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CARBON FOOTPRINT REDUCTION PROSPECTS IN UZBEKISTAN – PATHWAYS TOWARD SUSTAINABLE DEVELOPMENT

Hulkar Abdusalomova[1], Qilichbek Safarov[2], Utkirjon Kholbadalov[3]
[1] – Master's student, The Academy of Banking and Finance (hulkar1215@gmail.com, 94-648-48-41)
[2] – Tashkent Institute of Chemical Technology
[3] – Associate professor (PhD), The Academy of Banking and Finance

Abstract: *Climate change poses a major challenge to global sustainability, with carbon dioxide (CO_2) emissions remaining the largest contributor to anthropogenic warming. This study examines Uzbekistan's carbon footprint reduction prospects by integrating a bibliometric survey of academic literature with an analysis of national emissions trends. The bibliometric analysis, based on Scopus data (2020–2025), reveals growing research attention to renewable energy and sustainability but limited emphasis on project management approaches crucial for effective implementation. Emissions data show Uzbekistan's reliance on fossil fuels, particularly natural gas, leading to high carbon intensity despite its relatively small share of global emissions. The results also highlights that Uzbekistan ought to undergo the need for energy diversification and efficiency improvements. The findings underscore the importance of embedding project management practices into carbon reduction policies and projects, ensuring that strategies translate into measurable outcomes and supporting the country's transition to a sustainable low-carbon economy.*

Keywords: *Climate change, carbon footprint, Uzbekistan, bibliometric analysis, project management, emissions reduction, renewable energy.*

INTRODUCTION

Climate change has emerged as one of the most urgent challenges of the 21st century, posing severe risks to ecosystems, economic stability, and human well-being worldwide [1,2]. The scientific consensus is clear: the Earth's atmosphere is warming at an unprecedented rate due to the accumulation of greenhouse gases (GHGs). Among these gases, carbon dioxide (CO_2) remains the dominant contributor, accounting for nearly 76% of global anthropogenic GHG emissions [3]. Atmospheric CO_2 concentrations reached approximately 428 parts per million (ppm) in 2025, a level not observed in at least 3 million years, compared to 280 ppm in pre-industrial times [4]. This increase is directly linked to human activities such as fossil fuel combustion, industrial processes, and large-scale deforestation [3].

Globally, annual CO_2 emissions exceeded 36.8 billion metric tons in 2024, marking one of the highest levels ever recorded, despite international efforts to curb them [5]. The relationship between economic growth and carbon emissions complicates the global mitigation agenda: for example, the world's three largest emitters—China (29% of global emissions), the United States (14%), and India (7%)—

together account for more than half of all emissions, reflecting their dependence on coal, oil, and natural gas to power rapid industrialization, transportation networks, and urban expansion [6]. While developed economies have begun to decouple emissions from growth through renewable energy adoption and efficiency measures, many emerging economies continue to face the dilemma of balancing rising energy demand with climate commitments.

The international community has responded to the climate crisis with a wide range of carbon reduction strategies, reflecting both shared commitments and country-specific contexts. The European Union (EU) has been at the forefront of market-based climate policies, introducing the EU Emissions Trading System (EU ETS) in 2005 and complementing it with national carbon taxes [7,8]. Sweden, for example, has one of the highest carbon taxes in the world, currently set at around €134 per ton of CO_2, making it a benchmark for climate pricing policies [9].

Norway has advanced its carbon neutrality agenda through large investments in renewable energy and carbon capture and storage (CCS), particularly projects like Northern Lights, which aim to develop cross-border storage solutions in the North Sea [10,11]. In the Middle East, countries such as Saudi Arabia and the United Arab Emirates are diversifying their fossil-fuel-based economies [12]. Saudi Arabia's Vision 2030 and the UAE's net-zero pledge by 2050 are supported by flagship projects, including the massive Mohammed bin Rashid Al Maktoum Solar Park, planned to reach 5,000 MW capacity by 2030 [13].

