GREEN ECONOMY: THE ECONOMIC IMPACT OF CLIMATE CHANGE IN CENTRAL ASIA

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A B S T R A C T	K E Y W O R D S
The paper aims at gaining insight into the economic impact of climate change in Central Asian Countries such as Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan. Central Asia is highly vulnerable to climate change owing to a set of critical interactions between the region's socio-economic and environmental contexts. While some of the Central Asian countries are among the states contributing the least to global greenhouse gas emissions, they are already suffering directly from the effects of climate change. The main aim of the paper was introduction to green economics in Central Asia, much of the region is located in already difficult climate zones, where global warming exacerbates desertification, water stress, and rising sea levels. This trend entails fundamental economic disruptions, endangers food security, and undermines public health, with ripple effects on poverty and inequality, displacement, and conflict. Considering the risks posed by climate change, the central message of this departmental paper is that adapting to climate change by boosting resilience to climate stresses and disasters is a critical priority for the region's economies.	Green economy, climat change, global warming, food security, economic growth

Introduction

The history of green economy is a complex and evolving topic. According to the Sustainable Development Knowledge Platform, the term green economy was first coined in a pioneering 1989 report for the Government of the United Kingdom by a group of leading environmental economists, entitled Blueprint for a Green Economy [1]. The report argued that environmental problems could be addressed by incorporating environmental costs and benefits into economic decision-making [2].

However, the concept of green economy has its roots in earlier ideas of sustainable development, ecological economics, and environmental justice. The Club of Rome published a influential report in 1972 titled Limits to Growth, which warned of the dangers of exponential growth in population,

consumption, and pollution on a finite planet [2]. The report called for a shift to a more balanced and equitable economic system that respects the natural limits of the environment.

Since then, many international organizations, governments, civil society groups, and businesses have adopted and promoted the idea of green economy as a way to achieve social, economic, and environmental goals. Some examples of green economy initiatives are the UNEP Green Economy Initiative, the Partnership for Action on Green Economy, the Green Growth Knowledge Platform, and the UN Environment Inquiry into the Design of a Sustainable Financial System3. These initiatives aim to provide policy guidance, technical assistance, research, and capacity building to help countries transition to greener and more inclusive economic models [3].

The main characteristics of a green economy are that it reduces environmental risks and ecological scarcities, improves human well-being and social equity, values natural capital and ecosystem services, and accounts for the full costs and benefits of environmental impacts. A green economy also supports innovation, efficiency, resilience, and diversity in various sectors such as energy, agriculture, industry, transport, and tourism [3]. A green economy is not a one-size-fits-all solution, but rather a context-specific approach that takes into account the different needs and priorities of different countries and regions.

Green economics in Central Asia is a relevant and timely topic, as the region faces multiple challenges and opportunities related to environmental sustainability, economic diversification, and social inclusion. According to the World Bank Group, Central Asia is highly vulnerable to natural disasters and climate change impacts, such as droughts, floods, earthquakes, landslides, and melting glaciers. At the same time, the region has a vast potential for renewable energy sources, such as wind, solar, hydro, and geothermal power [4]. Moreover, the region has a rich natural and cultural heritage, which can be leveraged for green tourism and rural development [5].

Several initiatives and events have been launched or organized to promote green economy development in Central Asia. For example:

The Green Climate Fund and the European Bank for Reconstruction and Development are supporting the Green Cities Facility for Central Asia, which aims to help cities in Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan to address their most pressing environmental challenges through green investments and policy reforms. The Ministry of Economy and Commerce of Kyrgyzstan with its development partners UNDP, GIZ, OSCE, Accelerate Prosperity and private sector, organized the regional event "Green Economy Forum 2022: Green Economy Development in Central Asia" to offer a platform for all partners from Central Asia to discuss, find and apply green solutions in the region.

