USD 14.7 billion in 2021. The main export categories of Uzbekistan in 2021 were: Gold (USD 4.53 billion), Non-Retail Pure Cotton Yarn (USD 1.61 billion), Refined Copper (USD 741 million), Petroleum Gas (USD 722 million), and Radioactive Chemicals (USD 407 million). The most common destinations for Uzbekistan's exports are Switzerland (USD 2.4 billion), China (USD 1.94 billion), United Kingdom (USD 1.88 billion), Russia (USD 1.71 billion), and Turkey (USD 1.68 billion), as shown in Figure 10.4.

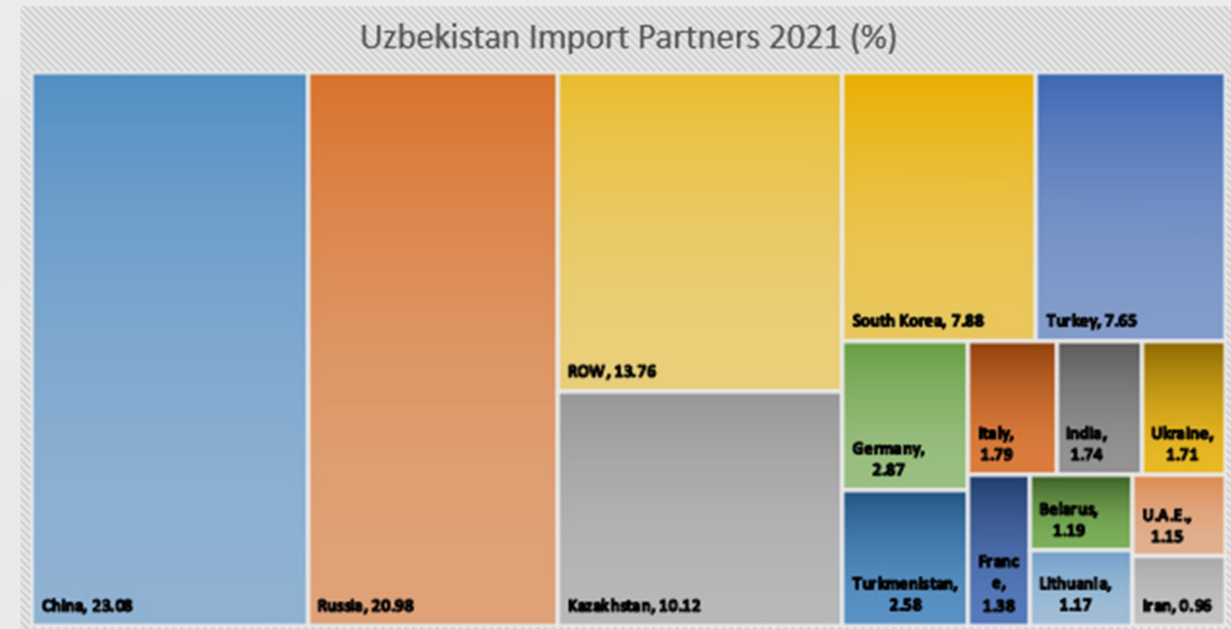
Figure 10.4: Uzbekistan’s Export Partners 2021 (%)



Source: (OEC, 2021)

Uzbekistan’s imports amounted to USD 24.4 billion in the year 2021, ranking it as 78th among the trade destinations in the world. During the last five reported years, imports by Uzbekistan increased by USD 14.8 billion from USD 9.6 billion in 2016 to USD 24.4 billion in 2021. The most recent imports of Uzbekistan are, Packaged Medicaments that amounted to USD 1.04 billion, Motor vehicles, parts and accessories (HS Code 8701 to 8705) amounting to USD 1.01 billion and Cars amounting to USD 656 million. The most common import partners for Uzbekistan in 2021 were China (USD 5.63 billion), Russia (USD 5.12 billion), Kazakhstan (USD 2.47 billion), South Korea (USD 1.92 billion), and Turkey (USD 1.87 billion), as shown in Figure 10.5.

Figure 10.5: Uzbekistan’s Import Partners 2021 (%)



Source: (OEC, 2021)

Uzbekistan has twelve trade agreements in force, as Table 10.2 shows. Of the economy's total exports for the year, 50% were directed towards its trade agreement partners, whereas 49.9% of its total imports came from its trade agreement partners in 2021.

Table 10.1: Trade Agreements of Pakistan

Title	Year Signed
Russian Federation-Uzbekistan	1993
Uzbekistan-Republic of Moldova	1995
Azerbaijan-Uzbekistan	1996
Tajikistan-Uzbekistan	1996
Ukraine-Uzbekistan	1996
Kazakhstan-Uzbekistan	1997
Kyrgyzstan-Uzbekistan	1998
Economic Cooperation Organisation Trade	2008
Agreement (ECOTA)	2010
Georgia-Uzbekistan	NA
Uzbekistan-Belarus	2022
Uzbekistan-European Union (EU)	2023
Uzbekistan-Pakistan	

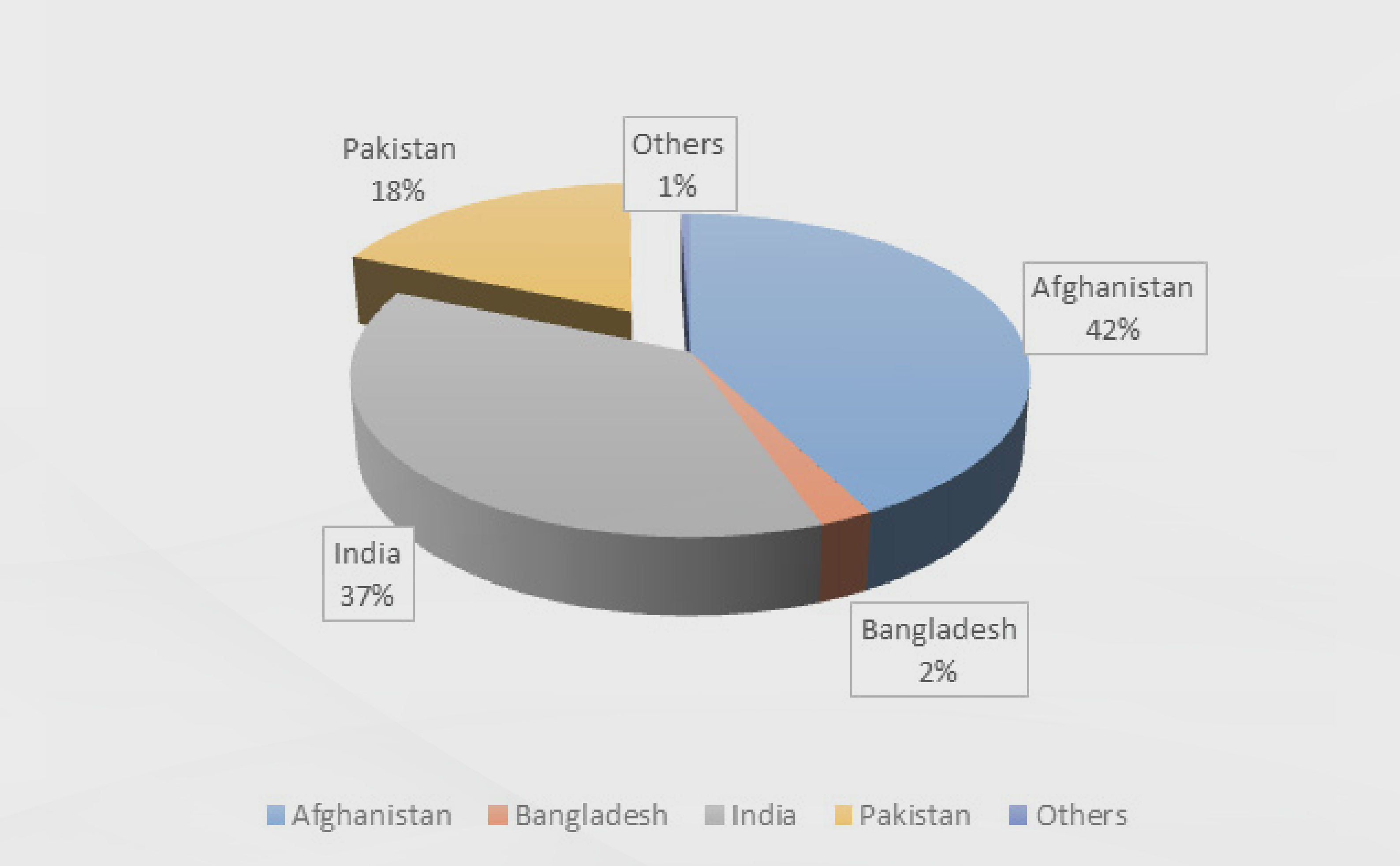
Source: (Dawn, 2023), (UNESCAP, 2018), (Europa, 2023)

10.3.3 Uzbekistan’s Trade with South Asia

The geographical location of Uzbekistan allows it to reach South Asia through Afghanistan. The country primarily uses its river ports to do so. In 2020, the total trade turnover of the CA states with the countries of South Asia amounted to USD4.4 billion, or 3.2% of their total foreign trade turnover (USD142.6 billion). Kazakhstan accounts for the largest share (52.8%), followed by Uzbekistan (31.2%) and Turkmenistan (10.4%). Afghanistan, India, and Pakistan are the CA countries’ main trading partners. Simultaneously, the CA countries conduct the most active trade and economic cooperation with Afghanistan because of their geographic proximity and the high dependence of Afghanistan’s domestic market on the import of food, industrial goods, and energy. [1]Please see Figure 10.6 below.

The total volume of Uzbekistan's foreign trade with South Asian countries in 2021 amounted to USD 1.22 billion. Afghanistan was its biggest partner, contributing to nearly half of total exports in the region, followed by India and Pakistan at second and third place, respectively.

Figure 10.6: Uzbekistan's Trade with South Asia 2021 (%)



Source: Nations Online Project

Uzbekistan's recent inclusive and sustainable approach to trade routes has marked a significant shift in regional engagement. The country received its first transit shipment via Pakistan and Afghanistan, reflecting a southward-looking policy to establish viable alternative trading partners and assert its identity in the region. The route involved a private trader exporting Indian sugar, with the cargo first arriving at Karachi port in Pakistan before being trucked across Pakistan and Afghanistan and finally reaching Uzbekistan. This move could reduce Uzbekistan's reliance on Iran and Russia for trade routes, thereby enabling a more independent trade policy. Uzbekistan should attract transit flows while simultaneously increasing its centrality and necessity within the entire transport network. A World Bank BRI (Belt Road Initiative) study estimates that the BRI will reduce trade costs in Uzbekistan by approximately 3% (Yusufkhonov et al, 2022).

To enhance trade, Uzbekistan focused on accessing Pakistani seaports. A Preferential Trade Agreement (PTA) between Pakistan and Uzbekistan aims to lower duties and minimise non-tariff barriers for 34 items. Additionally, the Pakistan-Uzbekistan Transit Trade Agreement allows Uzbekistan's trucks to carry goods directly to Pakistani seaports. The key to this trade transformation is cooperation with Afghanistan, with ongoing projects such as the Trans-Afghan Railway linking Uzbekistan to Pakistani seaports.

However, challenges remain due to security concerns and the internal discord among Taliban factions in Afghanistan. Uzbekistan is seeking alternatives to Russian trade routes that have been impacted by sanctions on Russia. By diversifying its trade options and exploring non-traditional markets, especially in Pakistan and Afghanistan, Uzbekistan aims to strengthen its regional position and reduce its historical dependency.

[1] Centre for Economic Research and Reforms (Tashkent, Uzbekistan)

10.4 CENTRAL ASIAN REPUBLICS AND TRANSPORT

The CA region, consisting of Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, is flanked by the Russian Federation in the north, China and Mongolia in the east, and the Islamic Republic of Iran and Pakistan in the south. The entire region is landlocked, making all the CARs dependent on land and air transport.

Prior to their independence, the CARs played a major role in providing raw materials (primarily cotton), minerals, and energy products to the USSR. The CARs struggled for a brief period after their independence. Their exports concentrated on a handful of primary products with differing transport requirements. Uzbekistan experienced a relatively good economic performance between 1992 and 1996 because its principal exports were cotton and gold that carried high value/weight ratios and could be shipped by air. The same cannot be said for Kazakhstan. Although coal, minerals, and grain could be exported reasonably easily, oil and gas exports were more problematic, as all the pipelines ran through Russia, leaving Kazakhstan and Turkmenistan vulnerable to high transit fees charged by the Russian pipeline monopoly (Pomfret, 2010). The current approach advocated by the Central Asian Regional Economic Cooperation (CAREC) institute and others is to promote transport corridors with the idea of improving both hard and soft infrastructure along them. This allows for a steadier approach, and the number of corridors provides flexibility. Presently, the CAREC has six economic corridors that connect landlocked CAREC member countries to their global markets, thus making trade easier.

10.4.1 Trade Facilitation Initiatives

Pakistan and Uzbekistan have taken numerous initiatives to facilitate trade. Examples of such initiatives are as follows.

Trade Facilitation and Expo Centre Division (Pakistan)

The responsibilities of the Trade Facilitation and Expo Centre Division include developing general policy proposals for consideration by the federal government, and supporting the Ministry of Commerce in the preparation of trade policy in consultation with sectoral divisions. It helps implement trade policy/federal government initiatives of a general nature, issuance of Certificates of Origin and all Generalised Scheme of Preferences (GSP) matters, matters related to public relations, including media coverage, newspaper advertisements, printing of all promotional materials, and web portal management, among many other vital aspects of trade enhancement (TDAP, 2023).

Pakistan Single Window (Pakistan)

The Pakistan Single Window (PSW) is a digital platform that enables the parties involved in trade to lodge standardised information and documents at a single entry point to fulfil all import, export, and transit-related regulatory requirements. It aims to reduce the time and cost of doing business by digitalising Pakistan's cross-border trade and eliminating paper-based manual processes. The PSW allows the electronic submission of information for the clearance of import, export, and transit-related goods, thus eliminating the need for multiple submissions of the same data to different agencies.

Electronic SPS Certificate / E-phyto

Many countries around the globe have implemented electronic Sanitary and

Phytosanitary (SPS) certifications under different names. Uzbekistan implemented Ephyto.uz in 2020. The E-phyto system inspects and issues internal phytosanitary movement documents and certificates, and quarantine import permits. The E-phyto solution allows Uzbekistan to receive advance information about the consignments intended for import that facilitates effective border inspection (FAO, 2022). In Pakistan, the National Plant Protection Organisation issues phytosanitary certificates to traders. In November 2023, under the PSW initiative, the Government of Pakistan integrated National Plant Protection with the International Plant Protection Convention's E-Phyto hub (Abbas, 2023). This integration will not only result in increased trade efficiency, but will also demonstrate a commitment to global standards.

