Sustainable Architecture in Uzbekistan: Incorporating Traditional Techniques into Modern Green Design

Dilnoza Kamalova[1]*

[1]Samarkand State Architecture and Construction University, Samarkand, Uzbekistan

Abstract. Uzbekistan's infrastructure shows that it can handle extreme weather while still looking good and working well. This study aims to determine the integration of modern sustainable design strategies with passive technologies, such as passive cooling, natural material insulation, and optimal building orientation. This study examines historic architecture in Samarkand, Bukhara, and Khiva to identify key characteristics that decrease energy consumption and, consequently, lessen environmental impacts. The results show how these old-fashioned ways can be brought back to encourage climate-friendly, long-lasting architecture in cities and towns today. Recent architectural projects show that it is possible to design and build sustainable and culturally important buildings by combining historical references with cutting-edge green technologies like solar panels, advanced climate control systems, and green roofs. This method lets Uzbekistan keep its unique architecture while also meeting the growing needs for energy efficiency and environmental sustainability. The article ends with suggestions for architects and policymakers on how to successfully mix old and new styles in Uzbekistan's modern architecture.

1 Introduction

Sustainable design is a new idea that is slowly gaining popularity around the world. It focuses on making buildings more energy-efficient and comfortable while having less of an impact on the environment [1-2]. This trend is especially important for Uzbekistan because of its harsh weather, fast-growing cities, and buildings that can help the environment [3]. Uzbekistan can solve social and environmental problems by combining traditional farming knowledge with new green design ideas while still being unique. Uzbekistan's participation in global environmental projects follows the principles of sustainable design, such as using renewable energy, managing water, and being energy efficient. One thing that makes this style of architecture stand out is that it uses better techniques that are suited to the climate of Uzbekistan. For a long time, people have used kanots (groundwater channels), houses (ponds), and sardobas (reservoirs) to show that passive cooling and water management work [4]. It is possible to design buildings that are environmentally friendly and use less energy by combining old building methods with new technologies like solar panels and

*Corresponding author: dilnoza.kamalova.zayniddinovna@gmail.com

green roofs. The cities of Samarkand and Tashkent are growing quickly, which is putting a strain on the infrastructure and people who live there. Parker passive solar heating, local building materials, and ventilation systems that fit with the architectural style of the mahalla [5] should all help with this. These strategies also help people use less energy and encourage the communal way of life that is typical of the Uzbek people [6]. The country's cutting-edge green architecture is set apart by its use of bioclimatic design and cutting-edge technologies from around the world [7]. It is important to remember that advanced engineering can work well with traditional values and principles when thinking about building a "green building" in Tashkent [8]. Nonetheless, for these projects to gain widespread acceptance, challenges related to cost, expertise, and government support emerge as significant obstacles [9]. This essay looks at how Uzbekistan can use its rich architectural history to encourage the building of new, environmentally friendly buildings. It looks at the possibilities of using integrated methods that mix traditional approaches with new technologies, as well as the problems that need to be solved to make the country a better place to live in cities [10].

2 Methods

This research on sustainable architecture in Uzbekistan utilizes a comprehensive research methodology to analyze and integrate traditional techniques with modern green architectural principles.

Literature Review: A literature review was performed to examine and compare the energy efficiency characteristics of ganch (gypsum plaster) and chillakhona (underground cooling systems) in both contemporary and historical Uzbek architecture. Contemporary green architecture articles and case studies were also cited to find connections in understanding [11].

Fieldwork and interviews: We used historical buildings like Khiva, Samarkand, and Bukhara to show how courtyards and windbreaks are usually set up. Interviews with architects, engineers, and cultural heritage professionals were used to get qualitative data on how well these methods work in today's world.

We looked at temperature, solar radiation, and wind data from Uzbek meteorological sites to see if modern design needs to include visual images. Geographic Information Systems and computer models were used to make a copy of the environment [12].

Examination of the Case Study: The analysis included specific examples of the practical application of sustainable buildings in Uzbekistan through traditional methods. Sustainable Tourism: The Samarkand Silk Road Cultural Centre project is a great example of how sustainability and heritage practices can work together.

We looked at how well traditional materials like adobe bricks and karakul wool insulation worked in terms of heat and structure. The findings led to suggestions for changes to make them follow current green building standards.

Design Prototyping: Conceptual designs were created to show how traditional methods can be used with sustainable technology. Software simulations were employed to evaluate the environmental impact and energy efficiency of these prototypes.