The Forbes Business Energy published an article titled "Central Asia To Green Its Economies", which highlighted the efforts of Kazakhstan and other countries in the region to adopt new environmental legislation, invest in renewable energy projects, and diversify their economies away from hydrocarbon dependence.

These examples show that green economics in Central Asia is gaining momentum and recognition as a viable and desirable path for the region's future. However, there are also many challenges and barriers that need to be overcome, such as lack of financing, institutional capacity, public awareness, regional cooperation, and policy coherence. Therefore, it is important to continue supporting and facilitating the exchange of knowledge, best practices, and innovative solutions among all stakeholders involved in green economy development in Central Asia.
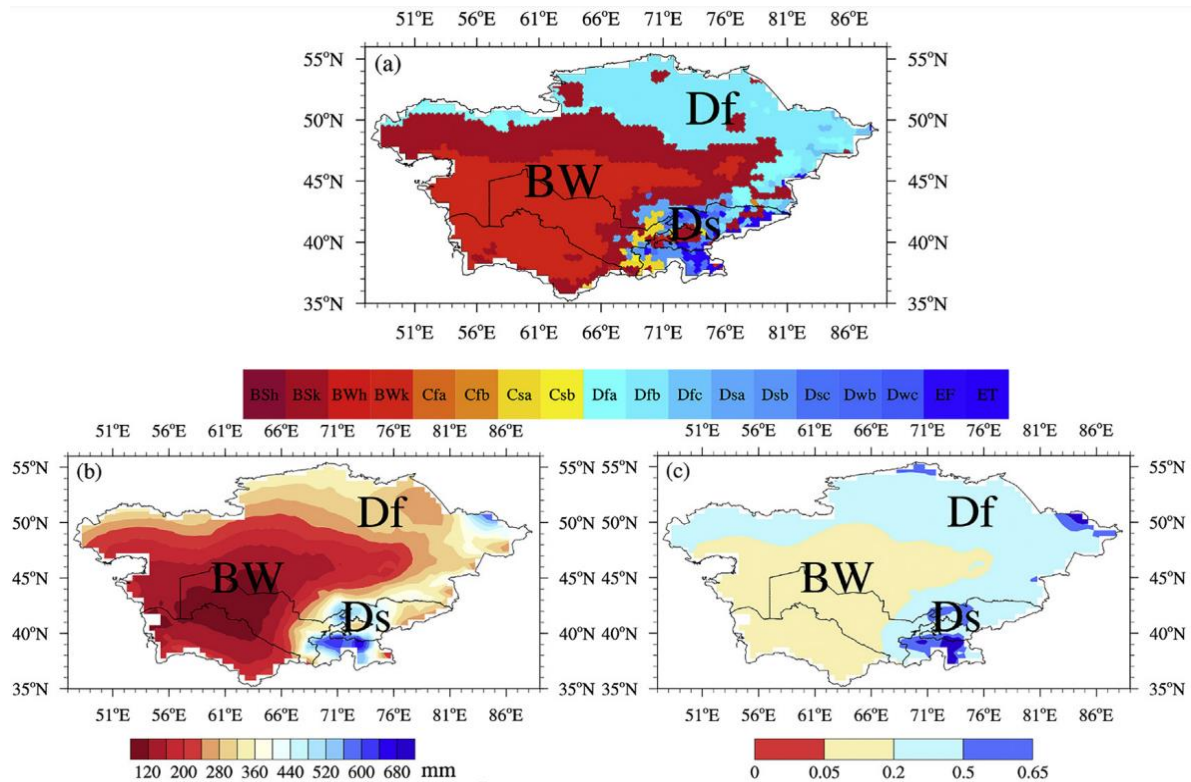
Fig. 1. Spatial distribution of (a) the three climatic zones (First letter: B, dry; C, mild temperate; D, snow; E, polar. second letter: f, fully humid; s, dry summer; w, dry winter; W, desert; s, steppe; T, tundra; F, frost. Third letter: h, hot arid; k, cold arid; a, hot summer; b, warm summer; c, cool summer), (b) long-term mean annual precipitation, and (c) aridity index over Central Asia in 1901-2010.