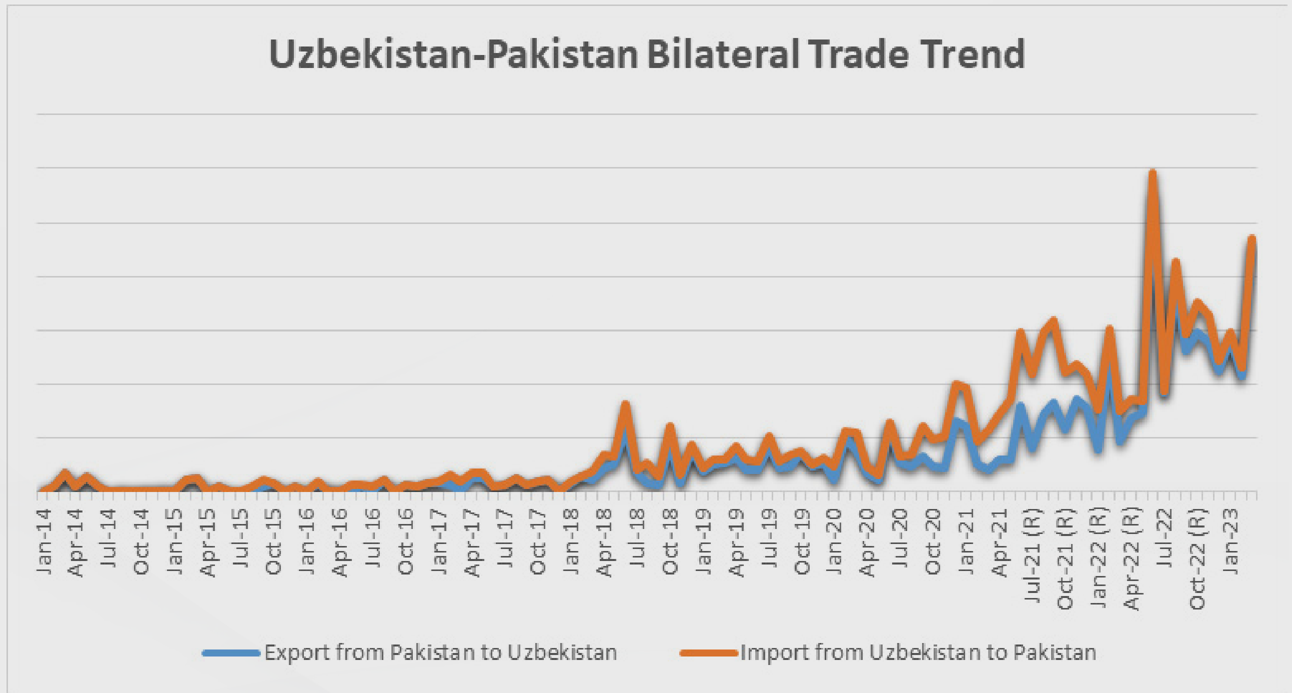
Uzbekistan Trade Info (Uzbekistan)

Uzbekistan Trade Info is a step-by-step trade information platform that allows businesses to save time and reduce the costs incurred in international trade. The platform was jointly developed by the Ministry of Investments and Foreign Trade and the State Customs Committee of Uzbekistan under the International Trade Centre's EU-funded Ready4Trade Central Asia project. This portal ensures the transparency of cross-border trade formalities (ITC, 2022).

10.5 PAKISTAN AND UZBEKISTAN BILATERAL TRADE

The relationship between Pakistan and Uzbekistan was established as soon as the country became independent after the dissolution of the USSR. Pakistan and Uzbekistan have a good relationship and have signed several bilateral trade agreements to improve their economies. The two countries have signed dozens of bilateral agreements and MOUs since the beginning of their relationship. The signed instruments cover economic trade, healthcare, agriculture, education, military, science, technology, tourism, banking, telecommunications, and transit. In 2015, Pakistan and Uzbekistan signed three documents to enhance bilateral cooperation in the fields of trade, economy, and foreign relations. Pakistan and Uzbekistan have signed several protocols to prevent double taxation and strengthen cooperation between the foreign ministries of the two countries. Bilateral trade between Pakistan and Uzbekistan has shown an upward trend in the past few years. Recent trade agreements between the two countries have benefitted bilateral trade, as shown in Figure 10.7.

Figure 10.7: Uzbekistan-Pakistan Bilateral Trade Trend



Source: State Bank of Pakistan

Pakistan and Uzbekistan have signed over 75 MoUs including commerce, medical science, avoidance of double taxation, science and technology, agriculture, and banking. Pakistan offers critical overland routes and connectivity for mutually beneficial intra- and inter-regional trade and energy transactions (Anwar, 2011).

10.5.1 Pakistan-Uzbekistan Preferential Trade Agreement

Pakistan gradually liberalised tariffs, albeit with occasional increases in tariff protection (GoP, 2019). To enhance bilateral trade activities, Pakistan and Uzbekistan signed a preferential trade agreement (PTA) in 2022 to lower duties on nearly three dozen products in the range of 20% to 100%, aimed at boosting trade value, which remains very low despite its vast potential (Tribune, 2022).

The PTA was signed during a visit of Uzbekistan's President Shavkat Mirziyoyev to Pakistan. The visit was the result of Prime Minister Imran Khan's trip to Uzbekistan in July 2021, when both countries signed a transit trade agreement. The PTA covering 34 goods boosts bilateral trade, which, according to the State Bank of Pakistan, have lagged in the past decade. Pakistan exported goods worth USD 22 million against USD 40 million worth of imports during the fiscal year 2021-22.

This agreement will remain in force for a period of five years, and any country can give notice of the termination of this agreement no less than one year before its expiration. The agreement can be extended further.

Appendix B provides a detailed list of products covered by the PTA signed by the two countries.

10.5.2 Joint Protocol for Rail Networks Between Uzbekistan and Pakistan

In a remarkable stride towards inclusive and sustainable growth, Pakistan, Uzbekistan, and Afghanistan signed a joint protocol on the 18th of July 2023. The focus of this protocol is to create an interconnected rail network that seamlessly links Uzbekistan's rail infrastructure with Pakistan's railways.

The envisioned railway route will traverse Termiz in Uzbekistan, Mazar-i-Sharif and Logar in Afghanistan, and culminate in Pakistan, crossing the Kharlachi border in Kurram. This transformative railway line is poised to cater to both passenger and freight services and is a potentially powerful catalyst for regional trade and economic prosperity (RadioPakistan, 2023).

This collaboration exemplifies the commitment to inclusivity and sustainability, as it aims to unlock the untapped potential of the region and foster equitable growth opportunities for all. As representatives of the respective countries gathered in Islamabad to sign this protocol, it marked a symbolic step towards a prosperous and interconnected future. By leveraging shared resources and synergies, this railway initiative promises to contribute significantly to the social, economic, and environmental wellbeing of the region, laying the foundation for a brighter and more sustainable future.

10.5.3 Potential Challenges to the Agreements between Pakistan and Uzbekistan

Pakistan and Uzbekistan have engaged in different mutual agreements, and it is but expected that several operational challenges will emerge as these agreements mature. Some examples of the issues faced by similar agreements made by Pakistan in the past are provided below. Learning from these obstacles will prove helpful for both sides.

·Turkmenistan-Afghanistan-Pakistan-India (TAPI) Gas Pipeline

The example of the TAPI pipeline is relevant as it involves Pakistan's recent association with another CAR, and the dynamics of engaging in the territory of Afghanistan. Construction of the TAPI pipeline began in 2015, and in early 2018, the construction of a 700 km long stretch was inaugurated in Herat, Afghanistan's north-western province.

The planned pipeline starts from the giant Galkynysh gas field located in Turkmenistan's eastern Mary Province, goes through five southern Afghan provinces, and then passes Quetta and Multan in Pakistan before reaching the state of Punjab in northern India. Partially funded by the Asian Development Bank, the USD10 billion pipeline runs 1,600 km and when completed, will transport 33 billion cubic meters of natural gas annually from the Galkynysh field in Turkmenistan to Afghanistan, India, and Pakistan for the next three decades (Zhunisbek, 2020). The TAPI pipeline was first proposed in the early 1990s and enjoyed the support of the United States as an alternative route to easing access to CA energy sources by global markets, thus alleviating the region's heavy dependence on Russian transportation infrastructure (Foster, 2010). However, the takeover of power by the Taliban in 1996 made crossing Afghanistan problematic, and significantly delayed the actual implementation of the project. The TAPI pipeline project made a decisive return when Turkmenistan started the construction of its 214 km segment of the pipeline in December 2015. However, certain hurdles like those related to financing and the provision of security along the proposed route must be addressed before the first gas from Turkmenistan can reach India (Zhunisbek, 2020).

Overall, scepticism related to financial and security concerns over the TAPI project remains, even though its relevance and prospective benefits for the parties involved are well established.

·Iran-Pakistan Gas Pipeline

The Iran-Pakistan Gas Pipeline Project has been under discussion between Iran and Pakistan since 1994. The two countries signed a preliminary agreement in 1995. Later, Iran suggested extending the pipeline from Pakistan into India, and the project was extended to India in February 1999. Pakistan, India, and Iran held several meetings and agreed on prices and other related issues. Pakistan and Iran signed a final agreement on the Iran-Pakistan Gas Pipeline at a meeting in Ankara on 16 March 2010. This pipeline has the potential to ease Pakistan's energy shortages and substitute expensive furnace oil used for power generation. A daily gas flow of 21.5 million cubic meters will have a variety of positive effects on Pakistan's economy (Munir et al., 2014). Work on establishing the Pakistani section of the project was officially launched by the Presidents of both Pakistan and Iran on 11 March 2013.

This project, which is linked to Iran, has several potential challenges. The foremost issue faced by the project is the hindrance caused by the United States and EU's sanctions on Iran. In addition to the United States and EU, the United Nations has also imposed sanctions on Iran that discourage potential trade partners from forming ties with the country. Second, Pakistan's physical engagement with Iran brings the security situation in Balochistan into the equation, which does not have a constantly positive status. Finally, Pakistan's engagement in any project with Iran may jeopardise its relations with Arab countries. Pakistan's diplomatic relations with the rest of the world have been tenuous since 2021, and any tension may cause significant damage to its economy.

Pakistan's trade agreements with Uzbekistan are bound to involve Iran and/or Afghanistan. Owing to the involvement of Gwadar Port in many agreements, Balochistan's security status will definitely be included in the equation. Due to economic deterioration, Pakistan may also have to deal with financial issues. Pakistan must adapt and learn from the challenges faced in recent arrangements with CARs to avoid repeating them with Uzbekistan in the future.

10.5.4 Pakistan-Uzbekistan Bilateral Trade Potential

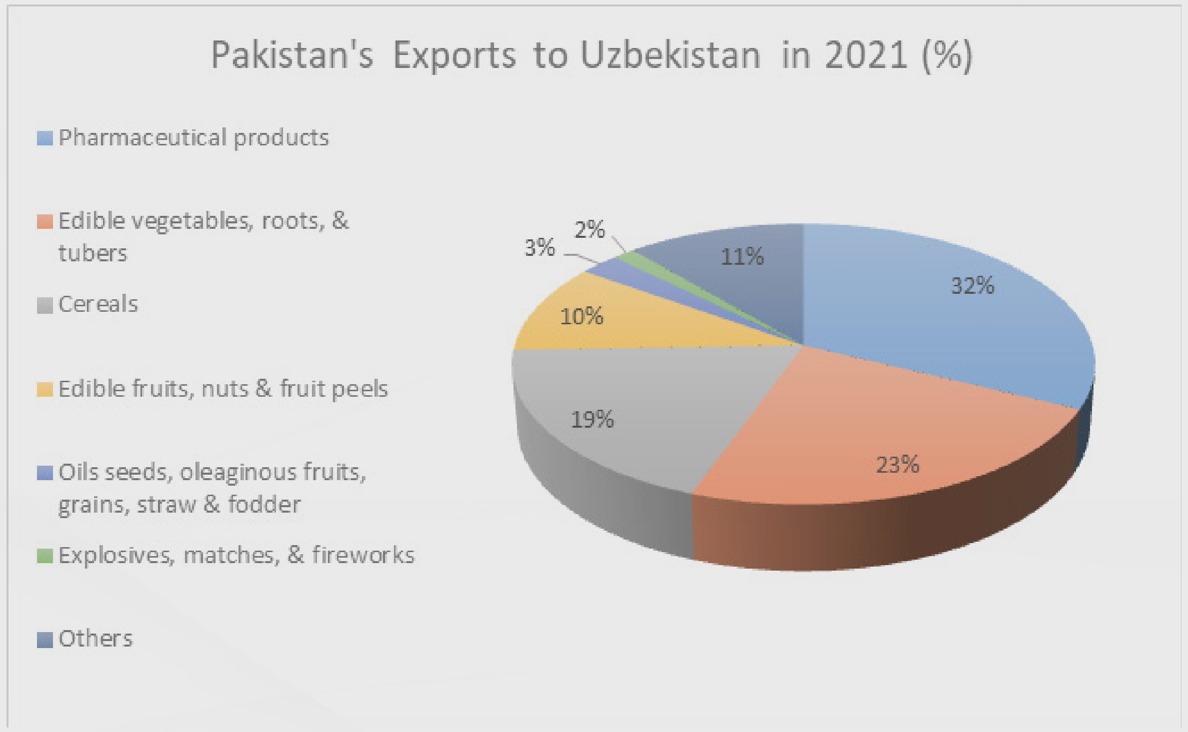
Data on the current standing of the trade of both countries in the region indicate that sectors can be targeted for the enhancement of bilateral trade. In 2021, 99% of

Afghanistan's trade constituted imports from Uzbekistan; which primarily comprised milling industry products (55% of exports), mineral fuel products (24.3%), and edible vegetables (4.82%).

India ranks second in terms of trade between Uzbekistan and the South Asian countries. Uzbekistan's exports to India consisted primarily of vegetable extracts (22.3%), medical and optical equipment (13%), and zinc articles (12.1%). Uzbekistan's imports from India comprised pharmaceutical products at 62.5%, and mechanical equipment in the second position at 9.28%.

In South Asia, Pakistan ranks third in terms of trade volume with Uzbekistan. In the structure of Uzbekistan's exports to Pakistan, edible vegetables and roots accounted for 51.8%, cotton 39.5%, and zinc articles 4.4%. Imports from Pakistan include 32.2% pharmaceutical products; 23.3% edible vegetables, roots, and fodder; 19% cereals; and 10.3% edible fruits and nuts. Please see Figure 10.8.

Figure 10.8: Pakistan's Exports to Uzbekistan 2021 (%)



Source: OEC

Uzbekistan in particular and Central Asia in general are favourable markets for Pakistani products (PBC, 2021). The five-year trend below shows Pakistan's positive trade balance with Uzbekistan and CA countries. The trends also show increasing growth of Pakistan's exports to Uzbekistan, whereas imports are growing at a lower rate.

Another potential advantage of the enhanced bilateral trade agreements between Pakistan and Uzbekistan is the decrease in road freight and increase in rail freight for the trade commodities to and from Uzbekistan. Trade transit via roads is known to emit six times more carbon than rail transit (Susmatize, 2022).

With such a favourable market, it is important to study the dynamics for further market expansion. Pakistan's current market share in Uzbekistan's trade is insignificant, as shown in Table 10.3 below.

Table 10.3: Pakistan's share in Uzbekistan's Global Trade

Year	Pakistan's share in Uzbekistan's Imports from World	Pakistan's share in Uzbekistan's Exports to World
2017	0.18%	0.087%
2018	0.35%	0.28%
2019	0.15%	0.67%
2020	0.17%	0.74%
2021	0.29%	1.02%

Source: OEC

·Export Potential for Pakistan

A brief comparative review of Pakistan's top-25 export commodities (HS Code level 4) (Table 10.4) and Uzbekistan's top-25 import commodities shows that several commodities have remained consistent during the past few years. In 2021, Uzbekistan imported USD 1.04 billion worth of Packaged Medicaments, and Pakistan's share was only 0.018%. The detailed tables are available in Appendix A.

An analysis of export commodities (HS Code level 4) from Pakistan to Uzbekistan in 2021 shows that Pakistan has a major market share in the Matches, Jute Woven Fabric, and Rice categories at 99.7%, 99.94%, and 66.6%, respectively. Commodities such as unpacked medicines, tropical fruits, other oily seeds, and potatoes accounted for 50.13%, 40.27%, 36.36%, and 26.82%, respectively. However, the market share of Pakistan's other specialised commodities is insignificant, like Sports equipment at 1.94%, medical instruments at 0.21%, other edible preparations at 1.14%; with a ready market and Pakistan's production capability, exports from these sectors can be expanded significantly. Such export expansion has the potential to generate approximately USD 0.179 billion.

