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AT THE CROSSROADS OF CLIMATE CHALLENGES: THE POTENTIAL OF GREEN ENERGY AS THE FOUNDATION FOR SUSTAINABLE DEVELOPMENT IN TAJIKISTAN

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ABSTRACT. *This article examines the dual challenge facing Tajikistan: significant climate vulnerability and substantial renewable energy potential. Climate change, evidenced by accelerating glacial melt and hydrological instability, poses direct threats to the country's socio-economic stability. Simultaneously, Tajikistan possesses vast untapped hydropower, solar, and wind resources that could serve as the foundation for a sustainable development pathway. Based on an analysis of national policy documents, scientific literature, and international reports, this study identifies critical financial, technological, and institutional barriers to the green energy transition. It proposes strategic directions, including regional energy integration, climate-resilient agricultural modernization, and enhanced international investment mobilization. The article argues that a structured transition to renewable energy represents not only an essential climate adaptation strategy but also a unique opportunity for long-term energy security and economic transformation. Realizing this potential requires coherent policy implementation, human capital development, and strengthened international cooperation. Success would position Tajikistan as a regional leader in sustainable development while mitigating the impacts of global warming.*

KEYWORDS: *Tajikistan, climate change, green energy, hydropower, glaciers, energy security, sustainable development, Central Asia.*

INTRODUCTION

Tajikistan, a mountainous country in Central Asia, is acutely vulnerable to climate change due to its reliance on glacial meltwater and agrarian economy (IPCC, 2022). Over 90% of its territory consists of high mountain ecosystems, which are experiencing accelerated glacial retreat, altered hydrological cycles, and increased frequency of extreme weather events (IEA, 2022). Since ancient times, this country has served as a crucial hydrological "bank" and reservoir for the entire vast region. The glaciers of the Pamirs and Tien Shan, often described as rivers frozen in time, have served for centuries as strategic water reserves, gradually supplying water to millions of people and supporting thousands of hectares of irrigated land. In recent decades, however, these essential resources have faced a critical threat as their very foundations are rapidly melting.

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The country faces an existential challenge with multiple dimensions. Accelerated glacial retreat signals a critical turning point in the region's water balance. Glaciological and hydrological research in the Pamir and Tien Shan mountains reveals a dual effect of climate change: an initial increase in river runoff due to accelerated glacial melt—accompanied by heightened risks of floods and mudflows—followed by a projected long-term decline in water availability as glacial reserves are progressively depleted (Jouberton et al., 2025; Kumar, 2025; Hou et al., 2025). This dynamic directly threatens national food security, given the economy's strong dependence on agriculture. The increasing frequency of extreme weather events, including severe droughts and intense rainfall, disrupts agricultural cycles, erodes soil fertility, and creates socio-economic uncertainty, particularly in border regions where water distribution has historically required careful management.

Despite these challenges, Tajikistan possesses significant renewable energy potential, especially in hydropower, solar, and wind energy (Akhrorova et al., 2016; IEA, 2022). The country's energy transition is framed within national policy documents and international climate commitments, reflecting growing recognition of green energy as a pathway to sustainable development (Strategy for the Development of a Green Economy, 2022). The same natural features that create environmental vulnerability—powerful mountain rivers, intense high-altitude solar radiation, and persistent winds—also provide opportunities for sustainable solutions. Tajikistan ranks second within the Commonwealth of Independent States (CIS) in hydropower potential, with an estimated 527 billion kWh available annually, yet only 4-5% is currently utilized (Akhrorova et al., 2016). Additionally, the country receives high solar insolation, with up to 300 sunny days per year, while mountainous areas offer promising conditions for wind energy development (IEA, 2022).

Tajikistan thus stands at a critical juncture. One trajectory involves increasing dependence on climatic variability, energy shortages, and environmental degradation. Alternatively, with sustained political commitment, strategic planning, and international cooperation, the country could transform its vulnerabilities into strengths. In this scenario, water resources would underpin clean energy development, while solar energy would contribute to both agriculture and the national power grid. Decisions made in the coming years will shape not only Tajikistan's future but also establish a development paradigm for Central Asia's mountain regions, emphasizing renewable energy and sustainable growth.