In Asia, Japan has positioned itself as a leader in green hydrogen development and experimental technologies such as microalgae-based carbon capture, showcasing how technological innovation can complement traditional renewable energy expansion [14,15]. Beyond Asia, Canada has established itself as a pioneer in carbon pricing and emissions trading, with federal and provincial systems shaping both industrial behavior and consumer choices [16]. Similarly, several countries in the European Union, including Germany and Denmark, have become global frontrunners in wind and solar energy integration, proving that renewable technologies can be scaled up while maintaining grid stability.

Uzbekistan, as the most populous country in Central Asia and a significant producer of fossil fuels, finds itself at a critical juncture [17]. On one hand, the country relies heavily on natural gas, coal, and oil to sustain economic growth and ensure energy security [18]. On the other, it faces rising pressure—both domestically and internationally—to align its development with global climate commitments, such as the Paris Agreement [19,20]. Recent government strategies, including the "Green Economy Transition Strategy 2019–2030," signal Uzbekistan's growing recognition of the need to diversify its energy mix and reduce carbon intensity. However, the country still faces multiple challenges, ranging from infrastructure readiness and financing to institutional coordination.

Against this background, the present article seeks to analyze Uzbekistan's carbon footprint profile, evaluate prospects for reduction, and examine the role of project management in implementing decarbonization initiatives. By combining bibliometric analysis of academic outputs with empirical data on carbon emissions, this study not only situates Uzbekistan within the global climate debate but also offers practical insights into pathways for sustainable development.

METHODOLOGY

This study employs a mixed-methods approach that combines a bibliometric survey of academic research with quantitative analysis of carbon emissions data in order to examine the prospects for carbon footprint reduction in Uzbekistan. By integrating these two complementary methods, the research is able to assess both the knowledge production within the academic field and the empirical realities of emission trends in Uzbekistan and Central Asia.

Bibliometric analysis is a systematic method for evaluating scientific output by examining publications, citations, and keyword networks [21]. It provides insights into how research themes evolve and how different actors—authors, institutions, and countries—contribute to the knowledge base. In the context of this study, bibliometric analysis was conducted to map the academic attention devoted to carbon footprint reduction, climate change, and sustainability in Uzbekistan.

The data for the bibliometric survey was collected from the Scopus database, one of the largest repositories of peer-reviewed scientific literature. The initial search employed specific keywords such as "green transition," "carbon emissions," "climate change," and "sustainability," limited to the years 2020–2025 and with Uzbekistan as the affiliation country. As the number of results proved insufficient for a meaningful co-occurrence analysis, the scope was broadened to include all types of scientific outputs (articles, conference papers, reviews, and book chapters) published during the same period. This yielded a total of 5,470 documents, which were subsequently analyzed using the software VOSviewer, a tool specifically designed for visualizing bibliometric networks.

A keyword co-occurrence map was generated, showing how research topics are interconnected. In such maps, the size of each "node" represents the frequency of occurrence of a keyword, while the thickness of the connecting lines indicates the strength of co-occurrence between terms. This method enables identification of dominant research themes, such as renewable energy, sustainability, or carbon footprint management, and highlights gaps in the academic landscape in Uzbekistan.

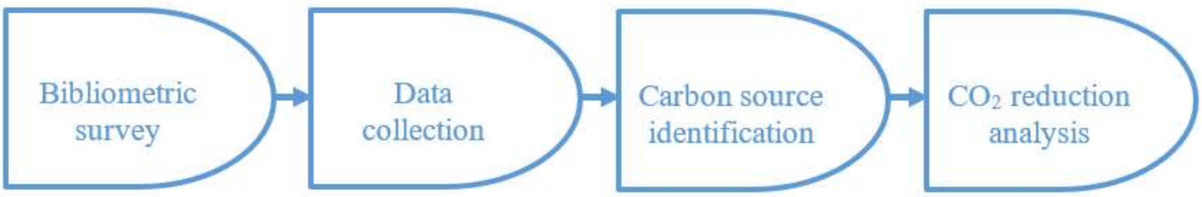

Figure 1. General flow diagram of this research

In parallel with the bibliometric analysis, quantitative data on carbon emissions was collected to provide an empirical foundation for evaluating Uzbekistan's mitigation prospects. Two main data sources were used to ensure accuracy and reliability: TheGlobalEconomy.com and Our World in Data (OWID). These databases provide harmonized datasets on national carbon emissions, energy mix, and economic indicators, which are widely recognized in policy and academic research.