Table 10.4: Export Trade Potential for Pakistan

HS4 ID	HS4	Uzbekistan's imports from Pakistan (USD thousands) (a)	Uzbekistan's imports from Pakistan (USD thousands) (a)	Pakistan's Share in Uzbekistan's Total Imports (%)	Export Trade Potential for Pakistan (USD thousands) (b-a)
63004	Packaged Medicaments	18721	1037673	1.80	1018952
20701	Potatoes	16432	61266	26.82	44834
21006	Rice	13457	20203	66.60	6746
63003	Unpackaged Medicaments	4148	8273	50.13	4125
20804	Tropical Fruits	3755	9324	40.27	5569
20805	Citrus	2963	16872	17.56	13909
21207	Other Oily Seeds	1761	4843	36.36	3082
63605	Matches	1014	1017	99.70	3
115310	Jute Woven Fabric	905	924	97.94	19
42106	Other Edible Preparations	891	77856	1.14	76965
63802	Activated Carbon	525	10660	4.92	10135
158212	Razor Blades	478	9111	5.24	8633
116301	Blankets	447	1513	29.54	1066
20803	Bananas	404	10961	3.68	10557
209506	Sports Equipment	386	19798	1.94	19412
116302	House Linens	380	3906	9.72	3526
62815	Sodium or Potassium Peroxides	335	11843	2.82	11508
168445	Textile Fibre Machinery	333	170751	0.19	170418
42009	Fruit Juice	317	6820	4.64	6503
62847	Hydrogen peroxide	284	5387	5.27	5103
189018	Medical Instruments	215	100462	0.21	100247
116203	Non-Knit Men's Suits	203	12756	1.59	12553
168414	Air Pumps	201	202668	0.09	202467
20810	Other Fruits	159	2315	6.8	2156
168448	Knitting Machine Accessories	126	51646	0.24	51520

Source: OEC

Several feasibility studies are being conducted to expand Pakistan's exports to Uzbekistan; however, to make most of the Pakistan-Uzbekistan deal, it is important to study both its export and import potential. With the depreciating currency of Uzbekistan, imports from Uzbekistan will be cheaper than those from other countries.

·Export Potential for Uzbekistan

A cursory review of Uzbekistan's top-25 exports from Pakistan in 2021 (HS Code level 4) shows that Uzbekistan exports a major volume (by share) of groundnuts to Pakistan at 22.66% of total exports to Pakistan, followed by buckwheat at 23.78%, and sulphur at 22.69%. The other major imported commodities were non-retail cotton yarn (17.37%), raw zinc (8.54%), and dried legumes (8.31%). If Uzbekistan targets the top-25 commodities imported by Pakistan from Uzbekistan (in the commodities presented in Table 10.5 below), there is the potential to increase exports to Pakistan by USD 5.3 billion.

Table 10.5: Export Trade Potential for Uzbekistan

HS4 ID	HS4	Uzbekistan's imports from Pakistan (USD thousands) (a)	Uzbekistan's imports from Pakistan (USD thousands) (a)	Uzbekistan's Share in Pakistan's Total Imports (%)	Export Trade Potential for Uzbekistan (thousand USD) (b-a)
20713	Dried Legumes	77537	932847	8.311	855310
115205	Non-Retail Pure Cotton Yarn	59080	340036	17.374	280956
157901	Raw Zinc	6664	77967	8.547	71303
52503	Sulphur	1729	7616	22.698	5887
21202	Ground Nuts	1210	4540	26.661	3330
21008	Buckwheat	774	3255	23.788	2481
63105	Mixed Mineral or Chemical Fertilizers	738	715412	0.103	714674
20806	Grapes	506	71953	0.703	71447
168446	Looms	463	299821	0.154	299358
73901	Ethylene Polymers	298	805248	0.037	804950
21207	Other Oily Seeds	201	69510	2.893	6750
115202	Cotton Waste	154	7437	2.077	7283
20904	Pepper	123	68741	0.179	68618
157308	Iron Structures	101	275149	0.036	275048
115004	Non-Retail Silk Yarn	66	4026	1.640	3960
20703	Onions	54	74468	0.071	74414
116305	Packing Bags	34	8043	0.428	8009
20702	Tomatoes	27	56557	0.047	56530
52701	Coal Briquettes	21	1648119	0.001	1648097
10106	Other Animals	20	1611	1.249	1591
84105	Tanned Sheep Hides	17	9617	0.177	9600
10504	Animal Organs	16	2731	0.576	2715
168433	Harvesting Machinery	13	25759	0.050	25747
21302	Vegetable Saps	11	28438	0.039	28427
168442	Print Production Machinery	10	10912	0.096	10901

10.5.5 Transit Trade Potential

·Potential-1

In 2021, Uzbekistan's global trade was worth USD 39.1 billion (USD 24.4 billion in imports and USD 14.7 in exports), of which trade worth USD 25.201 billion was conducted with neighbouring, proximate countries, and India. In a hypothetical situation, assuming that the remaining trade goods are routed through Pakistan, Pakistan can expect to potentially handle goods worth USD 13.899 billion in cargo transhipments to and from Uzbekistan. (See Table 10.6)

A similar transit potential through Pakistan can also be calculated for other CA countries to obtain the cumulative transit potential that would be helpful in determining the feasibility of such transit routes through Pakistan.

Table 10.6: Transit Trade Potential for Pakistan

Country	Imports	Exports	Country	Imports	Exports
China	5.63	1.94	Iran, Islamic Republic of	0.234	0.168
			Tajikistan	0.130	0.343
Russian Federation	5.12	1.71	Kyrgyzstan	0.184	0.773
Kazakhstan	2.47	1.03	Georgia	0.090	0.028
Turkey	1.87	1.68	Azerbaijan	0.035	0.074
Turkmenistan	0.63	0.095	Afghanistan	0.005	0.511
India	0.424	0.027			
Subtotal (a)	16.822	8.379			
World (b)	24.4	14.7			
Transit Trade					
Potential (b-a)	7.578	6.321			

Import and Export values in billion USD for year 202121 (Source: OEC)

·Potential-2

As previously discussed, Uzbekistan is a landlocked country, and to reach Uzbekistan, one must cross another country. Pakistan's northern border is close to Tajikistan and Kyrgyzstan. Pakistan's trade relationship with the CA region is skewed in its favour, where exports are expanding and imports are lagging. Since 2018, Pakistan's imports from Uzbekistan have risen steeply by 402%, whereas exports have grown at a sluggish rate of only 8.45% over the course of five years. Pakistan's imports from Kazakhstan grew at a rate of 303%, while its exports grew at 220%.

The country-wise trade breakup in Table 10.7 highlights nascent trade between Pakistan and Tajikistan, Turkmenistan, and Kyrgyzstan. With the establishment of trade routes, China and Pakistan can have direct market access to other CA countries enroute to Uzbekistan, which can facilitate efficient trade ventures. This access will shorten trade routes, resulting in decreased carbon emissions, which will contribute to the effort against climate change.

Table 10.7: Pakistan's Trade with CAR (million USD)

	Exports	Imports
CAR	289	196
Kazakhstan	193	20
Kyrgyzstan	8	1
Tajikistan	14	15
Turkmenistan	3	10
Uzbekistan	71	150

Source: OEC

10.6 CONCLUSION

Pakistan and Uzbekistan have much to offer each other in terms of bilateral trade partnerships. The greatest assistance that Pakistan can provide to Uzbekistan is access to its seaports, which are presently not being utilised to their full potential. Both countries stand to gain by enhancing their levels of bilateral trade.

Since 2018, Pakistan's imports from Uzbekistan have risen meteorically by 402%, whereas exports have grown sluggishly at only 8.45% over the course of five years. Pakistan's imports from Kazakhstan grew at a rate of 303%, while its exports grew at 220%. In 2021, more than half of Uzbekistan's trade was conducted with countries in its close proximity.

This restriction of trade partners for Uzbekistan can primarily be attributed to the double-landlocked nature of the country; this can be resolved by accessing roads, rails, and ports in Pakistan. New routes through Pakistan will not only shorten trade routes but also minimise carbon emissions because of decreased cargo transit time.

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APPENDIX A

Uzbekistan Top Imports (USD)

HS2	HS4 ID	HS4	2017	2018	2019	2020	2021
Pharmaceutical products	63004	Packaged Medicaments	662998434	666799098	744658945	925306221	1037673337
Cars, tractors, trucks & parts thereof.	178708	Motor vehicles; parts and accessories (8701 to 8705)	644096581	939820006	986289902	931910056	1008653867
Cars, tractors, trucks & parts thereof.	178703	Cars	172513971	397897784	531905938	477467236	656421614
Mineral fuels, mineral oils and products of their distillation	52710	Refined Petroleum	540375757	498049432	551885801	571449569	607830349
Cereals	21001	Wheat	196441925	286589699	371516578	597867108	534974411
Iron & steel	157208	Hot-Rolled Iron	142001177	204434179	234332949	236000010	478389538
Pharmaceutical products	63002	Vaccines, blood, antisera, toxins and cultures	66391933	70474362	82212413	105020144	383763608
Electrical machinery and electronics	168525	Broadcasting Equipment	91934087	123529535	181577300	293424398	354403995
Cars, tractors, trucks & parts thereof.	178704	Delivery Trucks	197755581	370368131	249203560	335190882	321796456
Wood, wood articles, & charcoal	94407	Sawn Wood	230351429	290495839	266680444	268181907	321128456
Iron & steel	157210	Coated Flat-Rolled Iron	297868440	405228819	388089779	379505129	272314736
Animal or vegetable fats, oils, & waxes	31512	Seed Oils	107066043	123206997	165355198	227355065	254028141
Mineral fuels, mineral oils and products of their distillation	52709	Crude Petroleum	116171661	229081993	113630511	216282721	234157881
Iron & steel	157207	Semi-Finished Iron	136719037	216751020	199289719	152658449	234058036
Machinery, mechanical appliances, & parts	168479	Machinery Having Individual Functions	98755017	156228402	229263232	222416516	232527601
Machinery, mechanical appliances, & parts	168474	Stone Processing Machines	111806009	151351358	387911394	359469772	230855561
Rubber & articles thereof	74011	Rubber Tires	164554042	156994232	194289115	222613126	211187610
Machinery, mechanical appliances, & parts	168429	Large Construction Vehicles	167738259	291631591	376816624	265677828	210067924
Machinery, mechanical appliances, & parts	168414	Air Pumps	99531126	232736583	242930409	230818143	202668546

Cars, tractors, trucks & parts thereof.	178705	Special purpose motor vehicles	53263523	148806947	192912905	72418977	200109097
Ores, slag and ash	52603	Copper Ore	10169465	5908523	136138137	18621514	198379179
Machinery, mechanical appliances, & parts	168471	Computers	76607680	80926420	126193797	136769584	195484278
Iron or steel articles	157305	Other Large Iron Pipes	52817592	36022810	30699657	195937549	179489544
Machinery, mechanical appliances, & parts	168411	Gas Turbines	20323757	345827644	78407149	82395287	176520500
Machinery, mechanical appliances, & parts	168445	Textile Fibre Machinery	166539799	381634641	301277135	179023820	170750522

Pakistan Top Exports USD

HS2	HS4 ID	HS4	2017	2018	2019	2020	2021
Used clothes & textile articles	116302	House Linens	3710831037	3777745058	3824975571	3625958037	4634290952
Cereals	21006	Rice	1752712116	2087751676	2363517550	2162594645	2258956035
Non-knitted clothing accessories	116203	Non-Knit Men's Suits	1798905252	1763005670	1969924475	1800692422	2033001848
Knitted clothing accessories	116110	Knit Sweaters	704169566	880547280	919847096	940083184	1502369888
Non-knitted clothing accessories	116204	Non-Knit Women's Suits	1024094577	969066711	1100885763	1056607997	1368830938
Cotton	115205	Non-Retail Pure Cotton Yarn	1256173188	1270180675	1101046978	820599862	1180940431
Cotton	115209	Heavy Pure Woven Cotton	1023277655	1021837241	967022400	723323781	915331631
Cotton	115208	Light Pure Woven Cotton	687488478	753304276	734974033	745981210	775767973
Leather articles	84203	Leather Apparel	611738612	624893965	634875511	588269392	694931311
Copper articles	157403	Refined Copper	26005765	141761243	293393031	333541472	658637751

Knitted clothing accessories	116115	Knit Socks and Hosiery	397785448	447738522	427607319	427202697	592399659
Knitted clothing accessories	116109	Knit T-shirts	426309740	455578124	532028730	450530341	585865810
Knitted clothing accessories	116103	Knit Men's Suits	332937769	353780033	356520881	338486443	542284618
Knitted clothing accessories	116104	Knit Women's Suits	256238187	271822915	313551686	360212473	533280239
Optical, photo, & film equipment; medical instruments	189018	Medical Instruments	362947054	406682706	430637432	390948604	454607866
Mineral fuels, mineral oils and products of their distillation	52710	Refined Petroleum	424683319	537768149	327174666	180644678	449349780
Beverages, spirits, & vinegar	42207	Alcohol > 80% ABV	461195128	577617806	459548999	386135442	439665579
Used clothes & textile articles	116307	Other Cloth Articles	338730393	351871986	343064516	377790477	415155494
Salt, sulphur, cement, lime, stone, & plaster	52523	Cement	240271768	291496712	300734317	323553999	322553077
Pharmaceutical products	63004	Packaged Medicaments	199517670	207859996	254489705	260301179	321479252
Toys, games, & sports	209506	Sports Equipment	289612165	294502649	290465438	240099587	304321685
Meat & edible offal	10201	Bovine Meat	197823856	187166691	276867357	259968289	290077099
Knitted clothing accessories	116116	Knit Gloves	214817646	211426490	215202567	217236473	277902106
Used clothes & textile articles	116309	Used Clothing	57989616	82378091	94026502	193921746	266478127
Ships, boats, & floating structures	178901	Passenger and Cargo Ships	1930200	430642	46141680	2618397	248964871

Uzbekistan's Top Imports from Pakistan

HS2	HS4 ID	HS4	2017	2018	2019	2020	2021
Pharmaceutical products	63004	Packaged Medicaments	9802471	4673451	10029508	16050030	18721179
Edible vegetables, roots, & tubers	20701	Potatoes	7135667	5693852	2290684	243754	16432215
Cereals	21006	Rice	--	1296844	2399886	3248559	13457189
Pharmaceutical products	63003	Unpackaged Medicaments	--	1809997	2092833	1949398	4148222

Edible fruits, nuts & fruit peels	20804	Tropical Fruits	808486	784385	3731820	3090545	3755252
Edible fruits, nuts & fruit peels	20805	Citrus	2466529	1260647	2664865	2776082	2963167
Oils seeds, oleaginous fruits, grains, straw & fodder	21207	Other Oily Seeds	20805	--	--	--	1761435
Explosives, matches, & fireworks	63605	Matches	--	--	--	725608	1014724
Vegetable textile fibres, paper yarn & fabrics	115310	Jute Woven Fabric	1358339	191863	363748	521754	905063
Miscellaneous edible preparations	42106	Other Edible Preparations	61	4471	293670	322610	891731
Chemical products n.e.s.	63802	Activated Carbon	788329	821394	1060059	611283	525418
Tools & cutlery	158212	Razor Blades	422500	472280	743552	126670	478326
Used clothes & textile articles	116301	Blankets	--	--	--	14893	447600
Edible fruits, nuts & fruit peels	20803	Bananas	--	11942	670059	608523	404481
Toys, games, & sports	209506	Sports Equipment	27238	100638	174292	233047	386399
Used clothes & textile articles	116302	House Linens	36266	46269	125184	275891	380566
Inorganic chemicals	62815	Sodium or Potassium Peroxides	--	--	--	275891	335246
Machinery, mechanical appliances, & parts	168445	Textile Fibre Machinery	--	--	--	--	333661
Preparations of vegetables, fruit, nuts or other plant parts	42009	Fruit Juice	--	--	--	--	317228
Inorganic chemicals	62847	Hydrogen peroxide	25171	--	--	124516	284625
Optical, photo, & film equipment; medical instruments	189018	Medical Instruments	318522	133853	110462	73818	215131
Non-knitted clothing accessories	116203	Non-Knit Men's Suits	46307	153457	160045	110134	203099
Machinery, mechanical appliances, & parts	168414	Air Pumps	--	--	25193	100384	201686
Edible fruits, nuts & fruit peels	20810	Other Fruits	--	2197	107611	90500	159633
Machinery, mechanical appliances, & parts	168448	Knitting Machine Accessories	811	31639	33375	61691	126407