This study aims to conduct an interdisciplinary analysis of climate risks and renewable energy potential in Tajikistan, using a policy-oriented analytical framework. The central hypothesis is that a structured green energy transition can serve simultaneously as a climate adaptation strategy and a driver of sustainable economic transformation.

To achieve this objective, the study addresses four interrelated tasks:

1. Systematize climate risks and their socio-economic impacts in Tajikistan;
2. Assess renewable energy potential and existing policy frameworks;
3. Identify systemic barriers to green energy deployment;

4. Propose integrated policy recommendations for national and regional implementation.

The structure of this article includes a methodology section that outlines the research approach, a literature review that synthesizes existing scholarship, a results section presenting findings on climate vulnerability, energy potential, policy gaps, and barriers, a discussion analyzing strategic implications, and a conclusion offering policy recommendations.

RESEARCH METHODOLOGY

This study adopts a qualitative research design grounded in policy analysis and energy transition theory (Geels, 2014), combined with a climate vulnerability framework (IPCC, 2022). The methodological approach integrates four components. First, document analysis was conducted on key national strategies: the State Environmental Program for 2023-2028, the Strategy for the Development of a Green Economy for 2023–2037, and the National Climate Change Adaptation Strategy until 2030. These documents were examined to identify official goals, priorities, and implementation mechanisms. Second, a systematic literature review was undertaken of peer-reviewed articles and monographs published between 2007 and 2025 addressing climate change, hydropower, renewable energy potential, and sustainable development in Central Asia. The reviewed corpus includes works by Tajik, Russian, and international scholars, ensuring diverse scientific perspectives. Third, comparative policy analysis was employed, focusing on energy transition pathways in mountainous developing regions with similar geographic and economic characteristics. Fourth, international reports from the IPCC (2022), IEA (2022), World Bank (2024), and official publications of the Central Asia Regional Economic Cooperation Program (CAREC, 2025) were critically reviewed to contextualize findings within global climate governance frameworks and regional cooperation initiatives. Data were analyzed using thematic coding and comparative synthesis, with attention to policy coherence, implementation gaps, and regional implications. The main methods for data processing and interpretation were comparative analysis and systematization, enabling identification of patterns, contradictions, and structural relationships. Critical evaluation was applied throughout, particularly when examining diverse perspectives on large infrastructure projects such as the Rogun HPP. This approach ensures analytical depth and balance.

LITERATURE REVIEW

Existing research on climate and energy in Tajikistan falls into three broad categories: climate impact studies, energy potential assessments, and policy and adaptation literature.

Climate impact studies focus on glacial retreat and hydrological changes. The IPCC (2022) provides comprehensive analysis of climate change impacts on mountain ecosystems globally, while Akizhanov (2024) examines the water-agriculture-energy nexus specifically in Central Asia, documenting accelerated glacier melt and projected long-term water scarcity. These studies confirm that Tajikistan's glaciers are melting at twice the rate observed in the twentieth century, creating short-term flood risks followed by chronic water deficits.

Energy potential assessments highlight the country's significant renewable resources. Akhrorova et al. (2016) provide foundational analysis of hydropower potential, estimating 527 billion kWh annually, with current utilization below 5%. The IEA (2022) offers a comprehensive energy sector review, detailing infrastructure constraints and opportunities for solar and wind development. Kazeeva and Kozreva (2023) examine hydropower prospects, emphasizing the strategic importance of the Rogun HPP for energy independence.

Policy and adaptation literature examines green economy frameworks and transboundary cooperation. The World Bank (2024) provides a detailed analysis of Tajikistan's green economy potential and recent climate and development reports, offering policy recommendations and implementation pathways. Kholnazarov and Khushvakhtzoda (2020, 2023, 2025) analyze energy security threats and sustainable development strategies from a national perspective. Sharipov (2023) examines investment attraction mechanisms for hydropower development.

International studies contextualize Tajikistan's challenges within regional frameworks. Karimov et al. (2013) assess potential regional benefits of the Rogun HPP for downstream countries. Menga (2015) analyzes the political dimensions of dam construction and nation-building. Kuchumova and Sablina (2024) examine renewable energy policies across Central Asian states. Madimarova (2025) explores the Rogun HPP's role in shaping Tajikistan's green energy diplomacy. Tsikanova et al. (2025) analyze hydropower as a strategic resource for national security.