This integrated framework ensures a balance between preserving cultural heritage and attaining modern environmental goals.

3 Result and discussion

The following information is based on a graph and chart from the Scopus database, which presents statistics on scientific articles published using the terms "modern AND green AND architecture" between 2010 and 2024 (Figure 1.).

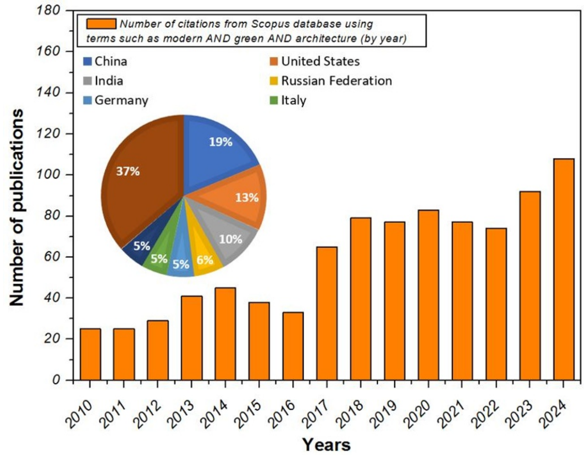


Fig. 1. Number of citations from Scopus database using terms such as modern AND green AND architecture (by year).

Annual dynamics of the number of publications: As shown in the graph, the number of scientific articles on this topic has been growing steadily over the years. While in 2010 only 20 articles were published, by 2024 this figure had exceeded 160. Since 2015, there has been a significant increase in the number of articles published, which indicates an increased interest in the topic of modern and ecological architecture. In particular, the promotion of ecological buildings and green technologies has gained urgent importance in recent years in connection with global problems - climate change and energy efficiency.

Country Contribution: The chart shows the distribution of scientific work by country over the years. The shares are distributed as follows.

China - 37%: As the chart shows, China is a leader in the field of ecological architecture. This is the outcome of political efforts made by the country to establish sustainable construction technologies, ecological city planning and energy efficient construction.

USA - 19%: The subsequent proportion of the USA illustrates the second place in scientific studies on this issue. This has made the country set many projects to develop technologies associated with green issues and apply innovative solutions.

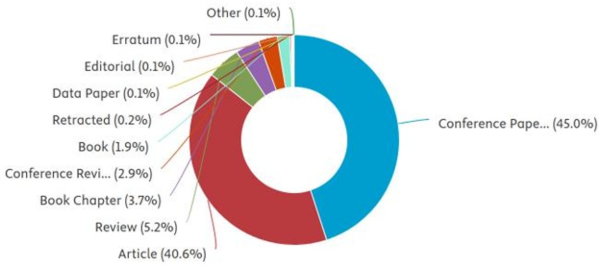
India - 13%: Eco architectural research done in India is in an effort to conserve energy resources and the ecology, which has hugely increased India’s contribution.

Germany - 10%: Germany has become hallmark when it comes to the promotion of energy efficiency along with the use of green building technologies.

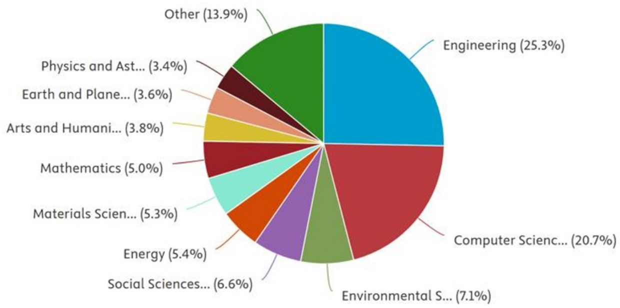
Italy and Russia - 5% each: Despite the fact that these countries have relatively low rates of scientific innovations related to green architecture, those rates are increasing.

Statistics show that the number of scientific works on modern and ecological architecture is increasing, and this topic is gaining global importance. The high percentage of countries like China and the United States is a direct result of the scientific and technological progress that is being made to bring green technologies to these countries. This process serves to save energy resources, solve environmental problems and ensure sustainability in urbanization processes. At the same time, the contribution of countries such as India, Germany, Italy and Russia is also growing significantly. This trend creates the basis for the implementation of many scientific research and practical projects on environmental sustainability and green architecture in the future. Therefore, it is necessary

to develop global scientific cooperation on modern green architecture and encourage more research in this area.
The following information is based on graphs and charts from the Scopus database, which shows the distribution of scientific articles published between 2010 and 2024 by field and area (Figure 2.).



a)



b)

Fig. 2. Distribution of publications published between 2010 and 2024 from the Scopus database by field and direction.

