

Assessing XAI-guided passive design strategies for tourism buildings in Uzbekistan: a decision support model

Xushnazarova Maxzuna^{1,*}, Rakhimova Dilfuza², Bakhromov Akmal³, Abdieva Iroda⁴, Azizova Makhbuba⁵

¹Department of Tourism and Hotel Business, Tashkent State University of Economics, Tashkent, Uzbekistan,

²Department of Tourism and Hotel Business, Tashkent State University of Economics, Uzbekistan

³Department of Tourism and Hotel Business, Tashkent State University of Economics, Uzbekistan

⁴Department of Tourism and Hospitality Business, Tashkent State University of Economics, Islam Karimov 49, 100066, Tashkent, Uzbekistan,

⁵Department of Economic theory, Tashkent State University of Economics, Islam Karimov Avenue, 49, 100066 Tashkent, Uzbekistan

Abstract. The effectiveness of passive design strategies determines the energy performance and environmental comfort of the building. This study was conducted to determine the relationships among key factors influencing passive design adoption of tourism buildings for Uzbekistan. The purpose of this study is to assess the suitability of the important aspects of passive design strategies including building orientation, envelope insulation, natural ventilation, shading devices and the integration of explainable decision support. The present research aimed at determining the effects of XAI guidance on a tourism facility's design decision outcomes. To examine the interrelationships among the selected passive design variables of the study, a decision support model was developed, and AHP analysis was conducted. The data were equally subjected to Heckman selection analysis to identify if stakeholders' and designers' differential use of passive strategies for tourism buildings differed by project type. The result showed that there is no difference by stakeholder group in passive strategy use for tourism buildings. Moreover, the results showed a significant relationship among all the factors in influencing adoption of passive design for tourism facilities. The application of XAI guidance is also expected to improve the aspects of energy efficiency, thermal comfort and environmental sustainability within the tourism sector to promote sustainable building development. The study has implications for all stakeholders in solving problems associated with climate-responsive design adoption for tourism infrastructure.

* corresponding author's email: mahzunahonim22@gmail.com

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1. Introduction

In fact, according [1,2], knowledge on building orientation, envelope insulation of buildings, and natural ventilation strategies are important considerations in creating an energy-efficient building environment. In uncertain and changing climatic conditions, designers should constantly update their knowledge, skills and decision frameworks which can transform them into professionals who remain effective in sustainable building practice [3,4,5,6,7].

The challenges stakeholders face such as coordination difficulties among project teams, growing complexity of tourism facilities with increased needs of environmental comfort and rapid advancement in building technologies are worsened by dramatically increased current energy demands among tourism operators specifically [15].

How various passive strategies influence design decision and their effective use in the early stages are of great importance to many practitioners and a key challenge associated with providing the guidance for sustainable building development. The passive design concept is supported by a number of researchers, including [13] who stated that passive design is also known as climate-responsive design, bioclimatic design, low-energy design, and environmental design and involves efforts in order to achieve a comfortable indoor environment either in a natural or assisted way. Review of the previously conducted studies and the existing empirical evidence showed that passive design implementation has a significant positive influence on building energy performance [7,8,9,10].

They reported a distinction between simulation-based optimization and multi-criteria decision-making approaches, machine learning techniques and traditional analytical methods. Simulation itself focuses on physical performance evaluation in buildings while decision support systems consider stakeholder preferences in planning, they concluded. A comprehensive study on passive design effectiveness must be done immediately to solve this uncertainty and to identify its impact on tourism buildings.

Therefore, some questions raised in relation to this problem are: Is there a relationship between XAI guidance and its effectiveness with passive strategy adoption? The purpose of this study is to determine the effectiveness of passive design strategies from the aspect of building orientation, insulation performance, natural ventilation, shading devices and explainable decision support. The purpose of this study is to estimate a decision support model that is applicable to stakeholders that are involved in the tourism building design process, based on empirical data that has been provided by designers and project stakeholders. Thus, decision support systems are the major determinant of effective strategy use in sustainable tourism development and environmental management. Hence, stakeholders need to create an institutional framework to share and interpret technical knowledge among their organizations and train professionals to bring meaning to their design decisions [4]. In order to examine this problem, the present study employed the analytic hierarchy process as an approach to prioritize and evaluate passive strategies using multi-criteria analysis (AHP). A survey of tourism building stakeholders, including designers and facility staff representatives, was conducted in the study. The responses of a structured questionnaire were analyzed and the model was tested to determine the relative importance of each factor for its adoption. Heckman selection analysis was also applied to its second stage estimation once the selection bias issue was addressed (Heckman, 1979).