Central Asia is located in the center of the Eurasian continent (35_e56_N, 45_e87_E) and is far from the sea. In this study, CA encompasses five countries: Kazakhstan, Uzbekistan, Kyrgyzstan, Turkmenistan, and Tajikistan (Fig. 1). CA has diverse topography, with mountains, plains, deserts, and valleys. Due to various geomorphological and water shortages, CA has a fragile and expansive mountain-oasis-desert environment that is sensitive to dry/wet climate changes.

Table 1. List of climatic regions referred to in this study

Abbreviation	Köppen climate classification	Subregion distribution
Df	Temperate continental (Dfb)	Northern Kazakhstan (48ϵ-54ϵ N, 61ϵ-86ϵ E)
BW	Dry arid desert (BWk)	Southwestern Kazakhstan, Uzbekistan, Turkmenistan (35ϵ-48ϵ N, 54ϵ-68ϵ E)
Ds	Mediterranean continental climate (Dsb)	Kyrgyzstan and Tajikistan (37ϵ-43ϵ N, 68ϵ- 77ϵ E)

Figure 1. shows the spatial distribution of the three climatic zones: temperate continental (Dfb), dry arid desert (BWk), and Mediterranean continental (Dsb). The Dfb (hereafter referred to as Df) zone is located in northeastern Kazakhstan. The BWk (hereafter referred to as BW) zone includes parts of southwestern Kazakhstan, Uzbekistan, and Turkmenistan, including the two largest deserts, Kara-

kum and Kyzyl-kum. The Dsb (hereafter referred to as Ds) zone is primarily distributed in western Kyrgyzstan and Tajikistan. These three climatic zones are affected by different atmospheric circulations. Western circulation is the primary water vapor belt supplying abundant moisture to Df regions. The Indian monsoon influences the BW and Ds regions. Grasslands, deserts, and mountains are geographically distributed in the Df, BW, and Ds zones respectively [10].

Climate change is one of the most pressing challenges facing the world today. It poses significant risks to human health, food security, biodiversity, and economic development. The impacts of climate change are expected to be unevenly distributed across regions and sectors, with some countries and communities being more vulnerable than others. Central Asia, a region comprising Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan, is one of the most exposed and sensitive regions to climate change in the world[1]. The region is characterized by arid and semi-arid landscapes, high mountain ranges, transboundary water resources, and a high dependence on natural resources for economic growth and livelihoods. Climate change is projected to increase the frequency and intensity of extreme weather events, such as droughts, floods, heat waves, and landslides, as well as to alter the hydrological cycle and water availability, affecting agriculture, energy, and ecosystems [6]. Climate change also poses significant challenges for the region's development prospects, as it may undermine poverty reduction efforts, exacerbate social inequalities, and constrain economic diversification and competitiveness [6].

In this context, a transition to a green economy, defined as an economy that is low-carbon, resource-efficient, and socially inclusive [6], is imperative for Central Asia to achieve sustainable development and resilience to climate change. A green economy can provide multiple benefits for the region, such as enhancing environmental sustainability, innovation, and long-term competitiveness; creating new opportunities for economic growth and job creation; reducing greenhouse gas emissions and air pollution; improving natural resource management and circular economy; and supporting social inclusion and cohesion [7]. However, a green economy transition also entails significant challenges and trade-offs, such as addressing the social costs of structural adjustment, ensuring a fair distribution of benefits and burdens across sectors and groups, mobilizing adequate financing and investment, fostering regional cooperation and integration, and strengthening institutional capacity and governance [7].