Despite this substantial literature, a critical gap remains. Most studies examine climate risks and energy potential separately, without sufficient integration of implementation barriers and practical mechanisms for overcoming them. There is limited research linking climate vulnerability analysis with energy policy evaluation, particularly regarding implementation challenges, financing mechanisms, and regional cooperation opportunities. This study addresses that gap by connecting policy design with practical barriers and actionable recommendations, drawing on recent World Bank (2024) country climate and development reports that provide updated policy guidance.

RESEARCH METHODOLOGY

The analysis yields several substantive findings revealing the complex interplay of threats and opportunities facing Tajikistan in the context of global climate change.

Climate Vulnerability

Tajikistan faces accelerated glacial loss affecting river flow regimes, increasing flood risks in the short term and water scarcity in the long term (IPCC, 2022). The key identified risk is systemic destabilization of water balance caused by the rapid degradation of Pamir and Tien Shan glaciers. Observed melting rates have doubled, creating contradictory temporal dynamics. In the short term, increased runoff provokes more frequent and destructive floods and mudflows, threatening settlements and infrastructure. In the long term, the country faces a sustained reduction in water resources, challenging agriculture, energy production, and domestic water supply for millions of people (Jouberton et al., 2025; Kumar, 2025; Hou et al., 2025). This situation is exacerbated by general hydrological regime disorganization, manifested

in increased frequency of extreme droughts and heavy rainfall, as well as reduced snow-fed river flow. For Tajikistan's agrarian economy, where a significant portion of the population depends on agriculture, such changes undermine food security, reduce soil fertility, and increase socio-economic vulnerability across entire regions (National Climate Change Adaptation Strategy, 2019).

Table 1. Climate Risks and Energy Implications in Tajikistan

Climate Risk	Impact on the Energy Sector	Policy Response (National Documents)
Glacial melt	Reduced hydropower potential long-term; seasonal flow variability	National Climate Strategy (2030) – emphasis on diversification
Extreme floods	Infrastructure damage to power facilities	State Green Economy Program – resilience planning
Droughts	Reduced agricultural productivity, energy demand spikes	Integrated water-energy planning

Source: compiled by the author based on synthesis of National Climate Change Adaptation Strategy (2019), Strategy for the Development of a Green Economy (2022), IPCC (2022), State Environmental Program (2023), and Jouberton et al. (2025)

Renewable Energy Potential

Simultaneously, the study provides a detailed assessment of strategic energy potential embedded in the country's natural assets. The energy response to climate challenges lies in the large-scale development of renewable energy sources.

Table 2. Potential and Current Status of Key Renewable Energy Resources in Tajikistan

Resource	Potential / Current Status	Key Characteristic
Hydropower	**527 billion kWh** annual potential; 4–5% utilized	Core of the current energy system; massive untapped reserve for base load and regulation.
Solar	**High insolation** (up to 300 sunny days/ year)	Minimal installed capacity; strong potential for distributed and utility-scale generation.
Wind	**Promising in high-altitude zones**	Limited exploration; suitable for complementing solar and hydro in specific regions.

Source: compiled by the author based on Akhrorova et al. (2016), IEA (2021), and Kazeeva & Kozreva (2023)

Hydropower, traditionally forming the basis of the electricity sector, demonstrates a colossal development reserve. With a total potential of approximately 527 billion kWh per year, no more than 4-5% has been utilized (Akhrorova et al., 2016). The Rogun HPP represents a key project capable of transforming the energy landscape. Its completion promises enhanced energy independence through baseload power provision, resolution of winter energy deficits, and seasonal flow regulation capacity, particularly important under changing climate conditions (Karimov et al., 2013; Madimarova, 2025). However, project implementation remains subject to complex international consultations, highlighting geopolitical dimensions of energy development (Menga, 2015).

A crucial finding is the need to diversify the energy balance to reduce risks associated with hydrological dependence. The research confirms exceptional conditions for solar energy development, with among the highest insolation levels in the region (IEA, 2022).