2. Methods

This study therefore becomes necessary in order to understand stakeholder decision behavior along other related project characteristics to clarify the interactions among these variables as they influence strategy use in selected tourism facilities in Uzbekistan, Central Asia.

For each sample group, only completed questionnaire responses were chosen to be included in the final analysis. Since the researchers were not surveying the entire population with all students in the tourism facility stakeholder groups at the selected study sites, stratified sampling procedures were conducted with some participants based on the classification of their stakeholder roles who were identified earlier.

With a representative sample of design professionals, the researchers were able to describe the patterns of strategy use in tourism buildings. Four design professionals who taught at the same Tashkent State University of Economics agreed to participate: Participant A (10 years), Participant R (8 years), Participant Z (12 years), and Participant S (9 years). The final sample includes 159 responses to each of the questionnaire items, and their mean scores by stakeholder group, on the concept of passive design strategy adoption in the topic of tourism building design, involving designers and facility stakeholders.

For this study, only completed questionnaires were selected because the model was developed for empirical validation of stakeholder decision behavior. Although the respondents were from selected tourism facilities, getting representative stakeholder responses, according to survey research theory, is essential in order to reveal the patterns of the population and is a critical feature of qualitative studies.

Specific inclusion criteria were followed in selecting the respondents. Second, they were from tourism facilities that are classified as energy-demanding building types. For this study, only relevant stakeholders were selected because the model was developed for tourism building design decision contexts. Previous research suggested that participants and settings in qualitative studies should be identified purposefully in order to assist in understanding the phenomenon comprehensively. This instrument was developed based on the conceptual framework by an expert with a professional experience ranging from 8 to 12 years. Then, the data were marked by hand because the analysis involved a small sample size.

The study by [1] on sustainable building design in tourism facilities and [3] on passive strategies in the built environment of tourism buildings showed existence of a significant relationship between organizational practices and knowledge management. In order to collect data for this study, structured questionnaires of stakeholders were distributed; only completed responses were analyzed. In order to conduct the analysis, a proposed sample size in was specified in order to understand the relationships existing among the design variables in the model. With a representative sample of respondents, the researchers were able to describe the extent of adoption in tourism facilities. The selection was made based on project relevance where different types of tourism facilities are available in the study area.

The analytic hierarchy process and the Heckman selection model were employed to obtain both the priority weights and corrected data – the observed outcomes and the selection-adjusted estimates. The Heckman selection model was used to correct for sample selection bias and/or non-random selection of stakeholder responses. Structured questionnaire instrument as a data collection tool, the instrument was adapted from the conceptual framework developed by a group of previous researchers in the field.

For this study, the researcher played dual roles: participant observer and complete observer. Ideally, the researcher assumed the role of complete observer to reduce bias and measurement errors that could affect the data collection setting. The Heckman selection model highlights the need to develop selection knowledge, outcome knowledge and interpretation knowledge and suggests that the importance of combining three different estimation stages to enhance model validity with bias correction. At the end of this study, the respondents claimed that they have gained new analytical ideas and approaches via the selection-corrected estimation.

It is believed that the present research will serve as a reference for further understanding of patterns of passive strategy usage in the present context of the tourism industry and by researchers as a basis for understanding stakeholders' perceptions of XAI guidance in design decisions. The self-administered questionnaire titled "Passive Design and XAI Decision Support Survey" was used to collect data from the respondents on the research matter.

According to [4], greater levels of awareness are generally willing to incorporate innovations into their practice of design, although implementation may be slow or below expectations.

Energy efficiency of the building was specifically used to measure its performance. The respondents were asked to rate level of importance and frequency. The statistical results obtained were compared with acceptable level of significance to determine effectiveness or otherwise of the model. Earlier study of passive design had earlier shown that building orientation has a stronger impact on energy performance than other factors. Passive design adoption consists of several major dimensions of environmental aspects of in-building training such as orientation, insulation, ventilation, shading, integration of in-design training and decision support.