Central Asia is a region of high climatic variability and diversity. The region spans from the Caspian Sea in the west to China in the east, covering an area of about 4 million square kilometres. The region's climate is influenced by several factors, such as its continental location, topography, altitude, latitude, and atmospheric circulation patterns. The region experiences four distinct seasons: winter (December-February), spring (March-May), summer (June-August), and autumn (September-November). The average annual temperature ranges from -5°C in the mountainous areas to 25°C in the lowlands. The average annual precipitation varies from less than 100 mm in the deserts to more than 1000 mm in the mountains.

According to historical observations and model simulations[2], Central Asia has experienced significant changes in its climate over the past century. Some of the main observed trends are:

A warming trend of about 0.3°C per decade since 1901, with higher rates in winter than in summer;

A decrease in precipitation of about 10% since 1950s;

A reduction in snow cover extent and duration;

A retreat of glaciers by about 35% since 1960s;

A rise in sea level by about 10 cm since 1950s;

An increase in frequency and intensity of extreme weather events.

These observed trends are projected to continue or intensify in the future under different emission scenarios. Some of the main projected changes are:

A warming trend of about 2-6°C by 2100 relative to 1986-2005 levels;

A decrease in precipitation of about 10-30% by 2100 relative to 1986-2005 levels;

A further reduction in snow cover extent and duration;

A further retreat of glaciers by about 50-90% by 2100 relative to 2010 levels;

A rise in sea level by about 30-60 cm by 2100 relative to 1986-2005 levels;

An increase in frequency and intensity of extreme weather events.

These projected changes will have significant implications for the region's natural resources, ecosystems, and socio-economic sectors.

Climate change affects the region's economy through direct and indirect channels. Direct impacts refer to the physical damages and losses caused by climate change-induced hazards, such as floods, droughts, heat waves, and landslides. Indirect impacts refer to the changes in productivity, prices, incomes, and welfare caused by the alteration of natural resources, ecosystems, and socio-economic systems due to climate change. The economic impact of climate change can be measured in different ways, such as the cost of adaptation, the cost of residual damages, the value of lost opportunities, or the change in gross domestic product (GDP) or welfare[6]. However, estimating the economic impact of climate change is subject to high uncertainty and complexity, as it depends on several factors, such as the emission scenario, the climate model, the impact model, the valuation method, the discount rate, and the time horizon. Therefore, the results of different studies may vary widely and should be interpreted with caution.

Despite these limitations, several studies have attempted to quantify the economic impact of climate change on Central Asia using different approaches and methods. The following subsections summarize some of the main findings from these studies for key sectors and groups in the region.

Agriculture is a vital sector for Central Asia's economy and food security. The sector accounts for about 15% of the region's GDP and employs about 40% of the region's labour force. The sector is also highly dependent on natural resources, such as land, water, and biodiversity. Climate change poses significant risks for agriculture in Central Asia, as it affects crop yields, water availability, soil quality, pest and disease incidence, and livestock productivity.

According to a study by World Bank (2013), climate change could reduce agricultural output in Central Asia by 2.5-4.4% by 2050 relative to a no-climate-change scenario. The study also estimates that the cost of adaptation for agriculture in Central Asia could range from $1.1 billion to $1.9 billion per year by 2050. Another study by Asian Development Bank (2017) projects that climate change could reduce crop yields in Central Asia by 8-23% by 2050 relative to a no-climate-change scenario. The study also estimates that the cost of adaptation for agriculture in Central Asia could range from $2.9 billion to $7.1 billion per year by 2050.

The impact of climate change on agriculture varies across crops and countries in the region. For instance, wheat is projected to experience a larger decline in yield than rice or maize under climate change. Kazakhstan is projected to suffer the largest loss in agricultural output due to climate change among Central Asian countries . Within countries, rural areas and smallholder farmers are more vulnerable to climate change than urban areas and large-scale farmers due to their higher dependence

on agriculture for income and livelihoods, lower adaptive capacity, and higher exposure to climatic shocks.