The analysis covers the period 2016–2023, allowing for the identification of short-term trends in both absolute emissions and per capita values. Furthermore, Uzbekistan's data was compared with that of other Central Asian countries (Kazakhstan, Kyrgyzstan, Tajikistan, and Turkmenistan) to place the country's carbon profile within a regional perspective. This comparative analysis helps to assess whether Uzbekistan's emissions trajectory aligns with, diverges from, or outpaces its neighbors. General flow diagram of this research is shown in Figure 1 below.

RESULTS & DISCUSSION

The bibliometric analysis revealed significant trends in the scientific literature related to climate change, carbon emissions, and sustainability in Uzbekistan [22]. Using VOSviewer software, a keyword co-occurrence map was generated based on the dataset of 5,470 documents published between 2020 and 2025. The map highlights clusters of frequently occurring keywords, with larger nodes indicating higher research frequency and thicker lines showing stronger associations between themes.

The most prominent clusters centered around terms such as "renewable energy," "sustainability," "climate change," and "carbon emissions" (See in Figure 2). These keywords formed the core of Uzbekistan's academic engagement with global climate debates. A secondary set of clusters included "economic development," "energy efficiency," and "green transition," reflecting a growing recognition of the link between environmental concerns and economic modernization. Notably, project management–related keywords such as "risk management," "policy implementation," and "innovation" appeared only marginally, suggesting that the academic discourse in Uzbekistan has yet to fully integrate project management perspectives into the field of climate action.

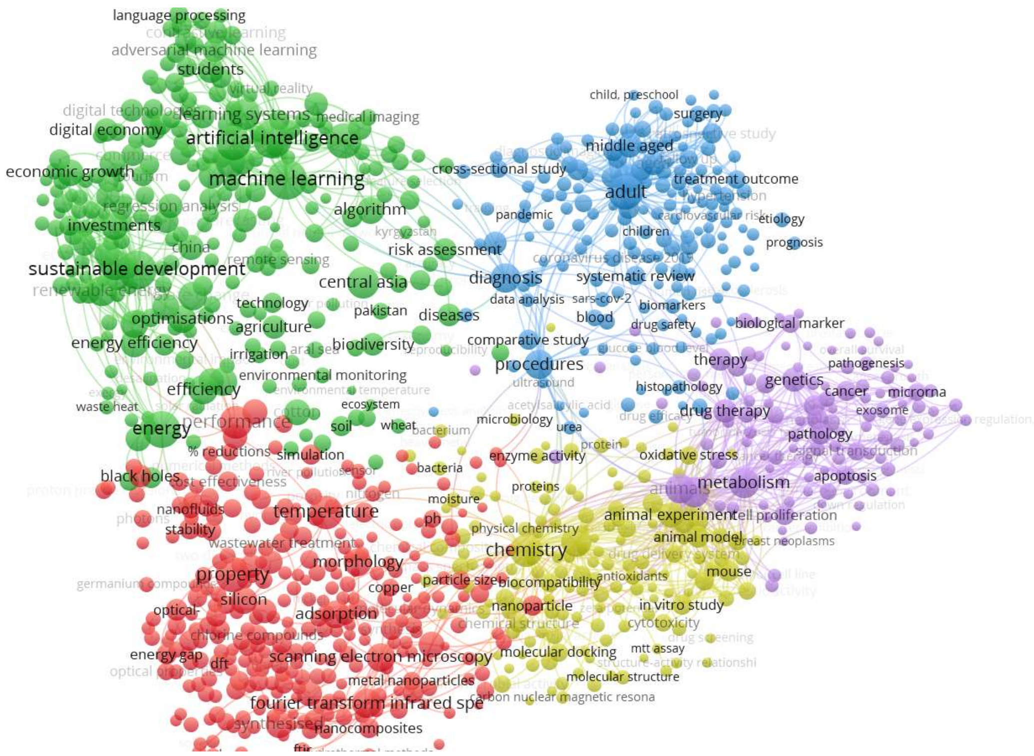

Figure 2. Keywords-based co-occurance map showing the last 5-year research trends in Uzbekistan in Scopus database.