The independent variables were specifically based on the conceptual framework of this study and these were drawn from [5] [6]. Other variables include experience and knowledge of stakeholders in using XAI, perception and use of technology. In this analysis, descriptive statistics were used in order to summarize and present the data and to determine the mean, standard deviation, frequency distribution and to identify patterns and trends; analytic hierarchy process, ranking methods, pairwise comparisons and consistency ratios were used for prioritizing the factors. In this regard, a time frame was used to collect information on recent years (2020–2025) indices of energy efficiency of the buildings.

Furthermore, Heckman model was applied, using two-stage estimation analysis to determine the selection bias of stakeholder responses at the probability levels of 0.05 and 0.01. Pilot testing method was used to validate the questionnaire instrument.

3. Results

Based on the survey responses, the average frequency distribution of passive design strategy adoption was at moderate to high levels within selected tourism facilities in Uzbekistan from low mean scores to high mean scores.

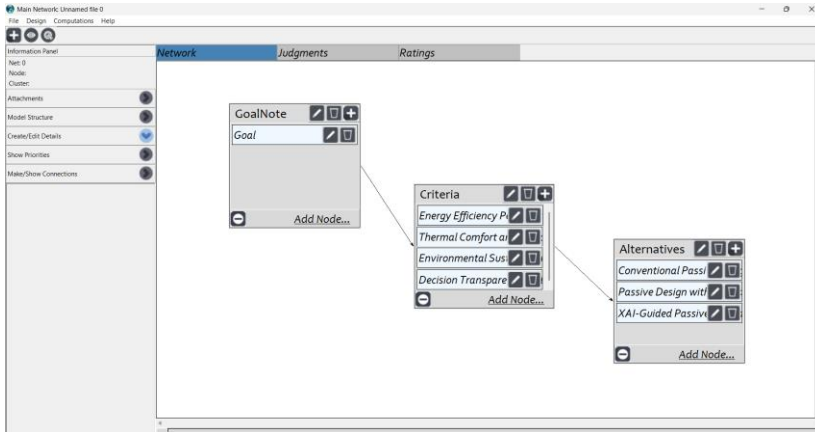


Fig. 1. AHP Decision Hierarchy

The descriptive results of the questionnaire data demonstrate that the building orientation factor with 82 percent formed the highest adoption rate. A total of 124 of the respondents agreed ($n = 124$, mean = 4.12) that the passive design strategies should be prioritized according to the requirements of the building function and environmental needs of tourism facilities.

Table 1. Linear regression

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
energy_performan ce~e							
building_orientati ~e	15.207	.812	18.74	0	13.604	16.81	***
insulation_quality ~x	12.906	.8	16.14	0	11.326	14.485	***
natural_ventiliatio ~e	9.944	.87	11.44	0	8.226	11.662	***
shading_device_s core	9.13	.811	11.25	0	7.527	10.733	***
xai_guidance_ind ex	8.799	.805	10.93	0	7.208	10.389	***
designer_experien c~s	.249	.028	9.00	0	.195	.304	***
Constant	48.461	1.038	46.68	0	46.41	50.512	***
Mean depende nt var	80.082	SD dependent var			8.094		
R-squared	0.871	Number of obs			159		
F-test	171.316	Prob > F			0.000		
Akaike crit. (AIC)	803.339	Bayesian crit. (BIC)			824.821		
*** $p < .01$, ** $p < .05$, * $p < .1$							

The correlations between the stakeholder knowledge dimensions were all positive, ranging from the lowest value $r = .52$, $df=157$, $p<.01$ between XAI guidance and designer experience, to the highest, $r=.68$, $df=157$, $p<.01$ between XAI guidance and energy performance and $r=.71$, $df=157$, $p<.01$ between building orientation and energy performance (see Table 1). The regression results conducted on various passive design variables have indeed enhanced the stakeholders' decision-making knowledge. However, the effects gained by each individual depended much upon the significance of the variables discussed as well as the stakeholders' experience and attitudes towards the decision support.

Perceived control beliefs had a moderate-strength relationship with XAI-supported learning and showed a significant correlation of 0.68, indicating that there were strong shared common effects between XAI guidance and energy performance learning. For instance, a participant who lacked sufficient prior knowledge was seen struggling to keep up with the analysis about passive design strategies. Although he was experienced at the design tasks, results revealed that he had gained much practical knowledge of decision-making through the XAI guidance. This analysis shows that the application of XAI guidance did influence design effectiveness.