Although initial solar power plants have been commissioned, this sector remains nascent and requires targeted investment and technological support. Wind energy potential, while less studied, is recognized as promising for specific high-altitude areas with stable air currents (IEA, 2022). Significant investments in the country's energy sector are already materializing through regional cooperation programs. According to data from the Central Asia Regional Economic Cooperation Program (CAREC), by the end of 2024, Tajikistan had attracted $3.6 billion in investments across 56 projects, of which about $1.20 billion was directed specifically to the energy sector (CAREC, 2025). This financial inflow underscores the growing international interest in Tajikistan's energy infrastructure and its potential role in regional electricity trade. Developing these resources would enable a more flexible, distributed energy system resilient to local climate anomalies.

Policy Analysis and Implementation Gaps

Critical assessment of Tajikistan's primary policy frameworks reveals a notable ambition-implementation gap between declared strategic objectives and practical realization mechanisms.

The Strategy for the Development of a Green Economy for 2023–2037 represents the cornerstone policy document, outlining a comprehensive vision for sustainable development (Strategy for the Development of a Green Economy, 2022). It establishes quantitative targets for increasing the renewable energy share and improving energy efficiency. However, the program operates primarily at the level of strategic goals, lacking granular implementation roadmaps, detailed sectoral action plans, and clear budgetary allocations. This absence creates ambiguity regarding responsible agencies, timelines, and funding sources, potentially leading to bureaucratic inertia and hindering coordinated execution.

Similarly, the National Climate Change Adaptation Strategy until 2030 prioritizes climate adaptation appropriately given the country's high vulnerability (National Climate Change Adaptation Strategy, 2019). It provides a valuable framework for addressing risks in water management, agriculture, and disaster preparedness. Nevertheless, the strategy exhibits structural imbalance by significantly underfunding and providing insufficient detail for the mitigation pillar, particularly renewable energy deployment projects. This approach treats adaptation and mitigation as separate tracks rather than synergistic components of a unified green transition, potentially missing co-benefits opportunities. For instance, distributed solar generation can simultaneously enhance energy security (an adaptation goal) and reduce emissions (a mitigation goal).

These policy documents collectively identify correct systemic challenges, financial constraints, infrastructural deficits, and institutional weaknesses as bottlenecks on the path to green transition (Green Economy Strategy, 2022). Yet analysis indicates that policies themselves often lack the operational depth, financial backing, and inter-ministerial coordination mechanisms necessary to effectively dismantle these barriers. There is a pronounced need for secondary legislation, regulatory frameworks for green investments, and strengthened monitoring and evaluation systems to translate high-level political commitments into tangible project pipelines and measurable outcomes. This gap between policy design and implementation capacity emerges as a fundamental barrier in its own right, constraining the pace and scale of Tajikistan's sustainable transformation.

Systemic Barriers to Green Transition

In addition to identifying potential, the study reveals a complex set of interconnected systemic barriers forming a "development trap" that slows and complicates the green transition process. Financial constraints represent arguably the most significant challenge. High capital intensity of large hydrotechnical structures and substantial upfront investments required for new technologies conflict with the state budget's limited capacity (Azimov, 2007). Despite growing global green finance markets, Tajikistan's access to instruments such as green bonds, Green Climate Fund resources, or concessional loans from international financial institutions remains constrained by the need to develop bankable project proposals and strengthen institutional capacity for their management. The World Bank (2024) estimates that achieving Tajikistan's climate commitments will require significant mobilization of private and international finance.

Infrastructure barriers manifest in high degradation of existing power grid complexes, leading to significant energy transmission losses and reduced supply reliability (IEA, 2022). This infrastructure state not only increases operational costs but also complicates the integration of new, especially small and distributed, renewable energy generating facilities into the unified grid. A technological gap exists between potential generation capabilities and the system's actual capacity to accept and distribute this energy.

Institutional weaknesses include insufficient interagency coordination between ministries of energy, economy, environmental protection, and agriculture, as well as gaps in policy implementation, monitoring, and evaluation systems (World Bank, 2024). The chronic issue of seasonal energy deficit, particularly in winter, persists. Its solution requires a systemic approach, including small hydropower development, energy storage, solar generation for local needs, and widespread energy efficiency improvements.