Energy is another key sector for Central Asia's economy and development. The region is endowed with abundant fossil fuel resources, such as oil, gas, and coal. The region also has significant potential for renewable energy sources, such as hydropower, solar power, and wind power. Energy accounts for about 10% of the region's GDP and provides about 80% of the region's electricity generation. Energy is also essential for meeting the region's growing demand for heating, cooling, lighting, transportation, and industrial production.

Climate change affects energy supply and demand in Central Asia through various mechanisms. On the supply side, climate change affects water availability and quality for hydropower generation; temperature and wind patterns for solar and wind power generation; soil stability and infrastructure integrity for fossil fuel extraction and transportation; and air quality and emissions for fossil fuel combustion. On the demand side, climate change affects heating and cooling needs for buildings; irrigation needs for agriculture; water pumping needs for domestic and industrial use; and transportation needs for mobility.

According to a study by World Bank (2013), climate change could reduce energy output in Central Asia by 1.8-3.2% by 2050 relative to a no-climate-change scenario. The study also estimates that the cost of adaptation for energy in Central Asia could range from $0.4 billion to $0.7 billion per year by 2050. Another study by Asian Development Bank (2017) projects that climate change could reduce energy output in Central Asia by 4-11% by 2050 relative to a no-climate-change scenario. The study also estimates that the cost of adaptation for energy in Central Asia could range from $1.2 billion to $2.9 billion per year by 2050.

The impact of climate change on energy varies across sources and countries in the region. For instance, hydropower is projected to experience a larger decline in output than solar or wind power under climate change. Tajikistan and Kyrgyzstan are projected to suffer the largest loss in energy output due to climate change among Central Asian countries. Within countries, urban areas and industrial sectors are more vulnerable to climate change than rural areas and agricultural sectors due to their higher dependence on energy for production and consumption, lower adaptive capacity, and higher exposure to energy shocks.

Water is a critical resource for Central Asia's economy and environment. The region is home to two major river basins: the Amu-Darya and the Syr-Darya, which originate from the glaciers and snowmelt of the Pamir and Tien Shan mountains and flow into the Aral Sea. The region also has several lakes, wetlands, and groundwater aquifers that provide important ecosystem services. Water is essential for agriculture, energy, industry, domestic use, and environmental conservation in the region. Water is also a source of regional cooperation and conflict, as it is shared among several countries with different interests and needs.

Climate change affects water availability and quality in Central Asia through various mechanisms. On the supply side, climate change affects precipitation patterns, snowmelt dynamics, glacier retreat, evaporation rates, and groundwater recharge. On the demand side, climate change affects irrigation needs for agriculture, cooling needs for energy, water pumping needs for domestic and industrial use, and environmental flows for ecosystems.

According to a study by World Bank (2013), climate change could reduce water availability in Central Asia by 11-30% by 2050 relative to a no-climate-change scenario. The study also estimates that the

cost of adaptation for water in Central Asia could range from $0.9 billion to $1.5 billion per year by 2050. Another study by Asian Development Bank (2017) projects that climate change could reduce water availability in Central Asia by 10-25% by 2050 relative to a no-climate-change scenario. The study also estimates that the cost of adaptation for water in Central Asia could range from $2.4 billion to $5.8 billion per year by 2050.

The impact of climate change on water varies across basins and countries in the region. For instance, the Amu Darya basin is projected to experience a larger decline in water availability than the Syr-Darya basin under climate change. Uzbekistan and Turkmenistan are projected to suffer the largest loss in water availability due to climate change among Central Asian countrieshttps://www.worldbank.org/en/news/feature/2013/06/25/growing-green-europe-and-central-asia [6]. Within countries, downstream areas and water-intensive sectors are more vulnerable to climate change than upstream areas and water-efficient sectors due to their higher dependence on water for production and consumption, lower adaptive capacity, and higher exposure to water shocks. Health is a fundamental human right and a key determinant of well-being and development. The region's health status has improved significantly over the past decades, as reflected by indicators such as life expectancy, infant mortality, maternal mortality, and communicable disease incidence. However, the region still faces several health challenges, such as high rates of non-communicable diseases, malnutrition, environmental pollution, and health inequities [6]. Climate change poses additional risks for health in Central Asia, as it affects morbidity and mortality due to heat stress, vector-borne diseases, water-borne diseases, respiratory diseases, mental health disorders, injuries, and food insecurity.