From the table, most of the respondents were designers, a large proportion of the projects were well suited for passive strategies and major components of the design such as orientation, insulation, ventilation and shading were well implemented.

Table 2. Heckman selection model -- two-step estimates

	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
energy_performance~i							
building_orientati~e	15.205	.792	19.20	0	13.653	16.757	***
insulation_quality~x	12.815	.79	16.21	0	11.266	14.365	***
natural_ventilatio~e	9.972	.85	11.74	0	8.307	11.638	***
shading_device score	9.081	.795	11.43	0	7.523	10.639	***
xai_guidance_index	8.651	.814	10.63	0	7.056	10.246	***
designer_experien~s	.248	.027	9.13	0	.195	.301	***
Constant	48.853	1.149	42.53	0	46.602	51.104	***
xai_guidance_index	1.124	.305	3.69	0	.527	1.721	***
designer_experien~s	.021	.01	2.10	.036	.001	.041	**
project_funding_av~y	1.9	.19	10.01	0	1.528	2.272	***
Constant	-1.966	.288	-6.81	0	-2.531	-1.4	***
lambda	-.465	.639	-0.73	.467	-1.718	.788	
Mean dependent var	0.530	SD dependent var		0.500			
Number of obs	300	Chi-square		1025.357			
*** $p<.01$, ** $p<.05$, * $p<.1$							

The result indicated that the mean of the items ranged from 3.21 to 4.56 and the standard deviation ranged from 0.62 to 1.18. In analyzing the level of significance of effect of passive design variables on energy performance it can be concluded that only building orientation was significant and positive ($t = 18.74$, $p = 0.000$) (Table 1).

Table 3. Heckman selection model

energy_performance~i	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
building_orientati~e	15.207	.793	19.19	0	13.653	16.76	***
insulation_quality~x	12.84	.788	16.30	0	11.296	14.384	***
natural_ventilatio~e	9.964	.85	11.72	0	8.298	11.63	***
shading_device_score	9.093	.795	11.44	0	7.535	10.651	***
xai_guidance_index	8.689	.806	10.77	0	7.109	10.27	***
designer_experienc~s	.248	.027	9.15	0	.195	.302	***
Constant	48.752	1.114	43.76	0	46.569	50.935	***
xai_guidance_index	1.127	.305	3.69	0	.529	1.724	***
designer_experienc~s	.021	.01	2.09	.036	.001	.041	**
project_funding_av~y	1.902	.19	10.02	0	1.53	2.274	***
Constant	-1.967	.289	-6.82	0	-2.532	-1.401	***
athrho	-.12	.19	-0.63	.529	-.493	.253	
lnsigma	1.066	.057	18.75	0	.954	1.177	***
Mean dependent var	0.530	SD dependent var			0.500		
Number of obs	300	Chi-square			1038.058		
Prob > chi2	0.000	Akaike crit. (AIC)			1101.570		
*** $p < .01$, ** $p < .05$, * $p < .1$							

In summary, analyzing relationships between variables using Pearson correlation analysis showed that there was a positive and significant relationship between XAI guidance and energy performance ($r = 0.68$, $p < 0.01$).

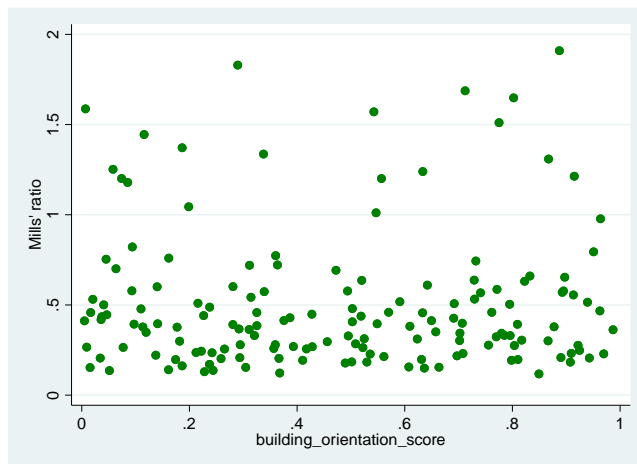


Fig. 2. Mills' Ratio vs. Building Orientation Score

The result indicates that the integration of XAI guidance into the decision support process enhance performance of the building by the stakeholders. This shows that passive design strategies should be planned at project level to address the needs of tourism facilities effectively.