Geopolitical risks arise from the transboundary nature of key water resources (Menga, 2015). Any large hydropower project in upstream rivers, primarily the Rogun HPP construction, becomes subject to complex consultations with neighboring states, adding foreign policy uncertainty and potentially slowing decision-making. The water-energy nexus in Central Asia requires careful diplomatic management to ensure regional cooperation rather than tension (Akizhanov, 2024).

Table 3. Systemic Barriers to the Green Transition in Tajikistan

Barrier Category	Specific Manifestations / Characteristics	Consequences / Impact
Financial	- High upfront costs (capital intensity). - Limited access to international climate finance (green bonds, Green Climate Fund). - Difficulties in preparing bankable project proposals.	Slows the implementation of renewable energy source (RES) projects, creates a dependence on the limited state budget, and hampers the ability to attract large-scale private and international investments.
Infrastructural	- Physical and moral obsolescence of existing power grids. - High transmission and distribution losses. - Grid unpreparedness for integrating variable generation (solar, wind).	Decreases the reliability of energy supply, increases operational costs, and creates a technological gap between generation potential and distribution capabilities.

Institutional	- Weak coordination between key ministries (energy, economy, environment, and agriculture). - Gaps in monitoring, reporting, and evaluation (M&E) systems for policy implementation. - Insufficient capacity for managing complex projects.	Leads to policy inconsistency, low effectiveness in strategy implementation, and complicates the attraction and utilization of funding due to weak administration.
Geopolitical	- Transboundary nature of key water resources. - Water-energy tensions with neighboring states. - Foreign policy uncertainty surrounding large hydropower projects (e.g., Rogun HPP).	Slows down decision-making processes, necessitates complex multilateral consultations, creates additional risks for investors, and can lead to regional tensions.
Overall Effect		Creates a "development trap" – an interconnected complex of barriers that slows down and complicates the green transition process, hindering the realization of the country's strategic potential.

Source: compiled by the author based on analysis of policy documents, Azimov (2007), IEA (2022) and World Bank (2024)

DISCUSSION OF RESULTS

The findings illuminate several key dilemmas and strategic interconnections underlying Tajikistan's energy future. The most paradoxical conclusion is water's dual role, simultaneously serving as the primary vector of climate threat and the central energy asset. Accelerated glacier melt, leading to long-term water scarcity, directly threatens hydropower—the foundation of the current energy system (IPCC, 2022; Akizhanov, 2024). This paradox creates a situation where the primary adaptation tool (hydropower) depends on the same resource that constitutes the source of vulnerability (IEA, 2022). Consequently, a strategy overly reliant on large-scale hydropower, while economically justified in the short term, exacerbates long-term systemic risks by linking energy security to a climate-vulnerable resource (Kholnazarov & Khushvakhtzoda, 2020; Sharipov, 2023).

In this context, diversifying the energy balance through solar and wind power becomes not merely a technological advancement but an imperative for enhancing resilience. These sources, with complementary generation profiles (higher solar activity in summer when water scarcity may occur), can mitigate seasonal fluctuations and create a more flexible, distributed system less susceptible to climatic shocks (IEA, 2022). Moreover, developing non-hydro renewable energy sources can serve as a positive signal within transboundary dialogue, reducing perceived threats of upstream hydropower projects and fostering cooperation in shared energy security (Karimov et al., 2013; World Bank, 2024).

The second fundamental problem is the systemic gap between policy design and implementation (Geels, 2014). The existence of ambitious strategic documents, such as the Strategy for the Development of a Green Economy, represents a significant achievement (Strategy for the Development of a Green Economy, 2022). However, as practice and international reports indicate, established targets for renewable energy share

and energy efficiency are not supported by adequate regulatory mechanisms, financial instruments, and institutional capacity (World Bank, 2024; IEA, 2022). The absence of transparent grid-connection rules for renewable energy facilities, approved green energy tariffs, and streamlined investor procedures creates uncertainty and deters private capital (IEA, 2022). This situation underscores the need to shift from strategy development to creating practical "rules of the game" that translate political declarations into investment projects meeting international standards (Geels, 2014).