According to a study by World Bank (2013), climate change could increase health damages in Central Asia by 1-2% of GDP by 2050 relative to a no-climate-change scenario. The study also estimates that the cost of adaptation for health in Central Asia could range from $0.1 billion to $0.2 billion per year by 2050. Another study by Asian Development Bank (2017) projects that climate change could increase health damages in Central Asia by 2-5% of GDP by 2050 relative to a no-climate-change scenario. The study also estimates that the cost of adaptation for health in Central Asia could range from $0.3 billion to $0.8 billion per year by 2050.

The impact of climate change on health varies across diseases and countries in the region. For instance, heat stress is projected to increase more than vector-borne diseases or water-borne diseases under climate change. Tajikistan and Kyrgyzstan are projected to suffer the largest increase in health damages due to climate change among Central Asian countries. Within countries, vulnerable groups such as children, elderly, poor, and marginalized are more susceptible to climate change than other groups due to their lower health status, lower adaptive capacity, and higher exposure to health shocks. A green economy transition in Central Asia can offer significant opportunities for enhancing the region's resilience to climate change, as well as for achieving other development goals, such as poverty reduction, social inclusion, and regional integration. A green economy transition can also help the region to contribute to the global efforts to mitigate climate change, as well as to benefit from the emerging markets and technologies for low-carbon and resource-efficient products and services. However, a green economy transition also faces significant barriers and trade-offs, such as political economy constraints, institutional and governance gaps, financial and technical limitations, and social and environmental risks. The following subsections discuss some of the main opportunities and barriers for a green economy transition in Central Asia.

A green economy transition can create new opportunities for economic growth and job creation in Central Asia by tapping into the region's potential for renewable energy sources, such as hydropower, solar power, and wind power; by improving energy efficiency and conservation in various sectors, such as buildings, industry, and transportation; by promoting sustainable agriculture and natural resource management practices, such as organic farming, agroforestry, water harvesting, and soil conservation; by developing green industries and services, such as recycling, waste management, eco-tourism, and environmental consulting; and by fostering innovation and entrepreneurship in green technologies and solutions [7].

A green economy transition can also create new opportunities for social inclusion and cohesion in Central Asia by addressing the social costs of structural adjustment associated with the shift from brown to green jobs; by enhancing the access and affordability of clean energy and water services for poor and marginalized groups; by improving the health and well-being of the population through reduced air pollution and increased food security; by empowering women and youth through increased participation and leadership in green sectors; and by strengthening regional cooperation and integration through joint management of transboundary water resources and energy markets [7].

A green economy transition can also create new opportunities for environmental sustainability and resilience in Central Asia by reducing greenhouse gas emissions and air pollution from fossil fuel combustion; by increasing carbon sequestration potential through landscape restoration and afforestation; by enhancing water availability and quality through improved water efficiency Here is the addition of the policy implications and recommendations for a green economy transition in Central Asia.

A green economy transition in Central Asia requires a comprehensive and coordinated policy framework that addresses the multiple dimensions of sustainable development: economic, social, and environmental. Such a policy framework should be based on the principles of participation, integration, coherence, and subsidiarity. The following are some of the main policy implications and recommendations for a green economy transition in Central Asia:

Enhance the enabling environment for green investments and innovations by reforming the fiscal, regulatory, and institutional systems to remove distortions and barriers, create incentives and standards, and provide support and guidance for green sectors and technologies [8].