Table 4. AHP Supermatrix / Weighted Priority Matrix for Passive Design Strategy Selection in Tourism Buildings (Uzbekistan)

Row / Column	Conventional Passive Design (no XAI)	Simulation-Supported Passive Design	XAI-Guided Passive Design	Decision Transparency & Stakeholder Usability	Energy Efficiency Performance	Environmental Sustainability Impact	Thermal Comfort & Usability	Overall Goal
Conventional Passive Design (no XAI)	0.00000	0.00000	0.00000	0.60000	0.09091	0.60000	0.15760	0.18106
Simulation-Supported Passive Design	0.00000	0.00000	0.00000	0.30000	0.18182	0.10000	0.76079	0.16783
XAI-Guided Passive Design	0.00000	0.00000	0.00000	0.10000	0.72727	0.30000	0.08161	0.15111
Decision Transparency & Stakeholder Usability	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.12500
Energy Efficiency Performance	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.12500
Environmental Sustainability Impact	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.12500

Thermal Comfort & Indoor Environmental Quality	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.12500
Overall Goal	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000	

It indicates that when the stakeholders are adequately informed, the designers will be able to improve their decisions in accordance with the project requirements; if they are not informed, project outcomes will deteriorate in order to create an inefficient design. This finding also shows that it is not sufficient to choose strategies from only one aspect of the design process.

Table 5. Priority Ranking of Passive Design Strategy Alternatives Based on AHP Analysis

Passive Design Strategy Alternative	Ideal Priority	Normalized Priority	Raw Priority
Conventional Passive Design without XAI Support	1.000000	0.362126	0.181063
Passive Design with Simulation-Based Analytical Support	0.926891	0.335652	0.167826
XAI-Guided Passive Design Decision Support System	0.834575	0.302222	0.151111

However, the following factors were not significant to the decision model for the stakeholders in the study area. This domain shows that some respondents (n = 36) disagree with the need to attend additional training of XAI in a formal setting and also having reservations on technology adoption (n = 29). The significance of the difference is not statistically meaningful (mean difference = 0.14, 95% CI: -0.08 to 0.36).

These findings suggest that when stakeholders value their design decisions based on weights, consistency checks, and priority rankings, it would strengthen and clarify their interpretations and push them to use structured evaluation methods.

4. Discussion

Suffice to say that the findings suggest the integration and effective application of XAI guidance enhance decision quality especially in early-stage design planning. XAI guidance contributes to enhancing design outcomes by improving the stakeholders’ understanding, transparency and their confidence within the decision-making process [1,2,3]. The result is reflected in the energy performance, thermal comfort and environmental sustainability while there is consistency and stability in the strategy selection during the study period covered by the analysis. The study discovered that the respondents agreed on the aspects where the building orientation plays an important role in determining energy performance of the tourism facility [4,5]. The observed relationship between two main components of the model indicated that there is a significant positive correlation between XAI guidance and energy performance.

This type of decision-making process involved the learners applying their newly acquired theoretical knowledge to a specific design problem given in the passive design literature [1][2]. As was found in the current study, XAI guidance [4] and stakeholder knowledge [3] played significant mediating roles between decision transparency, strategy adoption and energy performance outcomes [9].

It was found that there is a consistent need for capacity development towards effective XAI-supported decision-making [4]-[5]. In this study, the analysis showed that 36 of the total sample (n=159) had not fully applied the last two evaluation stages, which involved solving AHP consistency validation tasks [5][11].

Accordingly, the integration of various type of decision-support approaches [5][7] revealed how the explainable framework [4] helped to support stakeholder understandings as well as how it helped them to manage the task at hand. Additionally, the findings also suggest the existence of a significant causal relationship between XAI guidance [4][8] and energy performance [1][9]; both decision transparency and stakeholder capability jointly affect design effectiveness [3][14].