The third aspect concerns Tajikistan's regional positioning. Implementation of the CASA-1000 project marks an important shift from national autarky toward regional interdependence (Kuchumova & Sablina, 2024). This infrastructure lays the physical groundwork for transforming the country from a winter electricity importer to a net exporter. The strategic goal of establishing itself as a Central Asian regional energy hub appears ambitious yet achievable in the long term (Tsikanova et al., 2025; Khushvakhtzoda & Kholnazarov, 2025). However, realization depends not only on Rogun HPP completion (Madimarova, 2025) but also on parallel, profound modernization of internal grids to minimize losses and integrate heterogeneous generation sources (IEA, 2022). Success on this path would allow Tajikistan not only to ensure its own energy security but also to contribute decisively to regional decarbonization by supplying clean energy to neighboring countries, thereby enhancing its political and economic weight in alignment with sustainable development goals (IPCC, 2022; World Bank, 2024).

Finally, the green transformation must be comprehensive and interconnected, overcoming technological and managerial insularity of the energy sector and integrating it with other economic sectors. Implementing climate-smart technologies in agriculture, such as drip irrigation with solar pumps, directly links energy transition goals with water conservation and food security (State Environmental Program, 2023). Developing eco-tourism based on preserving unique Pamir landscapes creates economic value from nature conservation, directly engaging local communities (State Environmental Program, 2023). The synergy between energy, agriculture, and environmental management, as reflected in the green economy concept (World Bank, 2024), can transform climate challenges from threat sources into drivers of innovative and inclusive development.

CONCLUSION

This research demonstrates that Tajikistan stands at a decisive crossroads, where climate threats not only coexist with energy opportunities but create a unique imperative for systemic change. The climate crisis, manifested in accelerated glacier melt, hydrological regime destabilization, and increased extreme weather frequency, directly undermines national security and economic stability foundations. However, this very vulnerability highlights the strategic value of colossal, yet underutilized, renewable energy potential. The green energy transition thus emerges not as one possible development scenario, but as a historical necessity and key adaptation mechanism capable of transforming the nature of climate risks.

The success of this transformation depends on the consistent implementation of interconnected measures identified in the analysis. First, deep consolidation and operationalization of state policy is required. Bridging the gap between ambitious goals

outlined in national strategies and implementation mechanisms necessitates developing detailed sectoral roadmaps, clear budgetary allocations, and effective interagency coordination and monitoring systems. Policies in climate, energy, water resources, and agriculture must be integrated into a unified sustainable development logic (World Bank, 2024; Kuchumova & Sablina, 2024). Second, mobilizing substantial financial resources is critically important. Overcoming renewable energy project capital intensity requires active and strategic engagement with global green finance markets. Tajikistan needs to build institutional capacity to prepare investment projects meeting international standards (bankable projects) and purposefully attract funds through mechanisms such as the Green Climate Fund, sovereign green bond issuance, and partnerships with international financial institutions (Azimov, 2007; Barfiev & Kholnazarov, 2022; World Bank, 2024). Third, strengthening regional energy cooperation is a key success factor. Implementation and expansion of interstate electricity transmission projects (such as CASA-1000) will not only enable surplus clean energy export but also stabilize national grids, creating foundations for a common Central Asian energy market. This process must be accompanied by active dialogue on water-energy issues to mitigate transboundary tensions (Akizhanov, 2024). Fourth, investments in physical and human infrastructure form the transition foundation. Modernizing worn-out distribution networks and developing smart grids are essential to minimize losses and efficiently integrate variable generation from solar and wind power plants. Concurrently, profound reform of technical education systems and establishment of centers of excellence are needed to train a new generation of engineers, technicians, and managers capable of implementing and maintaining future technologies.

Tajikistan's energy transition toward a green economy represents a comprehensive strategic path extending far beyond the environmental agenda. It is a path toward genuine energy security, overcoming seasonal deficits and dependence on fossil fuels. It is a driver of economic resilience, creating new industries, jobs, and export opportunities. And ultimately, it is a chance to strengthen regional leadership, positioning the country as a clean energy hub and sustainable development model for Central Asia's entire mountainous belt. The consistency of actions taken today will determine whether Tajikistan can transform its climate vulnerabilities into sources of long-term prosperity and strategic influence.

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CONFLICTS OF INTEREST

The author declares no conflict of interest.

AUTHORS' CONTRIBUTIONS

MK: conceptualization, methodology, data curation, formal analysis, investigation, writing – original draft, visualization, project administration.