Distribution by type of publications: Graph a) shows the distribution of publications by different formats.

From this distribution it is clear that:

Conference Papers occupy the leading position with a share of 45%. This indicator shows that many scientific studies are presented at conferences, which indicates a high level of academic cooperation and discussion on the topics. Scientific articles occupy the second place with a share of 40.6%. This confirms the importance of publishing fundamental research in this area of scientific research. Review articles are next with a share of 5.2%. Review articles are of great importance in summarizing current issues in the scientific field and developing new ideas. Books and Book Chapters account for a total of 5.6%, indicating the presence of in-depth research and methodological developments on this topic. Other forms (Editorials, Retracted Papers, etc.) account for a much smaller share.

Distribution by field and direction: In Chart b), publications are divided into different fields and directions.

Engineering is the leading field with a share of 25.3%. This field includes technical and practical approaches to the development of ecological architecture and green technologies. Computer Sciences is in second place with a share of 20.7%. This field has conducted many studies on the application of information technologies in the design and management of ecological structures. Environmental Sciences occupies a share of 7.1%. This field is important for research aimed at ensuring environmental sustainability. Energy and Materials Science account for 5.4% and 5.3%, respectively. They include research aimed at the use of green energy and sustainable materials. Social Sciences accounted for 6.6%, Arts and Humanities for 3.8%, and Physics and Astronomy for 3.4%, reflecting different approaches to developing ecological architecture. Earth and Planetary Sciences accounted for 3.6%, with research in this area related to climate change and conservation.

As can be seen from the statistical data, the topic of modern and ecological architecture is being studied in depth in many fields. Recent articles in engineering and computer science also support these issues and the role of contemporary techniques in this field. Also, scientific activities in social and environmental sciences contribute to the dissemination of ecological and natural resource efficiency or green buildings. These analyses can also help in development of further cooperation of scientific with development of new projects.

Many cities include Khiva, Samarkand, and Bukhara that are famous for their historical and cultural significance and populated with unique building's constructions. In these cities, fieldwork and interviews were carried out in order to understand how design concepts from tradition can be incorporated in present day applications. For instance, possibilities of construction technologies relating to elements including courtyard and windbreak, and of environmental effects of modern renewable energy devices like those of solar power were discussed in detail.

Fieldwork: In the course of the fieldwork, historical buildings in Khiva, Samarkand and Bukhara have been observed and the I-A-structures and the design peculiarities of the buildings were studied. Like the clime conditions of these cities, the courtyards and windbreaks were formed, and the functions of heat control and natural ventilation were significant. For instance, windbreaks were useful for changing warm air for cold air and, courtyards for preserving coolness indoors. Their environmental implications, or energy efficient attributes, were also accorded a touch of priority.

Data collection through interviews: As part of this fieldwork, interviews with architects and engineers, cultural heritage experts were made. The interviews highlighted the fact that the aesthetic appearance of the construction were made using modified historical construction techniques that suits the modern market condition. As for key points, which are already contained in the latest architectural solutions, such as the adoption of courtyards and windbreaks in the construction of modern facilities, it is worth noting, firstly, it saves energy, and secondly, it implements the concept of sustainable architecture. The potential of such elements being processed with current materials was also considered.

For instance, there is often talk of the fact that it is possible to use the so called 'classic' windbreaks installed in the constructions of the modern type with very efficient ventilation.

For this reason, having ascertained the data, it would be crucial to examine the shapes of historical constructions and use them in contemporary constructions. This is not only beneficial in terms of historical preservation, but also gets ahead with solutions that contribute to energy management. This experience of Khiva, Samarkand, and Bukhara is unique for this process. This approach makes for a serious improbability to implement the ideas of sustainable architecture in combating the climate change, and may act as a motivation for new studies in the sphere of architecture in the future.

In order to understand whether it is possible to incorporate some of the traditional elements to the materials and designs of the contemporary constructions in Uzbekistan, it is possible to use certain climate, temperature, insolation, and wind data.