Mobilize adequate and diversified financing and investment for green sectors and projects by leveraging public and private sources, domestic and international sources, and grants and loans; by improving the access and affordability of green finance for small and medium enterprises and households; by developing green financial instruments and markets; and by enhancing the transparency and accountability of green finance.

Strengthen regional cooperation and integration for green economy transition by harmonizing policies, regulations, and standards; by facilitating trade, investment, and technology transfer; by establishing regional platforms and mechanisms for dialogue, coordination, and collaboration; by resolving transboundary disputes and conflicts; and by promoting regional public goods and services.

Build human capital and social capital for green economy transition by investing in education, training, and skills development; by creating decent and inclusive green jobs; by protecting the rights and interests of workers and communities affected by the transition; by enhancing social protection and safety nets; by fostering social dialogue and participation; and by raising awareness and advocacy.

Improve data collection, monitoring, evaluation, and reporting for green economy transition by developing indicators, metrics, and methodologies; by establishing information systems and databases; by conducting assessments, audits, and reviews; by disseminating best practices and lessons learned; and by engaging stakeholders and beneficiaries.

A green economy transition in Central Asia is not only a necessity but also an opportunity for the region to achieve sustainable development and resilience to climate change. The region has the potential to become a leader in green growth, innovation, and cooperation. However, the region also faces significant challenges and trade-offs that require concerted efforts from all stakeholders: governments, private sector, civil society, development partners, and regional organizations. A green economy transition in Central Asia is a long-term process that requires vision, commitment, action, and adaptation.

In conclusion, climate change poses a serious threat to the economic and social development of Central Asia, a region that is highly vulnerable to natural disasters, environmental degradation, and water scarcity. However, there are also opportunities for a green, resilient, and inclusive recovery that can enhance the region's prosperity and well-being. By investing in climate resilience, landscape restoration, urban air pollution management, circular economy, and renewable energy sources, Central Asia can transition to a more sustainable and efficient growth model that minimizes environmental impacts and accounts for natural hazards. The World Bank's Climate and Environment (CLIENT) Program supports Central Asia countries in achieving these goals through innovative environmental and economic analytical approaches and transboundary collaboration [9]. A green recovery in Central Asia can also contribute to the global efforts to mitigate climate change and protect the planet.

Similarly, there is also a lack of research on how local populations perceive climate change, its impacts, and risks. This is important because communities in Central Asia, especially in rural areas, are particularly vulnerable to the impacts of climate change. Their livelihoods depend on resource availability which degrades due to rising temperatures and natural disasters (floods, aridity, etc.) caused by climate change. Climate variability in dry and mountainous areas directly threatens populations, infrastructure, and arable land. Perception of increased risk of natural disasters causes parts of the rural population to migrate to other areas. Eco-migration in Central Asia has received only limited scholarly attention. In addition, this also raises the issue of climate justice for the rural population, which contributes much less to greenhouse gas emissions than the urban population. As our review has shown, the issue of climate justice in Central Asia has received no scholarly attention while it needs to be one of the priority areas for researchers and governments alike. Moreover, while the region and its international relations and security dynamics have been studied extensively in the past, the prospect of climate change influencing security and affairs among the states in the region has so far not been studied properly. [10] The very same scholars who over-securitized Central Asia have ignored the real security threats stemming from climate change. Therefore, little is known about how climate change affects and will affect security and relations among the states in Central Asia. [11] Climate change can cause conflicts around food security; exacerbate eco-migration and transform it into a foreign policy issue; complicate regional relations over scarce resources and exacerbate existing water disputes. Water-related tensions are likely to rise in Central Asia unless evidence-based research on the topic is carried out and proper preventive and adaptation policies are developed. In a similar vein, the existing literature does not discuss the position of Central Asia on

the Paris agreement. No studies examine the roles of the Central Asian states in inter-national climate change negotiations or climate scepticism and activism in the region.

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