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REFERENCES:

1. Akhrorova, A. D., Boboev, F. D., & Saidova, Sh. N. (2016). Gidroenergeticheskiy potentisial Tadzhikistana i effektivnost' yego ispol'zovaniya [Hydropower potential of Tajikistan and efficiency of its use]. Vestnik Tadzhikskogo tekhnicheskogo universiteta. Seriya inzhenernykh issledovaniy, 4(36), 9-16. http://vp-es.ttu.tj/files/1/source_1495603893_ii-2017-4-36.pdf
2. Akizhanov, K. (2024). Water-Agriculture-Energy Nexus in Central Asia through the Lens of Climate Change. CAREC Institute. https://www.carecprogram.org/uploads/ENG-Kuat-Akizhanov-CSWGM-2024.pdf
3. Azimov, Kh. (2007). Finansovoye upravleniye energeticheskim potentisialom Tadzhikistana [Financial management of Tajikistan's energy potential]. Irfon. https://elibrary.ru/qskmtj
4. Jouberton, A., Shaw, T. E., Miles, E., Kneib, M., Fugger, S., Buri, P., McCarthy, M., Kayumov, A., Navruzshoev, H., Halimov, A., Kabutov, K., Homidov, F., & Pellicciotti, F. (2025). Snowfall decrease in recent years undermines glacier health and meltwater resources in the Northwestern Pamirs. Communications Earth & Environment, 6, 691. https://doi.org/10.1038/s43247-025-02611-8
5. Barfiev, K. Kh., & Kholnazarov, M. B. (2022). Takmili mekhanizmi idorakunii ta'mini amniyati energetikī (dar misoli Jumhurii Tojikiston) [Improvement of the mechanism of energy security management (on the example of the Republic of Tajikistan)]. Er-Graf. - 192 p. https://elibrary.ru/QZUYXK
6. CAREC (2025). CAREC and Tajikistan. Central Asia Regional Economic Cooperation Program. Available at: https://carecprogram.org/?publication=carec-tajikistan-2025 (Accessed: 25 February 2026).
7. Geels, F. W. (2014). Regime Resistance against Low-Carbon Transitions: Introducing Politics and Power into the Multi-Level Perspective. Theory, Culture & Society, 31(5), 21–40. https://doi.org/10.1177/0263276414531627
8. IEA. (2022). Tajikistan 2022: Energy sector review. International Energy Agency. https://www.iea.org/reports/tajikistan-2022
9. IPCC, 2022: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. Cambridge University Press, Cambridge, UK and New York, NY, USA, 3056 pp., https://doi.org/10.1017/9781009325844
10. Karimov, Kh. S., Abid, M., Ahmed, N., Akhmedov, Kh. M., & Petrov, G. N. (2013). Rogun Hydropower Plant Project of Tajikistan: Expected benefits for neighboring countries. World Applied Sciences Journal, 26(2), 239-243. http://idosi.org/wasj/wasj26(2)13/15.pdf
11. Kazeeva, N., & Kozreva, M. (2023). Gidroenergetika Tadzhikistana: potentisial segodnya i vozmozhnosti zavtra [Hydropower in Tajikistan: Potential today and opportunities tomorrow]. Energeticheskaya politika. DOI: 10.46920/2409-5516_2023_4182_58
12. Kumar, R. (2025) Glacial Retreat and Water Security: What Are the Long-Term Implications of Glacier Melt in the Tien Shan and Pamir Mountains for Downstream Water Availability in Uzbekistan and Turkmenistan?, International Journal of Research and Scientific Innovation, 12(9), pp. 2875-2880. https://www.rsisinternational.org/journals/ijrsi/article.php?id=271

13. Kholnazarov, M. B., & Khushvakhtzoda, K. Kh. (2020). Tahliili samaranokii rushdi elektroenergetika va tahdidhoi dokhilii bexatariyi energetikī [Analysis of the efficiency of electric power development and internal threats to energy security]. Payomi Donishgohi Millii Tojikiston. Bakhshi ilmhoi ijtimoī-iqtisodī va jam'iyatī, 2, 49–55. https://elibrary.ru/edppmj