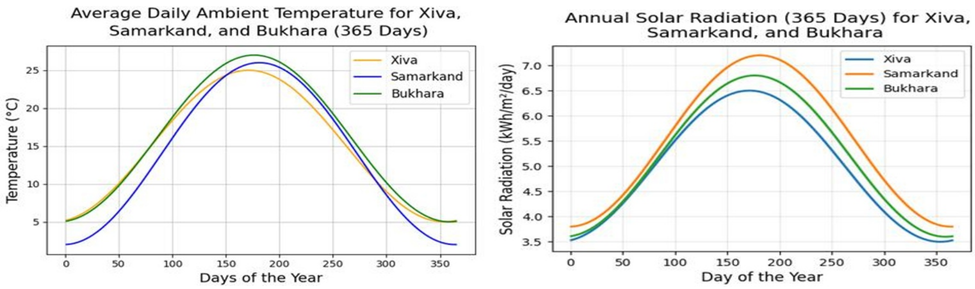


Fig. 3. Daily distribution of the average temperature of air (open conditions), Daily distribution of average daily temperature of the air for Khiva, Samarkand and Bukhara ((a) for the period of one-year, average quantities of the solar radiation Khiva, Samarkand and Bukhara ((b) within one year.

Among the best-known projects aimed at implementing green building technologies in Uzbekistan, the Silk Road Cultural Center in Samarkand can be noted – it acts as a reference for implementing sustainability in cultural context. This project was successfully carried out using conventional architectural parts including the courtyards and windbreaks as well as integrating the most advanced green technologies. Applying the principles of historical forms and shapes together with the improvements of the contemporary materials and technologies the project received the maximum energy efficiency and environmental friendliness. This center in Samarkand is an idea which shows how ecological constructions can be made. In heat considerations, courtyards were applied to heat control as well as natural convection, and windbreaks were applied to cool hot air. These techniques were integrated with energy saving devices in the center in addition to modern devices. Therefore, the present project not only preserves cultural properties of intangible cultural heritage but also advances green technology popularization and application. The project also looked at the environmental impacts of the traditional architectural product and their compliance with current standards. For instance, the efficiency of energy and heat retention capability, and the life span of fired bricks were all discussed. The results were especially valuable in establishing a foundation for the integration of present-day green structure technologies.

Conductive and convective heat transfer possibility of Uzbek traditional constructed material such as baked brick and the performance of karakul wool as an insulation material was also investigated. Most of these materials are sustainable and have been in use in the construction within this region for several years now. Specific characteristics of these materials were studied to fit the parameters of contemporary green building. Composed clay or baked brick possesses an excellent quality of heat storage capacity and poor heat transmitting ability. This assist in maintaining heat, during the coll weather and coolness during the hot weather conditions. It's also revealed that the component of the material is eco-friendly and recyclable. In addition, the density and mechanical staking of the brick was done and analysed with those of more modern types of construction materials. It was also revealed that baked brick can be incorporated into the new generation green buildings with valued changes only. Karakul wool was examined as an insulation material: environmental impact and thermal conductivity were valued, and the latter proved satisfactory. Wool is an organic fabric, which does not demand comparatively higher energy to be used as other synthetic fabrics. Experiments proved that the fibber of karakul can provide heat insulation equivalent to current insulating materials. Therefore, the conclusion was made that these materials can be valuable for the contemporary green building industry. Due to the results of the investigation, there were some conclusions about fired brick and karakul wool that produced new recommendations. In particular, it was suggested to use fired brick and composite materials in combination to reduce its mass and increase heat transfer coefficient.

To integrate conventional practices with contemporary ecological technology in green architecture, conceptual design prototypes were developed. Such designs provide ultra-modern energy utilizing systems in addition to the expansive use of baked bricks and karakul wool. The objective was not only to meet the key environmental principles of the country in recent construction designs, but also to remain loyal to the Uzbeks' ancestry. The prototypes employed features of courtyard-like structures as well as windbreaks. The courtyard acts as a natural ventilator to keep the inside of the building cool. Windbreaks, in their right, also assist in channelling cold air into the building and therefore, saving energy. A number of simulation exercises involving software were carried out to enhance the efficiency of these aspects. The simulation results further enabled the evaluation of energy efficiency of the prototypes for real environment. As for the equipment, the use of biodegradable materials for the cases, and of recyclable materials for the parts, and the choice of renewable energy sources in the prototypes, were kept in mind. For instance, the roof has solar panel installation to supply electricity to the whole building. However, rainwater harvesting systems are also integrated in the prototype at the same time. The simulation results indicated that prototypes are useful in raising the energy efficiency and reduce it by 30%. Such an approach does not only contribute to economies efficiency but also paves to foundation for using new technologies in green architecture for Uzbekistan. The prototypes illustrated various prospects of ecological construction technologies and will become the primary model of green projects in the future.