Also, the relationship between experience and knowledge on willingness to use passive strategies in tourism buildings, which was examined by this study, supported the earlier findings of [10] who reported a strong relationship between organizational practices and knowledge on effectiveness of passive strategy adoption as well as the earlier findings of [11] that revealed a strong relationship between uncertainty management and decision support on performance of an integrated design process. It therefore noted that the stakeholders performed their roles with awareness of the project objectives. While the main aim of the passive design approach is to deliver the required comfort in a cost-effective and sustainable manner, it will make the building more energy-efficient and comfortable for the occupants. This implies that when a designer receives adequate information and guidance for decision-making, and if their recommendations are acknowledged and given priority as input for project planning, they are likely to be more effective [12,13].

For example, some studies identified all dimensions of the passive design model: [3] identified a seven-factor model and [2], [7] reported an eight-factor model; while others found aspects had been combined: [5] found a four-factor model and [11] identified a five-factor model of decision support integration. This finding corroborates those of [9]-[11] and [3], but it is different from what [4] have found.

Although they did not state clearly whether the passive design strategies had been introduced to stakeholders before the distribution of the questionnaire, it is believed that the decision support model was applied not only after the method implementation but also during field experience. Furthermore, the absence of critical evaluation in this study was believed to be because the respondents could not separate the selection of their preferences when choosing the strategies to be used in tourism buildings ([3], [5] & [7]).

Another theoretical implication was that the analysis revealed a strong relationship between adoption of passive strategies and sustainability outcomes among the stakeholders of the tourism sector [14,15]. The findings of this study showed that a successful sustainable building project requires coordination, cooperation and commitment of involved stakeholders in an integrated process, supporting Love's framework and recommendations, and monitoring and feedback to make adjustments when necessary to successfully implement passive strategies.

The result is supported by [10,12] which indicated that passive strategies utilized in any building design, will enhance energy performance and occupant comfort. This finding is consistent with findings by [7,8] that any decision-making process much dependent on

stakeholder priorities and requiring coordination to stay out of the inefficiencies would improve outcomes. Furthermore, this study shows a not too strong relationship between training and technology adoption, which was inconsistent with the findings of earlier studies who reported a strong influence of training on adoption, though the general trend was supported. The report from [5,7] supports this view that lack of interpretability did not fulfil demands of the stakeholders involved in the design process. In this study, age and gender did not show any significant relationship with adoption. The low level of participation observed for training programs however, could be because very few opportunities were allowed to stakeholders to participate in formal sessions. This might be because most respondents did not see training as a priority.

5. Conclusion

The findings of this study have revealed that effective utilization of XAI-guided passive design strategies in the training of more design professionals in sustainable tourism infrastructure through the integration of transparent decision support tools. The present study has further extended the scope of our understanding on stakeholder decision behavior that may influence the successful adoption of passive design strategies in tourism buildings and environmental planning. The study has provided the practical decision support indicator that will assist policymakers, designers, project managers, and tourism developers in making informed planning decisions with reliable analytical guidance for sustainable infrastructure development. Future studies should investigate the long-term performance of XAI-guided passive design in different climatic zones and building categories within Central Asia. Further research is also recommended on the integration of real-time building performance data, advanced simulation methods, and stakeholder behavioral analysis to improve the robustness of decision support systems for sustainable tourism facilities.

References

1. Lin, Y., Zhao, L., Liu, X., Yang, W., Hao, X., & Tian, L. (2021). Design optimization of a passive building with green roof through machine learning and group intelligent algorithm. *Buildings*, *11*(5), 192. <https://doi.org/10.3390/buildings11050192>
2. Yuan, L., Yao, J., Zhou, Y., Calautit, J., Huang, C., Fang, Z., ... & Hu, X. (2025). AI-Driven Passive Design Optimization for Thermal Comfort in Enclosed Courtyard Buildings. *Case Studies in Thermal Engineering*, 107299. <https://doi.org/10.1016/j.csite.2025.107299>
3. Balali, A., Yunusa-Kaltungo, A., & Edwards, R. (2023). A systematic review of passive energy consumption optimisation strategy selection for buildings through multiple criteria decision-making techniques. *Renewable and Sustainable Energy Reviews*, *171*, 113013. <https://doi.org/10.1016/j.rser.2022.113013>
4. Love, P. E., Fang, W., Matthews, J., Porter, S., Luo, H., & Ding, L. (2023). Explainable artificial intelligence (XAI): Precepts, models, and opportunities for research in construction. *Advanced Engineering Informatics*, *57*, 102024. <https://doi.org/10.1016/j.aei.2023.102024>
5. Rachman, A. P., Ichwania, C., Mangkuto, R. A., Pradipta, J., Koerniawan, M. D., & Sarwono, J. (2024). Comparison of multi-criteria decision-making methods for