Sustainable Trade Bridges
CHAPTER 10

APPENDIX B

List of goods originating in the territory of the Republic of Uzbekistan and destined for the territory of the Islamic Republic of Pakistan

№	HSCode	Description	Tariff reduction %	Customs Duty (CD)%	Additional Customs Duty (ACD)%	Regulatory Duty (RD)%	Margin of Preference %	Revised duty rate %
1	071331	Dried, shelled beans of species 'Vigna mungo [L.] Hepper or Vigna radiata [L.] Wilczek', whether or not skinned or split	100 % decrease	3	2	-*	5	0
2	071339	Dried, shelled beans 'Vigna and Phaseolus', whether or not skinned or split (excluding beans of species 'Vigna mungo [L.] Hepper or Vigna radiata [L.] Wilczek', small red 'Adzuki' beans,kidney beans, Bambara beans and cow peas)	100% decrease	3	2	-*	5	0
3	081310	Dried apricots	100% decrease in CD and ACD	20	7	-*	27	0
4	120242	Groundnuts, shelled, whether or not broken (excluding seed for sowing, roasted or otherwise cooked)	100% decrease in CD	11	2	20	11	22
5	170490	Sugar confectionery not containing cocoa, incl. white chocolate (excluding chewing gum)	50% decrease in CD and 100% decrease in ACD and 25% decrease in RD	20	6	40	26	40
6	180690	Chocolate and other preparations containing cocoa, in containers or immediate packings of <= 2 kg (excluding in blocks, slabs or bars and cocoapowder)	50% decrease in CD and 100% decrease in ACD	20	6	10	16	20
7	200819	Nuts and other seeds, incl. mixtures, prepared or preserved (excluding prepared or preserved with vinegar, preserved with sugar but not laid in syrup, jams, fruit jellies, marmalades, fruit purée and pastes, obtained bycooking, and groundnuts)	100% decrease in CD and ACD	16	4	20	20	20
8	740811	Wire of refined copper, with a maximum cross-sectional dimension of > 6 mm	100% decrease in CD and ACD	11	2	-*	13	0
9	740819	Wire of refined copper, with a maximum cross-sectional dimension of <= 6 mm	50% decrease in CD	11	2	-*	5.5	7.5
10	841510	Window or wall air conditioning machines, self-contained or 'split-system'	20% decrease in CD	20	6	5% for 'in CKD/ SKD Condition', & 20% for 'Other'	4	27% for 'in CKD/ SKD Condition', & 42% for 'Other'
11								
12	841810	Combined refrigerator-freezers, with separate external doors	20% decrease in CD	20	6	5% on CKD, 20% on Other	4	27% for 'in CKD/ SKD Condition', & 42% for 'Other'
	850423	Liquid dielectric transformers, having a power handling capacity > 10.000 kVA	25% decrease in CD	20	6	-*	5	21
13	850450	Inductors (excluding inductors for discharge lamps or tubes)	100% decrease	20	6	-*	26	0
14	852872	Reception apparatus for television, colour, whether or not incorporating radio- broadcast receivers or sound or video recording or reproducing apparatus, designed to incorporate a video display or screen	25% decrease in CD	20	6	15	5	36

15	853710	Boards, cabinets and similar combinations of apparatus for electric control or the distribution of electricity, for a voltage <=1.000 V	20% decrease in CD	30	6	-*	6	30
16	853720	Boards, cabinets and similar combinations of apparatus for electric control or the distribution of electricity, for a voltage >1.000 V	100% decrease	20	6	-*	26	0
17	854449	Electric conductors, for a voltage <= 1.000 V, insulated, not fitted with connectors, n.e.s.	50% decrease in CD and 100% decrease in ACD	17	5	20% for Telephone Cables, & 10% for 'Multi core, flexible, flat type copper, insulated' & 'others'	13.5	28,5% for Telephone Cables,& 18,5% for 'Multi core, flexible, flat type copper, insulated' & 'others'

List of goods originating in the territory of the Islamic Republic of Pakistan and destined for the territory of the Republic of Uzbekistan

№	HS Code	Product Description	Tariff reduction%	Customs Duty (CD) rate %	Margin of Preference%	Revised duty rate %
1	080390	Fresh or dried bananas (excluding plantains)	20% decrease in CD	20, but not less than USD 0.20 / kg	4	16, but not less than USD 0.16 / kg
2	080529	Fresh or dried wilkings and similar citrus hybrids	20% decrease in CD	20, but not less than USD 0.20 / kg	4	16, but not less than USD 0.16 / kg
3	110812	Maize starch	100% decrease in CD	5	5	0
4	190531	Sweet biscuits	20% decrease in CD	20, but not less than USD 0.30 / kg	4	16, but not less than USD 0.24 / kg
5	190590	Bread, pastry, cakes, biscuits and other bakers' wares, whether or not containing cocoa; communion wafers, empty cachets of a kind suitable for pharmaceutical use, sealing wafers, rice paper and similar products (excluding crispbread, gingerbread and the like, sweet biscuits, waffles, wafers not mentioned, rusks, toasted bread and similar toasted products)	30% decrease in CD	20, but not less than USD 0.30 / kg	6	14, but not less than USD 0.21 / kg
6	240120	Tobacco, partly or wholly stemmed or stripped, otherwise unmanufactured	20% decrease in CD	5	1	4
7	252329	Portland cement (excluding white, whether or not artificially coloured)	100% decrease in CD	30	30	0
8	320810	Paints and varnishes, incl. enamels and lacquers, based on polyesters, dispersed or dissolved in a non-aqueous medium; solutions based on polyesters in volatile organic solvents, containing > 50% solvent by weight	20% decrease in CD	10	2	8
9	320910	Paints and varnishes, incl. enamels and lacquers, based on acrylic or vinyl polymers, dispersed or dissolved in an aqueous medium	20% decrease in CD	10	2	8
10	382499	Chemical products and preparations of the chemical or allied industries, incl. those consisting of mixtures of natural products, n.e.s.	20% decrease in CD	30	6	24

11	392020	Plates, sheets, film, foil and strip, of non-cellular polymers of ethylene, not reinforced, laminated, supported or similarly combined with other materials, without backing, unworked or merely surface-worked or merely cut into squares or rectangles (excluding self-adhesive products, and floor, wall and ceiling coverings of heading 3918)	20% decrease in CD	10	2	8
12	392062	Plates, sheets, film, foil and strip, of non-cellular poly 'ethylene terephthalate', not reinforced, laminated, supported or similarly combined with other materials, without backing, unworked or merely surface-worked or merely cut into squares or rectangles (excluding those of poly 'methyl methacrylate', self-adhesive products, and floor, wall and ceiling coverings of heading 3918)	100% decrease in CD	10	10	0
13	700529	Float glass and surface ground and polished glass, in sheets, but not otherwise worked (excluding wired glass or glass coloured throughout the mass 'body tinted', opacified, flashed or merely surface ground, or glass having an absorbent, reflecting or non-reflecting layer)	20% decrease in CD	10	2	8
14	701090	Carboys, bottles, flasks, jars, pots, phials and other containers, of glass, of a kind used for the commercial conveyance or packing of goods, and preserving jars, of glass (excluding ampoules, glass inners for containers, with vacuum insulation, perfume atomizers, flasks, bottles etc. for atomizers)	100% decrease in CD	10	10	0
15	730690	Tubes, pipes and hollow profiles 'e.g., open seam, riveted or similarly closed', of iron or steel (excluding of cast iron, seamless or welded tubes and pipes and tubes and pipes having internal and external circular cross-sections and an external diameter of > 406,4 mm)	100% decrease in CD	5	5	0
16	820559	Hand tools, incl. glaziers' diamonds, of base metal, n.e.s.	20% decrease in CD	10	2	8
17	851712	Telephones for cellular networks 'mobile telephones' or for other wireless networks	20% decrease in CD	5	1	4

CHAPTER 11

SUSTAINABLE COOPERATION MODEL OF THE COTTON INDUSTRIES IN CHINA, KAZAKHSTAN, AND UZBEKISTAN

Yu-Jia Deng, Xin-Yi Zheng, Guang-Xin Zhang, and Yu-Jie Li

11.1 INTRODUCTION

The year 2023 marks the 10th anniversary of the Belt and Road Initiative. Rooted in comprehensive development, the initiative's international influence is constantly increasing, and agricultural exchanges among countries along the Belt and Road have embraced new development opportunities. The Belt and Road Initiative is considerably significant for international cooperation. It has been more than 30 years since China and Central Asia established diplomatic ties. Countries will consider the 10th anniversary of the initiative as a new starting point.[1] In particular, the China-Central Asia Summit will be held from May 18 to 19, 2023, which will help China and Central Asian

[1] China-Central Asia Summit Xi'an Declaration (full text): https://www.mfa.gov.cn/web/ziliao_674904/zt_674979/dnzt_674981/zgzyfh/cgwj/202305/t20230519_11080194.shtml

countries exchange advanced experience and reach a consensus on deepening trade cooperation, developing smart agriculture cooperation, and enhancing cooperation in the application of water-saving, green, and other efficient technologies. Relying on the framework of bilateral and multilateral cooperation mechanisms, the two sides actively connect in the agricultural industry, expand the scope of cooperation, extend the chain of cooperation, and enrich the objects and modes of cooperation.

Constrained by international factors such as the increasing instability of global food production and the continuing war between Russia and Ukraine, as well as domestic realities such as the structural contradiction between the supply and demand of agricultural products, the lack of high agricultural quality and efficiency, and the prominent contradiction between the shortage of water and the scarcity of land, it has become important to guarantee a stable and safe supply of food and agricultural products (Zeng, 2023; Tong and Zhou, 2021). Cotton is one of the most important crops in China and plays a pivotal role in the light, chemical, medicine, and national defense industries. Cotton and cotton textiles are pillars of China's export earnings (Li and Chang, 2011). Open development has become a general trend. To continue enhancing the competitiveness of the cotton industry, we must make overall use of domestic and international markets and resources. The cotton industries of Kazakhstan and Uzbekistan have a certain scale among Central Asian countries but are not dominant in agricultural technology and yield per unit area (Tang et al., 2018). Moreover, problems remain in each link of the cotton industry chain, and an effective model for the entire industry chain has not yet been developed. Stabilizing cotton industry cooperation between Kazakhstan and Uzbekistan can help China expand its external cotton resources and cotton-related enterprises to improve agricultural modernization. The rapid growth in China's cotton consumption has attracted considerable attention. Fully utilizing overseas resources, ensuring the security of cotton supply, and achieving sustainable development of international cooperation are practical issues faced by Chinese cotton-related enterprises.

From the perspective of cotton production resources, the cotton industry resources of China, Kazakhstan, and Uzbekistan are complementary. By 2021, China's arable land area was 109 million hectares, accounting for 11.6% of the country's total land area; however, the per person arable land area was only 0.08 hectares, and the contradiction between people and land was extremely prominent. The current cotton-planting area is 3.028 million hectares. During the same period, Kazakhstan's arable land area was nearly 30 million hectares, accounting for 11.1% of the country's total land area. The per person cultivated land was 1.56 hectares, and the cotton planting area was 109,900 hectares. The agricultural population is 1.29 million, and although land resources are abundant, the utilization rate is low owing to the bottleneck of water resources. The only cotton-producing area, Turkestan Oblast, is located in the Syr Darya River basin. There are more rivers and lakes in the territory, but many rivers only have water in snow seasons and become dry in summer; therefore, the key to the development of the cotton industry in the state lies in the reasonable development and utilization of water resources. The arable land area of Uzbekistan is 4.02 million hectares, accounting for 9.1% of the total land area. The per person arable land area is approximately 0.12 hectares, and the cotton planting area is 1.03 million hectares. The agricultural population is 14.2 million, accounting for about 60% of the country's total population, and labor resources are abundant. Uzbekistan is located in the lower reaches of cross-border rivers, and the water resources in most areas are unevenly distributed and in short supply. Irrigation water mainly relies on Amu Darya and Syr Darya (Hao et al., 2021), and natural evaporation is large, indicating water scarcity in the lower reaches of the rivers (Lioubimtseva & Henebry, 2009). Water resource problems restrict the development of cotton in Uzbekistan.

There are significant differences in the cotton yield per unit area among China, Kazakhstan, and Uzbekistan. China's cotton production per unit area is much higher than that of Kazakhstan and Uzbekistan. The yield level in Uzbekistan reached its highest in 2018 at 797 kg/ha and lowest in 2020 at 513 kg/ha, a decrease of 284 kg/ha, before recovering in subsequent years. Kazakhstan's cotton yield per unit area peaked at 638 kg/ha in 2022 and has remained stable at this level for the past five years; nevertheless, owing to the increase in the world average, its yield per unit area is declining. China's total and per unit production of cotton is leading in the world, but the natural

endowment of more people and less land means that China's cotton has been in short supply for a long time. Overall, Uzbekistan has high levels of cotton cultivation and production. In terms of the per-unit yield, Kazakhstan has considerable potential for the development of cotton cultivation and is expected to strengthen cooperation based on resource complementarity.

Table 11.1: Total cotton output and yield per unit area in China, Kazakhstan, and Uzbekistan from 2016 to 2022

Year		China	Kazakhstan	Uzbekistan
2016	Total production (10,000 tons)	520.0	4.5	83.2
	Yield per unit (kg/ha)	1524	453	641
2017	Total production	490.0	7.1	96.0
	Yield per unit	1581	634	768
2018	Total production	589.0	7.1	96.1
	Yield per unit	1758	634	797
2019	Total production	604.0	6.9	63.7
	Yield per unit	1794	634	594
2020	Total production	580.0	8.3	53.1
	Yield per unit	1758	634	513
2021	Total production	591.0	8.0	70.0
	Yield per unit	1864	634	677
2022	Total production	573.0	8.0	59.0
	Yield per unit	1892	638	567

Source: International Cotton Advisory Committee.

11.2 LITERATURE REVIEW

Agriculture is the highlight of China's cooperation with countries along the Belt and Road, and it is an important approach to sustainable development. The Sustainable Development Agenda is a global development consensus with the broadest political will and a high degree of commonality for high-quality development in cooperation with foreign investment (Ma, 2020). Currently, China and countries along the Belt and Road are deepening their agricultural trade and cooperation (Wang et al., 2021).

Possible cooperation areas are mainly concentrated in complementary agricultural trade cooperation, agricultural science and technology cooperation with biological and irrigation technology, and comprehensive cooperation through the agricultural industry chain (Yan and Wang, 2016). The agricultural import and export trade among the five Central Asian countries and China is significantly complementary. Relying on regional advantages and characteristics, the agricultural cooperation between Xinjiang and Central Asia has significant potential (Shi and Wang, 2018). The international trade of agricultural products includes cooperation in agricultural processing and other aspects concerning the international trade of agricultural products (Shi and Liu, 2020). In the future, we should give full play to the enthusiasm of the border provinces, establish agricultural product processing bases in the border areas of Xinjiang and Central Asia, fully utilize agricultural product resources in Xinjiang and Central Asian countries, and conduct processing trade, such as processing imported materials (Jin, 2018). Existing cooperation paths and models provide important ideas and methods for Belt and Road countries to conduct agricultural cooperation and produce many representative results. For example, according to the different cooperation needs, Liu and Ma (2010) propose to adopt the overseas park construction model and the "two countries and two parks" model. According to the different cooperation subjects, Luo et al. (2014) propose the "dual enterprise" model, "dual research and learning" model, "dual enterprise + dual research and learning" model, and "dual government + dual enterprise + dual research and learning" model based on the study of the Guangzhou-Pearl River Delta and ASEAN agricultural international cooperation model. Cui (2016) proposes a public-private cooperation model involving private enterprises, non-governmental organizations, university research institutions, and foundations, which is a "hybrid value chain" that can create shared value and promote sustainable agricultural development. According to different cooperation businesses, the model can be divided into government-led demonstration international cooperation model of agricultural science and technology and market-led "project + base + enterprise" transnational cooperation model of agricultural science and technology (Cao et al., 2015). The main body of international agricultural cooperation has gradually spread from scientific research institutions to more diversified market-oriented subjects, further enriching its main body composition (Hu, 2020).