4 Conclusion

Through these new initiatives, Uzbekistan's valuable cultural backdrop as well as logical time-honoured architectural practices are being reconsidered based on the principles of the green building approach and combined with state-of-the-art construction solutions. Historic buildings associated with the ancient cities of Khiva, Samarkand and Bukhara, courtyards and windbreaks have been analysed as the primary components of sustainable energy use strategies. These elements afford ecological strategies for natural ventilation and control of heat.

The development of green technologies has become one of the major challenges in new buildings for different countries this issue is very well illustrated by the example of a model building – the Silk Road Cultural Center in Samarkand. Balconies and windbreaks are very useful for the natural cross-ventilation of buildings, and thereby for reducing energy demands. All of these approaches enhance energy efficiency and; the preservation of heritage for the benefit of the next generations.

Thermal and structural properties of the traditional materials such as baked brick and Karakul wool insulation are examined in detail. The studies also supported the compliance of this material with the current green building codes. Costs the heat in fireclay brick are also minimal due to its high heat storage capacity, energy is also saved and fireclay brick can be recycled as a green material. Karakul wool is another positive point as thermal efficiency of the natural insulating material and low energy consumption in processing it. Proposals for the large-scale use of these materials in the construction of modern buildings were made and on the basis of them, the proposal was made to combine them with new three-dimensional composite materials.

References

1. E.J. Mba et al. Evolving trends and challenges in sustainable architectural design; a practice perspective, Heliyon 10 (2024) e39400. https://doi.org/10.1016/j.heliyon.2024.e39400.
2. I.Kh. Tuychiev, Kh.S. Ahmadov, A.Yu. Ibodullaev, K.Yu. Rashidov, S.A Boltaev. Analysis of scientific publications based on the integration of polymer composite materials into solar thermal devices. Sixteen International Conference on Thermal Engineering: Theory and Applications. June 18-20, 2025 Bucharest, Romania. https://journals.library.torontomu.ca/index.php/ictea/article/view/2533.
3. Y.J. Ahn and Z. Juraev, Green spaces in Uzbekistan: Historical heritage and challenges for urban environment, Nature-Based Solutions 4 (2023) 100077.
4. Fuzhan Nasiri, Mohammad Saleh Mafakheri, Qanat water supply systems: a revisit of sustainability perspectives, Nasiri and Mafakheri Environ Syst Res (2015) 4-13, DOI 10.1186/s40068-015-0039-9.
5. Anand Kishorbhai Patel, Energy efficient building design with solar passive heating and ventilation systems, Global Journal of Engineering and Technology Advances, 2024, 20(02), 012–025. https://doi.org/10.30574/gjeta.2024.20.2.0144.
6. Uzbekistan Energy Profile, International Energy Agency, page 3-46, (2025). Website: www.iea.org
7. S.M. Mousavi Rizi et al., Bioclimatic architecture in thermal energy efficiency of sustainable urban residential buildings in developing countries: A synthesis review in Iran, Renewable and Sustainable Energy Reviews 218 (2025) 115743. https://doi.org/10.1016/j.rser.2025.115743.
8. Green Growth, Resources and Resilience Environmental Sustainability in Asia and the Pacific United Nations and Asian Development Bank publication, ST/ESCAP/2600, RPT124260, Printed in Bangkok 2012.
9. Abby Riddell, Issues and challenges raised by development agencies in implementing the new modalities of aid to education, Prospects (2008) 38:363–376. DOI 10.1007/s11125-009-9082-5.
10. A. Huovila et al., Carbon-neutral cities: Critical review of theory and practice, Journal of Cleaner Production 341 (2022) 130912. https://doi.org/10.1016/j.jclepro.2022.130912.
11. Pourhasan L. Review of green walls on building energy consumption. Architectural dimensions and beyond, 2(3), 204-214, (2025).
12. Askarov M.N, Avezov I.Y, Bahranova U.I, Yuldosheva N.Yu, Ahmadov Kh.S. Analysis of Porous Water-Absorbing Materials Used in Solar Water Desalination. Sixteen International Conference on Thermal Engineering: Theory and Applications. June 18-20, 2025 Bucharest, Romania. https://journals.library.torontomu.ca/index.php/ictea/article/view/2526.