This finding is particularly important because project management provides the tools necessary to structure and implement complex carbon reduction projects. The limited presence of project management concepts in Uzbekistan's academic output points to a gap between theoretical knowledge on climate change and the practical methodologies required for effective project execution.

In terms of the carbon emissions profile of the region, Uzbekistan's carbon emission profile was examined over an eight-year period from 2016 to 2023 using two independent data sources—TheGlobalEconomy and Our World in Data. To strengthen accuracy and reduce inconsistencies between datasets, an average value was also calculated. This combined approach provides a more robust picture of Uzbekistan's emission trajectory, which is illustrated in Figure 3.

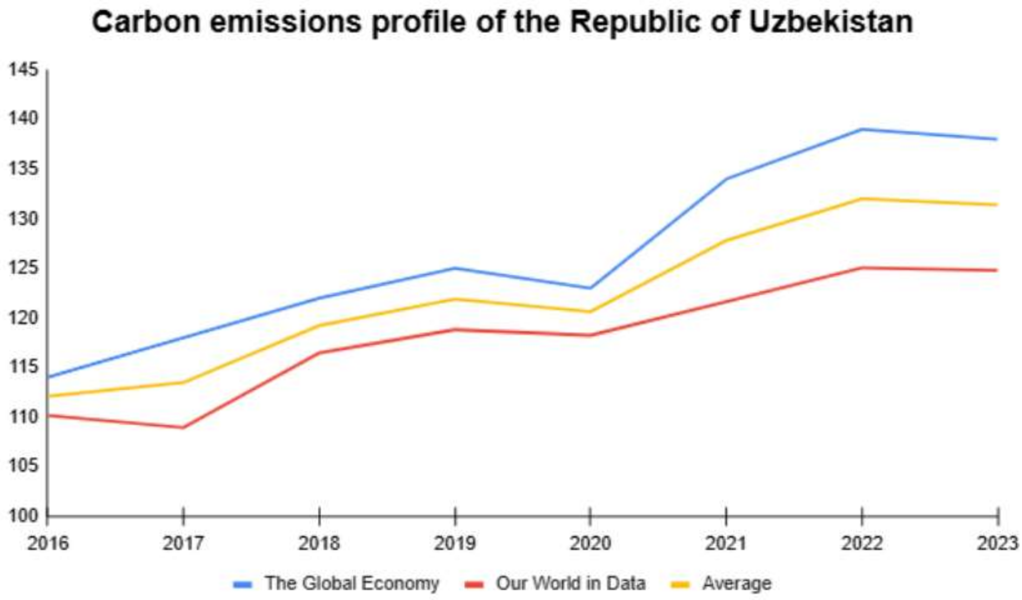

Figure 3. Uzbekistan's CO_2 emissions level from 2016 to 2023 using two different data sources and their average.

At first glance, the results reveal a clear upward trend in carbon emissions during the study period, with some fluctuations linked to external shocks. Between 2016 and 2019, emissions rose steadily across all datasets, increasing from approximately 110–114 units in 2016 to around 119–125 units in 2019. This growth reflects the country's expanding energy demand and continued dependence on fossil fuels.

In 2020, emissions fell modestly across both sources, most likely due to the global COVID-19 pandemic, which slowed industrial production, transportation, and energy consumption. However, this decline proved temporary, as emissions surged again in 2021 and reached their highest levels in 2022. According to TheGlobalEconomy, emissions peaked at nearly 140, while Our World in Data reported about 125, with the average standing at roughly 132. This rebound illustrates the strong link between economic recovery, energy demand, and emissions growth in Uzbekistan.