In the cotton industry economy, a competitive relationship in the cotton trade between China and the five Central Asian countries does not exist; the cotton industry and its related industrial economic areas require development (Wang et al., 2016). To strengthen cotton industry cooperation, we should fully consider the industrial base and technological level of both sides and explore realistic and feasible cooperation models. Cotton industry alliances begin with demand (Li, 2019); agriculture contracts are the links (Zhang and Shi, 2022) and use special cooperation funds or foreign aid funds to build overseas agricultural demonstration cooperation parks (Qin and Gao, 2008). Considering China's significant advantages in factors such as capital, technology, market, experience, and its long-term dominance, China's priority of agricultural cooperation presents a historic development opportunity (Zhao and Hu, 2015), and unfavorable factors in the cotton industry need addressing in cooperation with Kazakhstan and Uzbekistan, such as the cross-border supply channel of cotton. Although the comprehensive score of the bilateral relationship between Kazakhstan and China and Uzbekistan and China is higher, the logistics and transport shortcomings are considerably prominent (Ru et al., 2022). The overall development of Uzbekistan's cotton industry is worse than that of Xinjiang, and the status of production and scientific research is poor (Tian et al., 2017). Kazakhstan's cotton production is constrained by bottlenecks such as water resource allocation problems in cross-border rivers and a low degree of mechanization (Yu et al., 2018). The development of the cotton industry in Xinjiang contains problems, such as the rising cost of cotton planting and the continuous decline in the intrinsic quality of cotton.

Existing research, which provides a reference for this study, is mainly focused on the current situation of China's foreign agricultural cooperation, problems, countermeasures, and other aspects of bilateral cooperation from a research perspective. Thus, there is a lack of relevant research from the perspective of multilateral cooperation. Therefore, this paper aims to summarize the existing cotton bilateral cooperation model among China, Kazakhstan, and Uzbekistan, analyze the existence of constraints, build China, Kazakhstan, and Uzbekistan cotton multilateral cooperation models, and propose recommendations targeting risk avoidance. This study provides a reference for national cotton security, optimizing cotton allocation, and cooperation among the cotton industries of the three countries.

11.3 METHODOLOGY

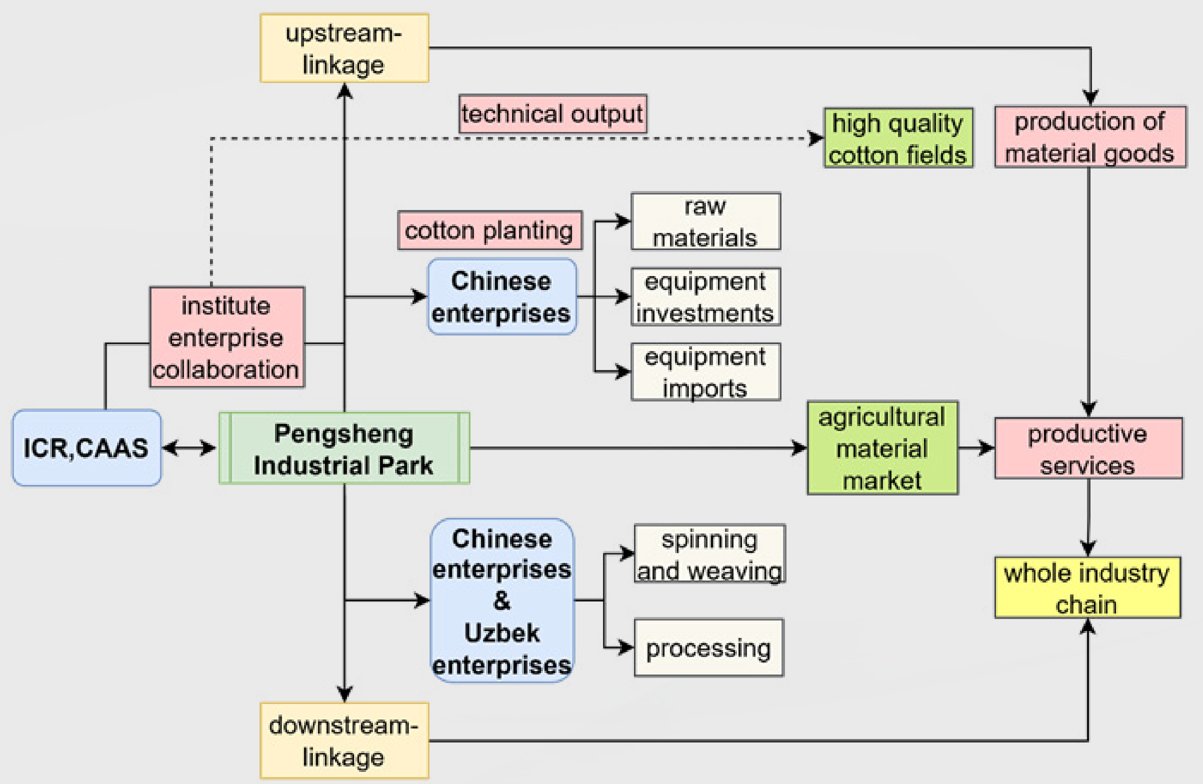
The case study method is widely used in management, economics, sociology, and other related disciplines. To solve the problem of "how" or "why," it is a method to explore general laws by describing facts and phenomena, tracing the causes, and drawing research conclusions or new research propositions through analysis (Yin, 2014; Ouyang, 2004). A case study comprehensively uses various technologies to collect data and information and, through in-depth mining, presents a detailed description of the background and process of important events or behaviors in specific social units, which are analyzed, interpreted, judged, evaluated, or predicted under the guidance of theories (Wang, 2007; Wang, 2013; Lee, 2020).

A case study is a flexible tool that requires sufficient information to describe and explain the unique characteristics of a case and identify the common characteristics of several cases (Ghauri, 2004). It can be applied to different areas at the business and government levels. Many scholars have used cases as analytical tools, and case studies have been adapted to other methods to achieve better results. Based on the China-Uzbekistan technology alliance model, China-Uzbekistan Park cooperation model, and China-Kazakhstan order agriculture model, this paper makes an in-depth study, drawing on the current situation and constraints of the bilateral industrial cooperation model and proposing models most advantageous to China to build a sustainable cooperation model of the China-Kazakhstan-Uzbekistan cotton industries. Data related to land, cotton production, and investment were sourced from the World Bank, the International Cotton Advisory Committee, and the Ministry of Commerce of the People's Republic of China, respectively.

11.4 CURRENT SITUATION AND CONSTRAINTS OF A BILATERAL SUSTAINABLE COOPERATION MODEL OF COTTON INDUSTRY BETWEEN CHINA AND KAZAKHSTAN AND UZBEKISTAN

Sustainable agriculture is an agricultural development model based on ecological, economic, and social benefits that should cover the concepts of environmental non-degradation, technical appropriateness, economic vitality, maintenance of land, water, animal, and plant genetic resources, and social acceptance. Guided by modern sustainable development, supported by modern science, technology, and material equipment, and guaranteed by advanced organizational systems, modern business forms and management are used to organically unify the economic, social, and environmental benefits of agricultural development. Agricultural industrial cooperation between China and Central Asian countries utilizes the benefits of industrial chain cooperation as a connection point. A cooperation model considers enterprises as the core and relies on government promotion, causing the division of labor and cooperation between the upstream and downstream of the cotton industrial chain, realizing capital integration. There are three representative models of bilateral sustainable cooperation in the cotton industry: the China-Uzbekistan technology alliance model, the China-Uzbekistan park cooperation model, and the order agriculture model of China and Kazakhstan".

Figure 11.1: Technology alliance model of Pengsheng Industrial Park

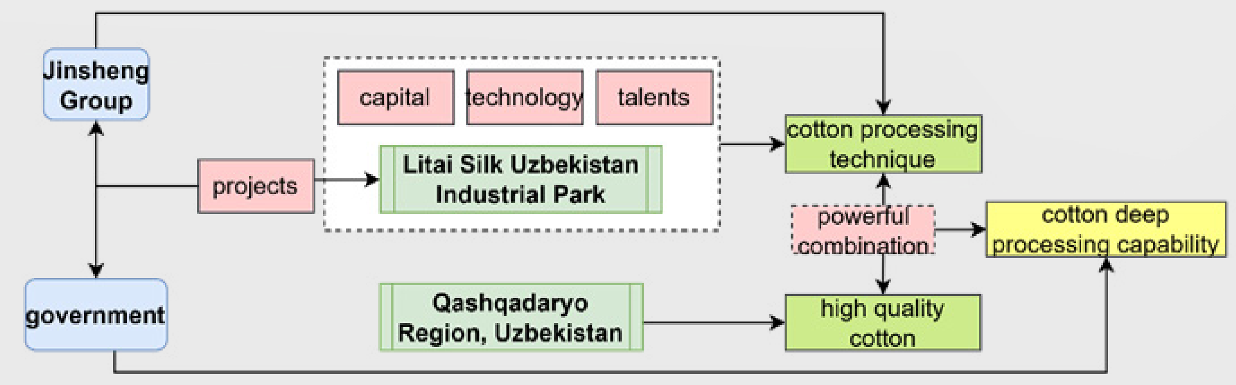


(2) Park cooperation model

The park cooperation model is a cross-regional economic cooperation model aimed at achieving win-win cooperation and adjusting, upgrading, and promoting the gradient transfer of industries; it is an advanced stage in the development process of industrial transfer. The core lies in implementing an industrial gradient transfer from developed to less developed areas in an organized and large-scale manner. It promotes the efficient and intensive utilization of resources, complements the advantages of parks, and realizes sustainable development of the regional economy (Zhang et al., 2017).

In 2014, the Jinsheng Group reached a project investment agreement with Uzbekistan and established the Litai Silk Road Uzbek Industrial Park, taking the park as a growth pole and gathering the advantages of capital, technology, and talent to spread outward from the growth pole. The park is located in the Qashqadaryo region, the largest cotton-producing state in Uzbekistan. The state's cotton quality is excellent, but the processing technology is not refined and lacks professionals. Thus, the Litai Group seized its advantages and brought China's advanced cotton technology to Uzbekistan, creating a strong combination of high-quality cotton and modern cotton. Litai Cotton Spinning International Co. Ltd. has vigorously promoted the development of Uzbekistan's domestic cotton industry. The annual lint production of the Qashqadaryo Oblast was 200,000 tons; after the Litai Cotton Spinning company invested in the operation, the capacity for deep processing of cotton was significantly enhanced from the initial 7% to 30%. Additionally, the Jinsheng Group has built a new modern and integrated Tashkent Industrial Park, signed an investment agreement with the government of Uzbekistan, and started a cotton planting business for production needs in 2020. In summary, the model of park cooperation, relying on the cotton resources of Qashqadaryo Oblast, compensates for the weaknesses of the cotton industry. This model ensures long-term cooperation and mutual benefits through the signing of long-term cooperation agreements.

Figure 11.2: Park cooperation model

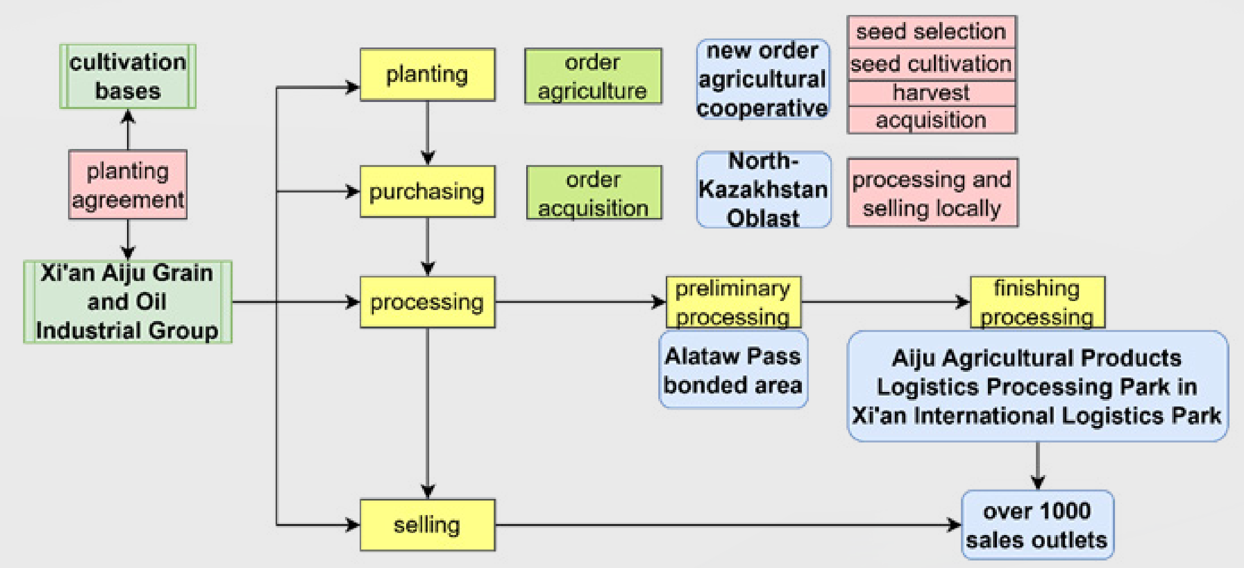


11.4.1.2 China-Kazakhstan agricultural industry cooperation model

The food production capacity cooperation is the most representative aspect of China's agricultural cooperation with Kazakhstan. The main model is the order agriculture model—a contractual production organization method that effectively solves the problems of blind production and sales revenue fluctuations in traditional agriculture. In Kazakhstan, the Aiju Group has implemented the cooperation model of "order agriculture + order purchase." Specifically, the Aiju Group promotes raw material planting in Kazakhstan; they signed a 10-hectare cultivation base for high-quality crops (such as wheat and rapeseed) and prepared for the establishment of a new type of order agricultural cooperative to realize a one-stop operation of selecting, breeding, planting, harvesting, and purchasing seeds.[3] After acquisition, the products are processed and sold locally, while some are transported to the flour mill built in the Alataw Pass bonded area for preliminary processing and returned to the Aiju Agricultural Products Logistics and Processing Park in the Xi'an International Harbor District for finishing. Finally, the products are sold through more than 1,000 outlets. The Aiju Group has implemented a three-ring drive, establishing three major agricultural products logistics and processing parks: Aiju Park in North Kazakhstan Oblast, Aiju Park in Alataw Pass, and Aiju Agricultural Products Logistics and Processing Park in the Xi'an International Port Area. The industrial chain enables the internal digestion of all the bargaining space needed in the processes of planting, processing, purchasing, and selling, avoiding the risks effected by exchange rate fluctuations. The cotton industry cooperation model is as follows: cotton is planted and purchased in Central Asia and processed and sold domestically or abroad through the bonded area. This model aims to integrate cooperation with market demand and achieve an effective connection in the cotton industry chain through market orientation. This establishes stable market channels, reduces market risks, and promotes the sustainable development of cotton industry cooperation.