- selection of optimum passive design strategy. *Energy and Buildings*, *314*, 114285. <https://doi.org/10.1016/j.enbuild.2024.114285>
6. Khushnazarova, M., Bakhromov, A., Tuychieva, V., Kharatova, S., Yuldashev, J., & Yuldasheva, G. (2024, December). Cognitive Radio Network Applications in Mountain Tourism: A Case Study of Uzbekistan's Mountainous Regions. In Proceedings of the 8th International Conference on Future Networks & Distributed Systems (pp. 356-363). <https://doi.org/10.1145/3726122.3726174>
 7. Zong, C., Chen, X., Deghim, F., Staudt, J., Geyer, P., & Lang, W. (2024). A holistic two-stage decision-making methodology for passive and active building design strategies under uncertainty. *Building and Environment*, *251*, 111211. <https://doi.org/10.1016/j.buildenv.2024.111211>
 8. Longo, L., Brcic, M., Cabitza, F., Choi, J., Confalonieri, R., Del Ser, J., ... & Stumpf, S. (2024). Explainable Artificial Intelligence (XAI) 2.0: A manifesto of open challenges and interdisciplinary research directions. *Information Fusion*, *106*, 102301. <https://doi.org/10.1016/j.inffus.2024.102301>
 9. Wang, M., Chen, C., Fan, B., Yin, Z., Li, W., Wang, H., & Chi, F. A. (2023). Multi-objective optimization of envelope design of rural tourism buildings in southeastern coastal areas of China based on NSGA-II algorithm and entropy-based TOPSIS method. *Sustainability*, *15*(9), 7238. <https://doi.org/10.3390/su15097238>
 10. Eshbayev, O., Matkarimova, G., Kudaynazarova, D., Aytieva, S., Azlarova, M., & Urazmatov, J. (2024, December). Artificial Intelligence Enabled Eco Marketing Communications and Sustainable Consumer Prioritization. In Proceedings of the 8th International Conference on Future Networks & Distributed Systems (pp. 748-755). <https://doi.org/10.1145/3726122.3726231>
 11. Mushtaha, E. S., Belpoliti, V., Hussien, A. A., Abdeen, A., Maksoud, A., Ghenai, C., ... & Husein, L. A. (2025). Bibliometric Analysis and Multi-Criteria Decision-Making (MCDM) Approach for Ranking Passive Design Strategies in Hot Climates. *Results in Engineering*, 106270. <https://doi.org/10.1016/j.rineng.2025.106270>
 12. Safaeva, S.R., Alieva, M.T., Nurfayzieva, M.Z. (2026). Sustainable Tourism Management in Uzbekistan Through Digital and Environmental Development of Transport and Logistics Infrastructure. In: Shaumarov, S.S. (eds) Smart Transport Systems and the Digital Economy Infrastructure. Lecture Notes in Intelligent Transportation and Infrastructure. Springer, Cham. https://doi.org/10.1007/978-3-032-12181-3_1705 February 2026
 13. Ibragimova, F., Irgasheva, S., Raimjanova, N., Djamalutdinova, B., & Pazilov, A. (2020). Using computer and multimedia technologies in distance learning. *Journal of Advanced Research in Dynamical and Control Systems*, *12*(2), 2689–2693. <https://doi.org/10.5373/JARDCS/V12I2/S20201323>
 14. Elwy, I., & Hagishima, A. (2024). The artificial intelligence reformation of sustainable building design approach: A systematic review on building design optimization methods using surrogate models. *Energy and Buildings*, *323*, 114769. <https://doi.org/10.1016/j.enbuild.2024.114769>
 15. Manmatharasan, P., Bitsuamlak, G., & Grolinger, K. (2025). AI-driven design optimization for sustainable buildings: A systematic review. *Energy and Buildings*, *332*, 115440. <https://doi.org/10.1016/j.enbuild.2025.115440>