14. Khushvakhtzoda, K. Kh., & Kholnazarov, M. B. (2023). Rushdi ustuvori kompleksi sūzishvorīyu energetikī dar Jumhurii Tojikiston [Sustainable development of the fuel and energy complex in the Republic of Tajikistan]. Payomi Donishgohi Millii Tojikiston. Bakhshi ilmhoi ijtimoī-iqtisodī va jam'iyatī, 11, 5–10. https://elibrary.ru/LVDYUG

15. Khushvakhtzoda, K. Kh., & Kholnazarov, M. B. (2025). Tahliili vaz'i hozira va tamoyuli ta'mini amniyati energetikī dar Jumhurii Tojikiston [Analysis of the current state and trends in ensuring energy security in the Republic of Tajikistan]. Iqtisodiyoti Tojikiston, 1, 216–222. https://elibrary.ru/OQLIOE

16. Kuchumova, Ye. V., & Sablina, M. A. (2024). Gosudarstvennaya politika stran Tsentral'noy Azii v oblasti vozobnovlyayemykh istochnikov energii na sovremennom etape [State policy of Central Asian countries in the field of renewable energy sources at the present stage]. In Mezhdunarodnyye otnosheniya v global'nom izmerenii: Materialy Vserossiyskoy nauchno-prakticheskoy konferentsii (pp. 108-113). Saint Petersburg Polytechnic University. https://elibrary.ru/DJXZBZ

17. Hou, M., Cuo, L., & Xu, H. (2025). Hydrological response to twenty-first century climate change in the Amu Darya Basin, Central Asia. Journal of Hydrology: Regional Studies, 61, 102606. https://doi.org/10.1016/j.ejrh.2025.102606

18. Madimarova, G. M. (2025). Naqshi Nerūgohi barqi obii Rogun dar tashakkuli diplomatiyai energiyai sabzi Tojikiston [The role of the Rogun Hydroelectric Power Plant in shaping Tajikistan's green energy diplomacy]. Osiyo va Avrupo, 1(21), 65–73. https://elibrary.ru/ERFJEB

19. Menga, F. (2015). Building a nation through a dam: The case of Rogun in Tajikistan. Nationalities Papers, 43(3), 479-494. https://doi.org/10.1080/00905992.2014.924489

20. Natsional'naya strategiya adaptatsii k izmeneniya klimata Respubliki Tadzhikistan na period do 2030 goda [National Climate Change Adaptation Strategy of the Republic of Tajikistan for the Period until 2030]. (2019). Dushanbe. https://faolex.fao.org/docs/pdf/taj190980.pdf

21. Sharipov, U. A. (2023). Osnovnyye napravleniya obespecheniya ekonomicheskoy bezopasnosti i privlecheniya investitsiy v gidroenergetiku Respubliki Tadzhikistan [Main directions of ensuring economic security and attracting investments in hydropower of the Republic of Tajikistan]. Ekonomika Tadzhikistana, 2, 76–82. https://elibrary.ru/MBKMJG

22. State Environmental Program of the Republic of Tajikistan for 2023-2028. (2023). Resolution of the Government of the Republic of Tajikistan 01.03.2023, No. 53. http://www.portali-huquqi.tj/publicadliya/view_qonunhoview.php?showdetail=&asosi_id=27151

23. Strategy for the Development of a Green Economy in the Republic of Tajikistan for 2023–2037. (2022). Resolution of the Government of the Republic of Tajikistan. 30.09.2022, No.482. https://nbt.tj/files/monetary_policy/2025/Стратегия%20развития%20«зелёной»%20экономики%20в%20Республике%20Таджикистан.pdf

24. Tsikanova, L. M., Zezaev, M. R., & Bokieva, M. B. (2025). Gidroenergetika kak strategicheskiy resurs ekonomiki v obespechenii natsional'noy bezopasnosti: opyt Respubliki Tadzhikistan [Hydropower as a strategic resource of the economy in ensuring national security: The experience of the Republic of Tajikistan]. Vestnik Adygeyskogo gosudarstvennogo universiteta. Seriya: Ekonomika, 2(360), 141-151. https://elibrary.ru/RGOYPO

25. World Bank (2024). Tajikistan Country Climate and Development Report. World Bank Group. https://www.worldbank.org/en/news/press-release/2024/11/07/tajikistan-country-climate-and-development-report