[3] Grasp the quality of raw materials at the source and the quality of processed products, build a chain network sales system, and create a whole industry chain development model: http://www.lswz.gov.cn/html/zt/qglscy/2018-06/14/content_237016.shtml

Figure 11.3: Aiju Group order agriculture model



11.4.2 Constraints of bilateral sustainable cooperation model in cotton industry between China and Kazakhstan and Uzbekistan

The main constraints in the development of China's cooperation with Kazakhstan and Uzbekistan are agricultural science and technology, the business environment, foreign exchange control, and infrastructure. First, regarding agricultural science and technology, the three models are constrained by the technical levels of Uzbekistan and Kazakhstan. There is a lack of reliable agricultural scientific research cooperation projects, particularly in the cotton industry. Concurrently, scientific research investment is low, and the ability to update scientific research equipment is poor; thus, output, quality, and energy consumption cannot meet expectations. The popularization of agricultural scientific and technological knowledge is low, and the transformation of scientific and technological achievements, as well as the proportion of commercialization, is relatively low. For example, the scientific research institutions in Uzbekistan think conservatively and have a low awareness of reform and relatively backward scientific research systems. Their progress in basic and applied research on breeding high-quality varieties, high-yield and super-high-yield treatment of cotton, new ginning, and textile equipment has been slow. Thus far, yield traits and major quality indicators have not improved. The textile market in Uzbekistan is entirely dependent on imports, more than 90% of which are made in China, and the market share of locally produced textiles is extremely low. In terms of the business environment, the three models are affected by various unfavorable factors in the domestic markets of the two countries, including low coherence of policymaking, poor market order, high operating costs, frequent rent-seeking phenomenon, an imperfect legal system, low policy implementation, and administrative efficiency. As Uzbekistan has not yet joined the World Trade Organization, the lack of an effective cooperation platform and cooperation mechanism has created certain obstacles to deepening the cooperation in the cotton industry. Additionally, regarding foreign exchange control, there exists the refusal of normal currency exchange or the suspension of foreign exchange business and the high inflation caused by the devaluation of the currencies of Uzbekistan and Kazakhstan

and the foreign exchange risk caused by foreign exchange regulation (Yao and Huang, 2014). Finally, Kazakhstan's and Uzbekistan's infrastructure is backward. The return on investment is low, the transport model is relatively single, the short-term upgrading of aging facilities is difficult, and the road network is difficult to optimize. The risks and problems associated with these three models of bilateral cooperation are listed in Table 11.2. Affected by the above risks and problems, it is difficult to form a joint force in cotton industry cooperation. Without the participation of large leading enterprises with strong investment cooperation and business strength, the sustainability of commercial operations and cooperation is not guaranteed.

Table 11.2: Comparative analysis of risks and issues of the three models of bilateral cooperation

Model	Risks and issues		Representative park
Technology alliance model	Agricultural science and technology	Low level of technology in agricultural production and lack of major agricultural research cooperation projects	Pengsheng Industrial Park
	Business environment	Less favorable, Uzbekistan has not yet joined the World Trade Organization, and the domestic market has more drawbacks	
	Foreign exchange control	There were cases of refusal of normal currency exchange	
	Infrastructure	More backward, large capital investment, long time, low return on investment, higher investment risk	
Park cooperation model	Agricultural science and technology	Outdated processing technology, low yield, high energy consumption, low quality	Litai Silk Road Uzbek Park
	Business environment	Lack of coherence in policy formulation and implementation and high levels of official corruption	

	Exchange control	High inflation due to severe devaluation of the Uzbekistan's local currency, stricter foreign exchange regulations	
	Infrastructure	External transport is predominantly land-based, and it is unsuitable for long-distance transport and the transport of large quantities of goods	
	Agricultural science and technology	Agricultural technology is backward, the popularization of agricultural scientific and technological knowledge is low, and the transformation and commercialization of scientific and technological achievements are low	
Order agriculture model	Business environment	Uncertainty and weak implementation of policies, poor market order, rent-seeking, and high production and operating costs for enterprises	Xi'an Aiju Grain and Oil Industry Group
	Exchange control	Fluctuations in the exchange rate of the Kazakhstan local currency due to the Russian-Ukrainian crisis and, in February 2022, the suspension of foreign exchange operations by major Kazakhstan banks	
	Infrastructure	Generally underdeveloped, with aging and poorly designed infrastructure; uneven distribution of electricity resources, with electricity constraints in the west and the south	

11.5 CONSTRUCTION OF A MULTILATERAL SUSTAINABLE COOPERATION MODEL FOR THE COTTON INDUSTRY AMONG CHINA, KAZAKHSTAN, AND UZBEKISTAN

In the context of adhering to the principle of extensive consultation, joint contribution, and shared benefits and aiming to enhance industrial innovation capacity, there are differences in model selection among the government, enterprises, and research institutes with different needs, basic conditions, and advantages. The adapted model had a significant impact on improving the suitability of each participant to play to their advantage. First, under the government's promotion, the cotton industry can break through the political system, trade protection, social system, cultural traditions, and other barriers to provide a broader space for its development. Second, the main industries involved can develop together through the division of labor and cooperation in the industrial chain, upgrading the structure of the cotton industry to meet market demands. Simultaneously, this arrangement can achieve mutual benefits to reduce disorderly competition and waste of resources. Finally, the government-enterprise alliance, research institute-enterprise alliance, enterprise-farmer, or multi-party alliance are specific practical arrangements that can effectively mitigate and avoid multiple risks.

11.5.1Cooperation body

Under the Shanghai Cooperation Organization framework, governments, enterprises, research institutes, farmers, and others participate in multilateral sustainable cooperation. Agribusiness follows the Belt and Road Initiative, China's agricultural development strategy, and is at the core of multilateral agricultural cooperation. Under the guidance of the agricultural development strategy, agricultural enterprises directly participate in the international cooperation of the cotton industry by integrating the advantages of professional talent, capital, information, and technical knowledge, as well as the evaluation, feedback, and optimization of the cooperation model. With agricultural enterprises as the main body and agricultural industrial parks as carriers, the construction of multilevel multilateral cooperation mechanisms in the cotton industry can accelerate the process of multilateral cooperation in the cotton industry in China, Kazakhstan, and Uzbekistan.

11.5.2 Location selection

Xinjiang cotton is widely recognized as a high-quality natural fiber raw material, occupying an important position in the global cotton industry. Xinjiang's cotton output in 2022 reached 5.3906 million tons (accounting for approximately 90% of the country's total output), which is more than a thousand times that of 0.51 million tons (accounting for 1.1% of the country's total output) at the beginning of the founding of New China. Taking advantage of the high degree of mechanization and large-scale production of Xinjiang Corps, Xinjiang pioneered the "dense, short and early" model of cotton—a set of theoretical and technical systems established by dense planting in view of the unique climate characteristics of Xinjiang (Lou et al., 2021). This system adopts dwarfing measures to achieve early maturity and increased production. The technology of drip irrigation under mulch, the integration of water and fertilizer, and the precision of on-demand sowing technology on mulch in China have realized the transformation of cotton production from extensive to fine and standardized. While saving water and improving land utilization, the cost of growing cotton continues to decrease, and the yield and quality continue to improve. Over the years, Xinjiang has gradually established an improved seed-breeding system for arid oasis ecological zones and has continuously increased the construction of agricultural water-saving demonstration projects, reducing the negative impact on the environment, protecting the stability of the ecosystem, and ensuring the sustainable use of farmland soil. Concurrently, it helps improve the quality of cotton and its sustainable development capacity. Xinjiang has

several leading cotton-related enterprises with large production scales and domestic and foreign markets. These enterprises are strong in breeding, processing, acquisition, and scientific research, and some have established long-term cooperative relations with Central Asian countries, providing a good platform for future cooperation in cotton production capacity in Central Asian countries.

The Turkestan Oblast—the main cotton-growing region of Kazakhstan—was developed as a special textile economic zone under a presidential decree in 2005, and its advantages include exemptions from customs duties, land tax, corporate income tax, property tax, and exemption from land rents before 2030. In Kazakhstan, 74,400 ha of agricultural land is leased to seven legal entities with foreign participation, and the lease term of agricultural land will not be extended,[4] making it possible to invest in local agribusinesses or conduct international agricultural leasing with Kazakhstan agricultural cooperatives and agricultural companies. As the most densely populated region in Kazakhstan, the Turkestan Oblast has certain advantages in terms of its labor force.

Qashqadariyo, Uzbekistan's largest cotton-producing state, has a superior geographical location, connecting Tajikistan and Turkmenistan outside and several connected states inside. Qashqadariyo has an existing railway line with improved efficiency and capacity following electrification, which is convenient for transportation. The state has a long history of cotton cultivation, the quality of which enjoys a high reputation in the international market; additionally, the continuous improvement of planting technology increases production every year. Owing to Uzbekistan's restrictive cotton export policy in recent years, the state has transformed from a cotton production area to a production cluster developing in the direction of spinning yarn processing. The area has extended downstream from the production process, providing a broad market space for Chinese textile enterprises.

[4] Agricultural land in Kazakhstan is under government supervision: http://kz.mofcom.gov.cn/article/jmxw/202104/20210403057349.shtml

11.5.3Model construction

Currently, relatively mature bilateral cooperation models in the cotton industry include the technical alliance model represented by the Pengsheng Industrial Park and the park cooperation model represented by the Litai Silk Road Uzbek Park. Considering the characteristics and conditions of cooperation among China, Kazakhstan, and Uzbekistan, we explored and constructed a model for multilateral sustainable cooperation in the cotton industry.

11.5.3.1Overseas agricultural park cooperation model

In recent years, the bilateral trade volume between China and Kazakhstan has grown, economic and trade cooperation has deepened, and the two governments can try to negotiate preferential policies and matters related to the cotton industry and strive to broaden the cooperation areas and deepen the level of cooperation. This model intends to realize the complementarity of high-quality cotton resources among the three parties through the technology integration of cotton-planting ports.

(1) Participants

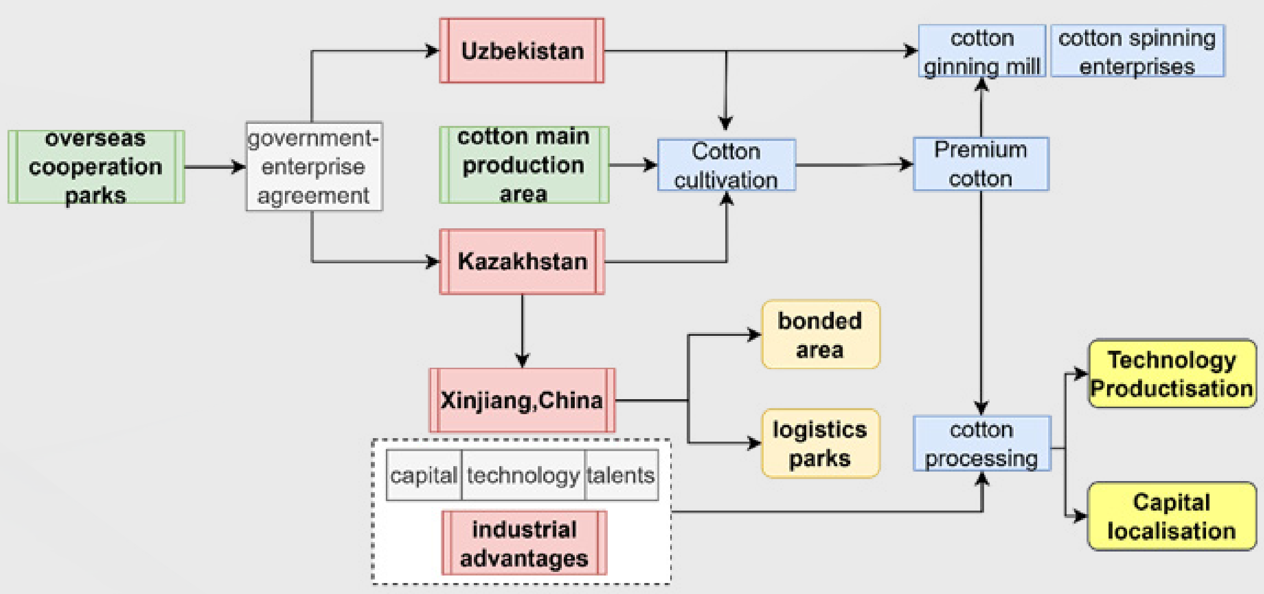
The main participants in this model are the government, enterprises, and overseas agricultural parks. The government and enterprises have signed agreements to export advanced technologies, such as cotton planting, cultivation, and management, relying on the main cotton producing areas, and implement industrial cooperation from planting to primary processing in overseas agricultural parks through technology integration. Moreover, the governments have signed cooperation agreements to build a three-in-one community of interests among the "Chinese government, park enterprises, and host government" in overseas agricultural parks to ensure the parks' sustainable development.

(2) Practice plan

The short-term plan is to focus on investment cooperation in planting, ginning, and textiles in Uzbekistan, relying on overseas agricultural parks to make up for the weak links in Uzbekistan's cotton industry chain. In Kazakhstan, relying on overseas agricultural parks, we will focus on cotton planting and local primary processing projects. Concurrently, with the help of the advantages of the Chinese (Xinjiang) cotton industry and the Xinjiang Pilot Free Trade Zone, supplemented by comprehensive bonded zones and international logistics parks, we will realize primary cotton processing and deep processing. The long-term plans are as follows: establish overseas agricultural parks through Uzbekistan and Kazakhstan; take industrial parks as carriers; realize the industrialization and group management of cotton production, processing, and sales; extend the cotton industrial chain from cotton planting, harvesting, and ginning processing to downstream textile industrial parks; realize high-quality cotton planting and advanced ginning technology; realize technical productization and capital localization. However, in this model, the connection with the downstream cotton textile industrial park is not sufficiently close, and the domestic support policy system is imperfect. The local government's support service level for park construction is limited, and it remains in the financial support stage, such as financial subsidies.

The subsequent investment promotion and customs clearance services have not been solved. Therefore, the government should provide subsidies for infrastructure construction of production and processing enterprises, export subsidies for production materials, discount loans, and premium subsidies for self-produced cotton and cotton yarn. In terms of trade policy, to meet the strategic needs of China's cotton industry's "going out," the relevant government departments should give a certain number of cotton general trade import quotas to enterprises cooperating with the cotton industry in countries along the Belt and Road and encourage enterprises to sell overseas self-produced cotton domestically to control cotton resources.

Figure 11.4: Overseas agricultural park cooperation model



11.5.3.2 "Agricultural Demonstration Park + order agriculture + cross-border e-commerce" model

This model intends to form a market-oriented "production-logistics-consumption" whole-process cotton processing trade system.

(1) Participants

The main participants in this model are core enterprises in the cotton industry chain, cotton farmers, and customs. The Chinese cotton industry chain core organization group relies on a project to establish a high-standard, modern, and mechanized agricultural demonstration park. Cotton farmers in major or high-quality cotton-producing areas plant cotton according to orders, and enterprises purchase cotton according to standards. Generally, newly ordered agricultural cooperatives provide a package of services. During customs clearance, customs actively instructs cotton-related enterprises to utilize customs trade facilitation measures fully.