By 2023, emissions slightly decreased compared with 2022, yet they remained significantly above pre-pandemic levels. The consistent gap between the two datasets—where TheGlobalEconomy reports higher values than Our World in Data—

indicates differences in measurement approaches, but both sources confirm the same overall trajectory.

In short, Uzbekistan's emissions profile from 2016 to 2023 reflects a long-term upward trend interrupted briefly by the pandemic, followed by a rapid rebound. These findings underline the country's increasing reliance on carbon-intensive energy sources and point to the urgent need for comprehensive emission reduction policies, renewable energy deployment, and efficiency improvements to prevent continued emissions growth in the coming years.

The upward trajectory of Uzbekistan's carbon emissions highlights the urgency of accelerating decarbonization measures. The heavy reliance on natural gas and other fossil fuels for electricity, heating, and industrial production suggests that without significant reforms, emissions will remain structurally high. However, the rebound observed after the COVID-19 decline also demonstrates the potential for emissions to respond quickly to shifts in economic activity, policy interventions, and technological adoption. This indicates that with targeted strategies—such as scaling up renewable energy, improving energy efficiency, and adopting cleaner production methods—Uzbekistan can alter its current trajectory and achieve meaningful reductions.

From a project management perspective, the challenge lies not only in introducing new technologies but also in ensuring effective planning, financing, and stakeholder engagement. Uzbekistan's ambitious policy framework, including goals to raise renewable energy's share in the power mix to 20% by 2025, provides a solid foundation. Yet, successful implementation will require coordinated action between government, private investors, and international partners. This calls for robust project management approaches that can translate policy targets into operational projects, ensuring that emission reduction initiatives are both technically feasible and economically sustainable.

CONCLUSIONS & FUTURE RECOMMENDATIONS

This study explored Uzbekistan's prospects for carbon footprint reduction by combining a bibliometric review of academic research with an analysis of the country's emissions profile. The findings indicate that while research activity on sustainability and renewable energy has grown in recent years, project management perspectives—such as planning, risk assessment, and financing—remain underrepresented.

At the same time, Uzbekistan's emissions profile shows continued dependence on fossil fuels, with natural gas dominating electricity generation and industry. Although its share in global CO_2 emissions is below 0.3%, per capita emissions remain relatively high compared to countries with similar income levels. This highlights structural inefficiencies and the urgent need for transition.

For Uzbekistan to meet its renewable energy targets and align with global climate goals, policies must be complemented with effective project management frameworks that ensure projects are planned, financed, and executed efficiently. Greater collaboration between academia, government, and industry will be essential to close the gap between knowledge and implementation.

In short, Uzbekistan is well-positioned to advance toward a low-carbon future, but success will depend on its ability to translate ambitious strategies into practical, measurable outcomes through structured project management.

Based on the findings of this study, several forward-looking recommendations can be proposed to strengthen Uzbekistan's efforts in reducing its carbon footprint. First, there is a need to accelerate the diversification of the national energy mix. While natural gas will likely remain a transitional fuel in the medium term, large-scale investments in solar, wind, and hydropower should be prioritized. Expanding renewable energy capacity not only reduces emissions but also enhances energy security and reduces exposure to global fossil fuel price fluctuations.

Second, carbon reduction strategies must be supported by innovative financing mechanisms and international cooperation. Uzbekistan should explore opportunities within carbon markets, green bonds, and climate finance facilities offered by institutions such as the World Bank, the Asian Development Bank, and the Green Climate Fund. Such instruments can mobilize the significant capital needed for low-carbon infrastructure while providing incentives for private-sector participation.

Finally, stronger integration of project management practices is essential for the success of emission reduction initiatives. Future projects should incorporate clear timelines, measurable performance indicators, and risk management frameworks to ensure accountability and impact. Moreover, building local capacity through training and knowledge transfer will help bridge the gap between policy ambition and implementation. By combining technical innovation, financial innovation, and robust project management, Uzbekistan can not only achieve its renewable energy and climate goals but also position itself as a regional leader in sustainable development.

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