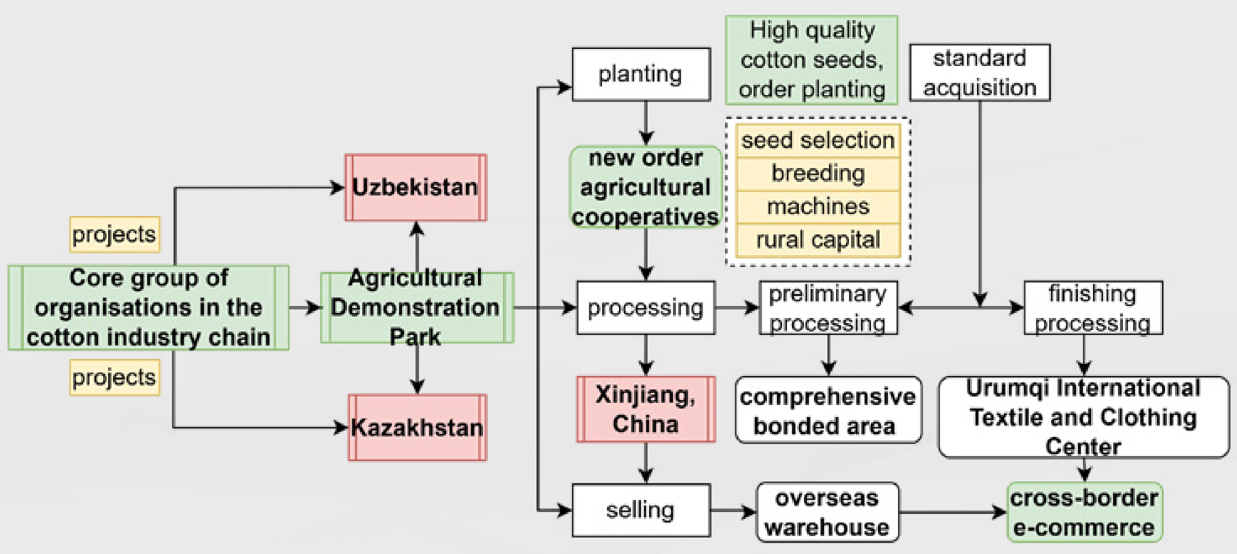
(2) Practice plan

In the short term, China's cotton-related enterprises will establish agricultural demonstration parks in Kazakhstan and Uzbekistan to supply excellent cotton quality and textile enterprises. Each variety was tested and demonstrated on a standard scale, and cotton production contracts were signed with local cotton farmers and enterprises to provide technical and financial support, unified seed supply, and unified standard acquisition. Order production refers to the signing of orders in advance according to the characteristics of downstream cotton textile products to ensure the quality of cotton and textiles. Cross-border e-commerce is developing rapidly, and small-batch personalized customization is becoming increasingly popular in the cotton textile and garment industries. Order-based agricultural models and cross-border e-commerce can be integrated. Given its superior geographical location, Xinjiang relies on the

Urumqi International Textile and Clothing Center and the comprehensive bonded area located in the Xinjiang Pilot Free Trade Zone to connect the cotton textile markets of China, Kazakhstan, and Uzbekistan, grasp the order data information of the markets in Kazakhstan and Uzbekistan, establish overseas warehouses, and sell through e-commerce platforms. The long-term plan is to form an entire industrial chain model of cross-border cotton in China, Kazakhstan, and Uzbekistan from seed research and development, agricultural planting, and intensive processing of agricultural products. Agricultural demonstration parks attract enterprises and promote the sustainable development of cotton industry cooperation. This cooperation model requires a high degree of perfection of the logistics system; however, the infrastructure construction of land transportation in Kazakhstan and Uzbekistan remains insufficient, and the cost of building an international supply chain alone is high, requiring enterprises to build overseas warehouses and use digital tools to make cross-border and domestic e-commerce systems work together efficiently.

Furthermore, the customs should give support to cotton-related enterprises to "go out" and "bring in" related products to facilitate customs clearance. The first point is the "two-step declaration" reform pilot. The "two-step declaration" allows enterprises to take delivery of goods without submitting all import documents at one time and only declare the bill of lading information outline in the first step. The second step is to complete the whole declaration within the specified time (14 days after the arrival of the means of transport). This can further optimize the port clearance process and operation model, incorporate the control of trade time costs into the pilot construction, implement the "Authorized Economic Operator" mutual recognition project, reduce document review and inspection, improve border port clearance conditions, and improve the import and export clearance efficiency of cotton and transport vehicles. The second point is to strengthen supply chain security supervision and facilitate cooperation and promote the online verification of cotton and cotton yarn inspection and quarantine certificates. Relying on the "Single Window" (a public information platform for enterprises to submit relevant application materials to customs, foreign exchange, taxation and other departments at one time, which can run the business of relevant departments), "Internet + Customs," "Integrated Management of Customs and Inspection Business," and other integrated supervision and operation platforms, the "check and inspection" and "integrated" approaches can be adopted. The third point is to strive to build an electronic online verification mechanism of origin with countries along the Belt and Road, include information and data related to the cotton industry in customs supervision, establish a "Belt and Road" customs information exchange and sharing platform, and share project information and data to create a more convenient and fair trade environment.

Figure 11.4: Overseas agricultural park cooperation model



11.6 RISK AVOIDANCE MEASURES FOR THE MULTILATERAL SUSTAINABLE COOPERATION MODEL OF COTTON INDUSTRY AMONG CHINA, KAZAKHSTAN, AND UZBEKISTAN

Considering the constraints of agricultural science and technology, business environment, foreign exchange control, and infrastructure, we will optimize policy support, strengthen industrial support, promote agricultural technology, and innovate financial services to make multilateral cooperation in the cotton industry more resilient, efficient, sustainable, and inclusive. [5]

11.6.1 Optimizing policy support: Relying on the Xinjiang Pilot Free Trade Zone to improve agricultural production efficiency

Sustainable agricultural cooperation should focus on improving the agricultural production efficiency. On November 1, 2023, the China (Xinjiang) Pilot Free-Trade Zone was officially established. By optimizing policy support, the cost of enterprises was reduced, the added value of agricultural products was increased, the comprehensive benefits of sustainable agricultural development were improved, and new opportunities for open development were shared. As the first pilot free-trade zone established by China in the northwest border area, the Xinjiang Pilot Free-Trade Zone aims to create an open, inclusive, flexible, efficient, and dynamic economic environment and promote trade liberalization, investment facilitation, and market opening. First, against the background of the deep adjustment of the global economy, enterprises are always the main body of foreign economic cooperation and participate in international market competition. To make enterprises "go out, stabilize, and develop," we should

[5] Countries should improve resilience of agri-food systems to cope with shocks and stresses: http://kz.mofcom.gov.cn/article/jmxw/202111/20211103221343.shtml

"add" in institutional innovation, refine and improve institutional arrangements, ensure the coordinated development of cotton industry investment and trade, reduce transaction costs caused by uncertainty and ignorance in bilateral and multilateral cooperation, and actively respond and satisfy them. On the premise of conforming to the national agricultural product import policy, we need a quota policy for cotton-spinning enterprises with a spinning capacity of more than 50,000 spindles and to utilize cotton's superior agricultural product resources. Second, we should subtract the approval process, deepen the reform of "one window acceptance," "one network operation," "deputy agency," and "license joint operation," and take "the simplest process, the fastest speed and the highest efficiency" as the goal, shorten the establishment time of enterprises, provide more efficient and convenient services for enterprises, and promote the business environment to become world-class.

11.6.2 Strengthening industrial support: Relying on offshore parks to drive the construction of cotton cross-border industrial chain

Agricultural production risk, low yield, and participation in cotton industry cooperation enterprises engaged in cotton production are likely to find it difficult to protect business operations, let alone sustainable cooperation. It is necessary to expand the construction of high value-added cross-border industrial chains through the rational arrangement of cotton production and processing links, resource integration, and division of labor cooperation to achieve complementary advantages and promote sustainable agricultural development. Actively supporting domestic enterprises in integrating into the construction of the Silk Road Economic Belt, relying on overseas industrial parks, deeply integrating cooperation targets, and expanding cross-border industrial chains are crucial steps. First, the strategic planning of enterprises should change from cutting to integration, actively integrate into the cotton processing industry of Kazakhstan and Uzbekistan, vigorously promote the development of cotton industry clusters, and establish a complete production system for spinning, weaving, bleaching, and dyeing finished products in cotton areas. By relying on overseas parks and government support, cooperation can be achieved with the Cotton Industry Committee, directly under the president of Uzbekistan. Relying on this committee, it has formulated precise fertilization programs, standardized pesticide use, and developed pest-control technologies.

Meanwhile, subsidies can be provided for textile export enterprises and exporters to rent overseas warehouses and provide corresponding policy preferences and other responsibilities to consortiums with more than 50% production and processing capacity of cotton raw materials produced or purchased. This will stimulate and release the development potential of the cotton textile industry and broaden the space for cooperation. Concurrently, we can strengthen the organizational level of enterprises to achieve the following: "go out"; fully utilize the advantages of flexible mechanism of private enterprises, strong state-owned enterprises, and broad channels of foreign enterprises; encourage enterprises to actively explore the establishment of overseas investment entities with mixed ownership nature; encourage and support enterprises to form multinational companies or multinational groups through sole proprietorship, joint ventures, and cooperation.

11.6.3 Promoting agricultural technology: Fostering scientific and technological integration to promote quality and efficiency in the cotton industry

Sustainable cotton industry cooperation should consider the rights and interests of cotton farmers, focus on their participation in development, provide agricultural training and technical support, and promote their self-development. Modern agricultural extension systems primarily rely on human resources, cutting-edge technologies, and advanced machinery and equipment. First, it is necessary to create a moderately sized, competent, and efficient professional team. According to the actual situation and needs of the two countries, it is necessary to increase the exchange and cooperation between agricultural experts, scholars, and technicians in terms of production technology and models. High-quality talent in cotton production and trade should be cultivated by jointly establishing scientific research teams, scientific research projects in the field of agriculture, and the exchange of students in related majors. Exchanges between research institutes and talent should be strengthened to realize the integration of advanced science and technology in the entire process of cotton cultivation and management in China, Kazakhstan, and Uzbekistan through the integration of production, education, and research. Second, we should strive for government financial support, strengthen science and technology, personnel, and technical support, and improve the productivity of agro-industrial complex enterprises. The funds should be primarily used to implement agricultural science and technology projects in the fields of precision agriculture, seed selection and breeding, and talent training, to help the main body of the cotton industry chain improve the skills of cotton production, processing, transportation, and trade, and promote the rapid development of the cotton industry. Finally, we should develop a foreign promotion system for Chinese agricultural technology, establishing several agricultural technology demonstration centers and agricultural cooperation demonstration parks. Through the promotion and exchange of advanced agricultural production technology and production experience, we should implement different promotion programs according to the different national conditions of Kazakhstan and Uzbekistan; absorb multiple exchange subjects; embed agricultural knowledge and technology such as the introduction and propagation of cotton varieties, planting technology, and the introduction of digital intelligent agricultural machinery and equipment into local cotton industry planning; and further expand to the fine processing of cotton value chains, driving the whole industry chain cooperation through this seed industry cooperation. The landforms and natural conditions of Uzbekistan and Xinjiang are similar; thus, we can promote China's advanced and efficient cotton planting technology, actively plan the China-Uzbekistan modern water-saving agricultural technology demonstration center in Syr Darya Oblast, continue to expand the area of water-saving demonstration applications, and train technical management personnel to achieve the goal of increasing production and efficiency. [6] Additionally, the links between agricultural technology research and development, promotion, and application should be highly unified so that the promotion of agricultural technology

[6] China's under-membrane drip irrigation technology goes abroad again; over 6,000 mu of demonstration and promotion in Uzbekistan: http://www.chinanews.com.cn/sh/2020/05-22/9192074.shtml

can be suitable for local development, improve productivity, and meet the development needs of the local cotton industry.

11.6.4 Innovative financial services: Accelerating capital integration to reduce foreign exchange risk

The sustainability of cotton industry cooperation considers its long-term economic viability—the cooperation project can be economically sustainable, maintain profitability and return on investment, and provide continuous support and guarantee for cotton production and the well-being of cotton farmers. We should strengthen the product portfolio and professional services of financial institutions to deal with the two-way fluctuations of the Renminbi exchange rate, innovate financial products, enrich the types and modes of use of foreign exchange derivatives, and combine financial innovation with trade investment and financing facilitation to conduct pilot programs of "offshore guarantee and foreign loan" and "offshore guarantee and domestic loan" in overseas parks, and launch cotton futures varieties that meet regional characteristics. This can provide enterprises with personalized, differentiated, and customized financing support based on credit, supplemented by investment leasing and information consulting for overseas investment cooperation as suppliers of funds for the cotton industry chain. Financial institutions play an important role in promoting the development of the cotton industry chain. Through the multi-party cooperation of financial institutions in China, Kazakhstan, and Uzbekistan, they can expand new types of financial services and increase the financial services to the main body of the industry chain in each link. Simultaneously, Chinese enterprises must pay attention to the financial convenience and security of Kazakhstan and Uzbekistan.

Moreover, we can fully utilize the Asian Infrastructure Investment Bank (AIIB) and the Silk Road Fund to provide loans, equity, debt, and other forms of financial support for the "Belt and Road" bilateral and multilateral economic and trade cooperation. The Silk Road Fund can sign a package of cooperation agreements with relevant enterprises

and financial institutions in Kazakhstan and Uzbekistan and establish a cotton industry cooperation fund to support projects in production capacity cooperation and related fields and provide preferential policies.

Additionally, we can build an offshore RMB financial market, strengthen the RMB's function of pricing, settlement, and investment in the field of production capacity cooperation between Kazakhstan and Uzbekistan, and actively explore RMB settlement with Tenge and Som for Central Asian countries adjacent to Xinjiang. We should promote the Cross-border Interbank Payment System, rely on bilateral intergovernmental cooperation platform and linkage mechanism to promote the co-construction of "the Belt and Road Initiative" countries to conduct RMB cross-border settlement in the field of commodity trade, and help foreign-invested enterprises avoid exchange rate risks, improve settlement security, save exchange costs and improve capital efficiency. In the pilot work of the RMB settlement of cross-border trade, Xinjiang should continue to expand its actual cross-border RMB collection and payment business, pay attention to innovation, and give full play to the unique location advantages of the China-Kazakhstan Khorgos International Border Cooperation Centre, the world's first cross-border economic and trade cooperation zone. Thus, strengthening bilateral and multilateral cooperation in agriculture and upgrading cross-border RMB financing services create an efficient and convenient environment for the cross-border use of the RMB to help enterprises conduct international investment, financing, and import and export.

11.7 FUTURE PROSPECTS OF THE MULTILATERAL SUSTAINABLE COOPERATION IN THE COTTON INDUSTRY AMONG CHINA, KAZAKHSTAN, AND UZBEKISTAN

The cotton industries in China, Kazakhstan, and Uzbekistan have distinct characteristics and strong complementarity, and there is significant potential for future multilateral cooperation. All three countries are expected to benefit from broadening the boundaries of cotton industry resource allocation, resolving the dilemma of cotton industry cooperation, and consolidating the benefits of agricultural industry cooperation.

11.7.1 Broadening the boundary of cotton industry resource allocation

By actively expanding cotton import channels and strengthening cooperation with important cotton producing countries, China can ensure the stability of its domestic cotton industry and supply chains. From the perspective of the value chain, middle- and low-end cotton yarn, as an intermediate product of the cotton textile industry, does not have a comparative advantage in China. However, the middle- and low-end cotton yarn production in Uzbekistan, Kazakhstan, and other countries have greater advantages, which fully utilize the international cotton yarn production capacity to develop processing trade. This will be conducive to further improving the efficiency of the industrial chain and promoting the depth of China, Kazakhstan, and Uzbekistan's participation in the international division of labor and the global industrial chain. From the perspective of domestic demand, it is urgent to promote the agricultural enterprises in western China to "go out." Additionally, their geographical advantages, cultural advantages, natural conditions advantages, and similarity advantages of agricultural industrial structure should be used to realize cooperation from point to plane along the Silk Road Economic Belt and broaden the allocation boundary of cotton industrial resources.

11.7.2 Resolving the dilemma of cotton industry cooperation

With the gradual industrialization of emerging countries and regions represented by China, the gradually formed pattern of economic division of labor between Western countries and countries in the Global South has been broken. The collaborative division of labor, such as raw materials in Xinjiang, design in Shenzhen, and manufacturing in the Yangtze River Delta, has allowed China to continue climbing into the global cotton textile industry network. The relationship among the cotton industry of China, Kazakhstan, and Uzbekistan is more complementary than competitive, and the cooperation is conducive to the sustainable development of the national cotton industry and resolving the dilemma of "high cost, weak demand, and high inventory" faced by Chinese cotton.[7] China's textile industry is increasingly at the center of the global industrial chain. China, Kazakhstan, and Uzbekistan take technology as the core, the market as the guidance, the platform as the carrier, and the enterprise as the unit to build a multilateral cooperation model. These three countries built a more stable trade environment to deepen cooperation, jointly promote the development of high-quality cotton certification systems, and master the dominant power in the supply chain.[8]

11.7.3 Consolidating the benefits of agricultural industry cooperation

China has the best industrial and supply chain foundations. Since the development of "the dual circulation strategy" (in which China should rely on a robust cycle of domestic demand and innovation as the main driver of the economy while maintaining foreign markets and investors as a second engine of growth), trade and transportation are rapidly recovering. The multilateral sustainable cooperation model established by China, Kazakhstan, and Uzbekistan can deepen the strategic positioning and thinking

[7] Facing the dilemma of "high cost, weak demand, and high inventory," cotton textile enterprises seek development: https://www.163.com/dy/article/HAF9HFFH05508UEO.html
[8] The global industrial battle behind cotton: https://news.southcn.com/node_54a44f01a2/ade35b3111.shtml

of the capital operation of enterprises and investments in the entire cotton value chain. This cooperation model promotes the upgrading of the local agricultural infrastructure, supports industrial chains, increases the ratio of investment to output, and improves the production efficiency of enterprises. Through the production of high-quality cotton and the improvement of cotton technology, the three countries will promote product upgrading and value appreciation, ultimately enhancing the core competitiveness of the cotton industry and consolidating the benefits of cooperation in the cotton industry.

11.8 CONCLUSION

In international agricultural cooperation, China mainly relies on bilateral cooperation, which has caused some problems. However, multilateral cooperation in agriculture is still in its early stages. Regarding the cotton industry, China also needs to draw nourishment from bilateral cooperation and promote a comprehensive, refined, and pragmatic multilateral cooperation approach. This paper selects three different cases: technology alliance model, park cooperation model, and Aiju Group order agriculture model, while explaining the operation status, effectiveness, and shortcomings of each model. Bilateral cooperation has accumulated rich experience for multilateral cooperation between China, Kazakhstan, and Uzbekistan. Based on the investigation of cooperation regions and partners, it is proposed to establish two multilateral cooperation models for the cotton industry between China, Kazakhstan, and Uzbekistan. Once these two complex but sustainable multilateral cooperation models are established, it will effectively alleviate the shortcomings in China's cotton supply structure and cotton resource allocation, facilitate the development of cotton production potential in Uzbekistan and Kazakhstan, and ultimately promote the rapid economic development of the three countries. However, this study has some limitations: (1) Currently, the achievements of the park cooperation model can only be found with relevant data as of 2018, and there has been little relevant content in recent years; (2) There is not much literature related to the research topic of "multilateral cooperation in the cotton industry", which leads to a lack of solid theoretical foundation. Further research in this field is required in the future.

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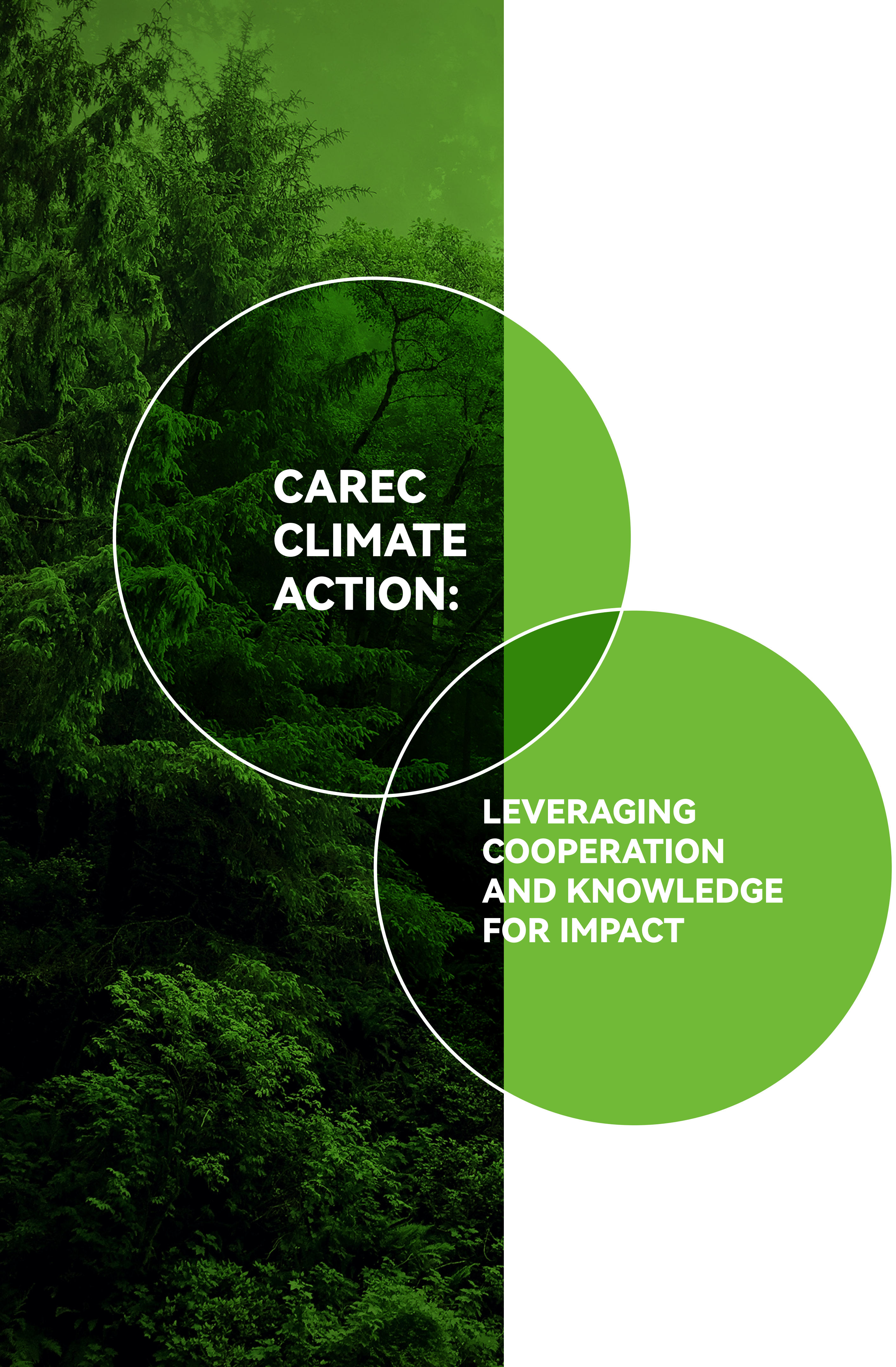

CAREC CLIMATE ACTION:

LEVERAGING COOPERATION AND KNOWLEDGE FOR IMPACT

On November 30, 2023, the CAREC Ministerial Conference endorsed the strategic document “Regional Action on Climate Change: A Vision for CAREC,” outlining the roadmap for regional collaboration on climate action among CAREC member countries until 2050. The document underscores the pressing need for unified action to combat the visible impacts of climate change in the region, including heightened temperature fluctuations, erratic weather patterns, water scarcity, floods, droughts, desertification, agricultural challenges, food insecurity, migration, health issues, and conflicts.

This strategic approach emphasizes the significance of advancing energy efficiency, sustainable agriculture, industrial modernization, renewable energy investments, water management, efficient transportation systems, sustainable urban development, robust healthcare and education systems, and early warning mechanisms for climate-related disasters. The Vision stresses the necessity of fostering cooperation and knowledge sharing through dialogues and joint initiatives among CAREC nations to address interconnected regional challenges effectively.

Climate action is explicitly integrated as a cross-cutting priority in the CAREC 2030 Strategy, emphasizing the importance of aligning regional efforts with national strategies to address Sustainable Development Goals and climate change challenges.

The CAREC Institute serves as a pivotal entity in advancing the implementation of the Regional Action on Climate Change by fostering a robust knowledge base and facilitating capacity building in sector-specific and thematic areas with a regional climate change focus. Through its active involvement in significant climate change knowledge initiatives, the CAREC Institute collaborates closely with academic institutions, think tanks, and development partners to enhance expertise, conduct research, and deliver training programs. By leveraging these partnerships, the Institute equips member countries with essential insights to comprehend climate and disaster risks comprehensively, formulate informed policies, and strategically allocate resources to bolster climate resilience.

Furthermore, the CAREC Institute's knowledge dissemination and capacity enhancement underscores its commitment to supporting member countries in navigating the complexities of climate change challenges. By intensifying its efforts in knowledge-sharing activities and forging strong partnerships with academic and research institutions, the Institute plays a pivotal role in empowering nations to proactively address climate-related issues. Through collaborative endeavors and targeted capacity-building initiatives, the CAREC Institute contributes significantly to building a sustainable future for member countries, fostering resilience, and promoting effective climate action strategies within the region.

CAREC will pursue three broad goals under the Climate Change Vision:

- Mitigate climate change: CAREC shall explore possibilities to support its member countries to achieve carbon neutrality during the middle of the 21st century by targeting activities at national and regional levels in various areas (energy, transport, agriculture, urban development, etc.) to reduce greenhouse gas (GHG) emissions and increase GHG sequestration, consistent with the United Nations Framework Convention on Climate Change and its Paris Agreement.

- Adapt to climate change: CAREC shall explore possibilities to assist its member countries to adapt to actual or expected climate change and its effects and to protect their economies and people by promoting and implementing climate adaptation, disaster risk reduction and financing measures, protecting natural resources (agriculture, water, biodiversity, and human health), and supporting complementary actions in other sectors (education, social protection, financial services, etc.).

- Cooperate across borders: CAREC shall explore possibilities to achieve mutually beneficial climate and development outcomes by cooperating in areas with strong cross-border linkages and spillovers and by sharing technologies, knowledge, and experience in all areas of climate action.

CAREC Climate Action: Leveraging Cooperation and Knowledge for Impact CONCLUSION

CAREC serves as a pivotal platform for coordinating climate actions among member countries, facilitating the operationalization of the climate agenda across its five operational clusters. It encourages active engagement from Developing Member Countries (DMCs) and Development Partners (DPs) to promote regional climate resilience. DPs, including major institutions like the Asian Development Bank and the World Bank, are expected to support the implementation of the CAREC Climate Change Vision. Additionally, the CAREC Institute plays a key role in driving knowledge enhancement and capacity building in climate change areas, collaborating with academic institutions and think tanks to intensify climate-related initiatives.

CAREC will support DMCs in crafting and executing national climate strategies with a regional focus, including assessing and refining their Nationally Determined Contributions (NDCs) and adaptation plans. Further analysis and support are needed to enhance regional cooperation and address gaps in NDC implementation. Additionally, CAREC will align sectoral strategies and project methodologies with the Paris Agreement and Multilateral Development Bank (MDB) principles, ensuring climate considerations are integrated for effective monitoring and reporting.

The regional climate agenda of CAREC will prioritize energy, water, agriculture, transport, climate-smart cities, disasters, and health, education, and social protection. Implementation will be tailored to DMC needs and the organization's capacity to manage diverse activities. Success hinges on the effective integration of climate priorities into strategies, analysis, and actions by cluster committees and expert groups within CAREC.

i. Energy: CAREC aims to facilitate a smooth transition to a low-carbon energy system in its member countries, addressing challenges such as universal energy access, security, governance, and sustainability. The organization will focus on enhancing regional electricity trade by leveraging hydro, solar, and wind resources and promoting cross-border investments aligned with the Paris Agreement. Additionally, the ADB and other

DPs will explore deploying the energy transition mechanism to accelerate the shift away from coal-fired power plants, supporting DMCs in developing green job skills and social protection mechanisms during the transition to a low-carbon economy.

ii.Water: CAREC will explore supporting DMCs in water sector adaptation actions due to water scarcity and climate change impacts in the region. The organization aims to address issues like glacier melting and water resource management, aligning with the UN General Assembly's resolution for Glacier Preservation in 2025. By focusing on efficient water use, storage, and investment based on climate risk assessments, CAREC seeks to protect regional water resources and mitigate environmental and social impacts caused by poor water management.

iii.Agriculture: CAREC countries aim to develop a climate-smart agriculture system to address the impact of climate change on agricultural productivity and food security. Through the Cooperation Framework for Agricultural Development and Food Security, CAREC will enhance agricultural practices by implementing climate-smart policies, technologies, and methods. This includes promoting sustainable farming practices, reducing greenhouse gas emissions, fostering innovation, improving water resource management, enhancing forestry practices, and establishing efficient agricultural trading systems across the region.

iv.Transport, Transit and Trade: CAREC aims to reduce the carbon footprint of regional transport services and enhance connectivity with climate-smart technologies. The organization will align its Transport Strategy with the Paris Agreement, focusing on green freight, electrification, and climate-resilient infrastructure. Additionally, CAREC will explore greening regional trade, including carbon tracking and promoting sustainable trade practices. Through the Integrated Trade Agenda 2030, CAREC will assess trade policies, digitize processes, and invest in resilient infrastructure to support climate solutions and reduce reliance on fossil fuels.

CAREC Climate Action: Leveraging Cooperation and Knowledge for Impact
CONCLUSION

v.Cities: CAREC supports the development of climate-smart cities to meet climate goals and promote sustainable urban growth. By focusing on carbon reduction, efficient urban planning, and sustainable transport, cities can enhance resilience and reduce environmental impact. Regional collaboration can further strengthen climate-smart city initiatives, sharing best practices, technology, and promoting low-carbon development. Examples in Kazakhstan, Mongolia, and the PRC showcase successful regional cooperation for more sustainable and resilient cities.

vi.Disaster Risk Management: CAREC supports countries in enhancing climate and disaster resilience in the region. By addressing natural hazards and extreme weather events, CAREC aims to reduce the impact of disasters and improve adaptation efforts. Cooperation among CAREC countries facilitates data exchange and reduces the financial burden of disaster response and recovery. Additionally, CAREC serves as a platform for regional disaster risk management and financing initiatives, working with the ADB to enhance disaster risk modeling and support climate adaptation measures. Regional collaboration can strengthen disaster resilience and mobilize resources for emergency relief and reconstruction.

vii.Social Development Actions: Health, Education and Social Protection: CAREC, under its human development cluster, will support DMCs in developing regional climate-related actions in health, education, and social protection. While these areas have fewer regional linkages, coordinated action is crucial for preparedness, capacity building, and policy implementation. Climate change impacts health, education, and social protection in the region, necessitating improvements in health systems, climate education, and social protection measures. CAREC will facilitate the sharing of approaches and lessons among DMCs to enhance regional resilience.

viii.Other Areas for Possible CAREC Climate Engagement: The CAREC Secretariat and Institute will explore additional areas of engagement, including macroeconomic policy coordination, emissions trading systems, nature-based climate solutions, and green public sector management. These initiatives aim to address climate and disaster risks, reduce carbon emissions, enhance climate resilience, and promote sustainable practices. Collaboration among CAREC countries and MDBs can support the implementation of effective climate policies and initiatives.

For guiding and monitoring results for implementing the Climate Vision Action, CAREC will establish a high-level Climate Change Steering Committee comprised of government officials to oversee climate action efforts, coordinate with relevant institutions, and develop a 3-year Climate Change Action Plan. The Committee will report annually to the CAREC Ministerial Conference. Additionally, a Cross-Sectoral Working Group and Climate Expert Group will support the Steering Committee in aligning activities with the Paris Agreement and providing technical advice on climate issues.

The CAREC Institute is dedicated to advancing regional action on climate change by fostering a robust knowledge base, facilitating capacity building, and forging partnerships with academic institutions, think tanks, and development partners. Through these collaborative efforts, the Institute aims to empower member countries to understand climate and disaster risks, develop informed policies, and strategically invest in enhancing climate resilience.

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Prospects for Inclusive Green Growth and Sustainability in the CAREC Region is a compendium of chapters by prominent researchers addressing critical economic growth issues in the CAREC region. The book targets advanced researchers, policymakers, and senior practitioners, aiming to serve as a valuable resource to harness the potential of green growth and sustainable development for CAREC countries.