

EVALUATING THE IMPACT OF AUTOMATION IN CONSTRUCTION ENGINEERING AND MANAGEMENT

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Abstract

This study aims to examine how automation can be integrated into the construction industry, as well as its advantages, limitations, and future. Primary data were collected from construction professionals (project managers, engineers, contractors, and policy-makers) using a structured questionnaire (removed in the study). Data analysis were done using SPSS to determine means, while computational analysis, including Relative Importance Index (RII) and Analytic Hierarchy Process (AHP), were used to measure the relative importance and priority of the different variables of adopting automation. The results suggest that automation technology in construction has developed rapidly, but the degree of its application is not very high yet. Key benefits recognized include improved efficiency, cost-effective solutions, enhanced safety, and quicker project delivery. However, early expense and a shortage of trained personnel were pinpointed as the greatest challenges to full implementation. Project management software, drones, and robotics appeared to be the most popular types of automation technology, and advanced types of tech – such as AI or 3D printing – had not yet seen rapid uptake. The investigation concludes that automation offers a high potential for boosting productivity and quality in construction, but requirements for overcoming challenges with cost, the development of skills, and resistance to change are important prerequisites prior to integration on a larger scale. The study also suggests actions such as incentives, training, and industry cooperation to enable the successful deployment of automation in the construction process. This study provides useful implications for decision-makers, practitioners, and technology providers in the decision-making for the adoption of automation in the construction field.

INTRODUCTION

The construction industry is evolving; automation drives efficiency, accuracy, and productivity. The use of advanced technology such as robotics, artificial intelligence (AI), and Building Information Modelling (BIM) has transformed the traditional construction process. Examples include bricklaying, concrete pouring, and material handling, in which robotics can both significantly reduce the dependence on labor and enhance the accuracy and safety of the process [1]. In addition, AI-powered solutions enable capabilities such as real-time data analysis, predictive analytics, and more efficient project management, leading to better decision-making and the more effective management of risk [2]. Likewise, BIM acts as a digital medium to facilitate cooperation among various project participants, resulting in better design accuracy and coordination during the building lifecycle [3].

However, most of these technologies have yet to be adopted in the construction industry. This delay is mostly due to the natural complexity of the construction industry [4], the investment required to introduce automation technologies, and the penetration of the acceptance of a formerly manpower-based industry [5]. But there are increasing pressures on the industry to automate because of problems with labor (both a lack thereof and the need to work more because of shortages), material costs, and requirements of sustainability and efficiency in construction [6]. These pressure points highlight the growing importance of better understanding automation's ability to deliver responses to these challenges [8].

Recent research proves that automation can highly improve project performance in terms of construction time, cost efficiency, and error reduction [9]. One example is prefabrication and modular construction enabled through Automation for its potential to optimize workflow efficiency and waste reduction [10]. Additionally, there is an increasing number of automated machines, including drones and self-driving vehicles, used for tasks such as site surveying and materials transfer, and this is further evidence of the viability of automation in the construction domain [11].

This study seeks to comprehend the diffusion and usage of automation technologies in the construction industry, particularly how they influence project management and productivity. Through a questionnaire survey of industry experts, this study explores the pros, cons, and barriers of adopting automation for construction projects. The study also aims to investigate how industry players view and are prepared to accept these technologies [12].

The results of this study are anticipated to enrich the emergent literature concerning automation in construction and offer actionable insights to construction practitioners, governmental stakeholders, and researchers. The results will provide insight into the current level of automation uptake whilst also providing guidelines for addressing implementation obstacles and optimizing the opportunities for realizing benefits from these technologies. By taking the lead to solve these fundamental problems, the research contributes to the process of transforming the construction industry to be more innovative, efficient, and sustainable [13].

LITERATURE REVIEW

Project management software (PMS) is one of the most commonly used automated devices in the construction sector. With tools like Builder trend and Autodesk Construction Cloud, important tracking analytics and project resources are available in real time, and assist with resource management, task management, and enhance communication of stakeholders [14]. These software tools are increasingly automating a wide range of manual processes, such as scheduling, costing, and procurement organization, which were historically error-prone, given their human-centered nature [15].

Adoption of PMS can significantly minimize administrative burden and enhance decision-making by means of "Data-based insights" [16]. Just to mention a few, PMS can schedule your projects automatically and thus minimize lag and ensure that tasks are done on time. Furthermore, they facilitate improved communication and coordination between disparate groups within the construction industry to avoid

misunderstandings and mistakes on the construction site [17].

Construction robotics is the application of robotic automation to construction tasks. These tasks include bricklaying, welding, concrete work, and other simple manual jobs. Robotics; that is, a brickwork robot named SAM (Semi-Automated Mason) has been shown to enhance productivity and accuracy, and minimize labor costs [18]. Robots are particularly well suited for repetitive tasks, with little or no tolerance for human error, which can result in savings and quality[19].

Robots can also take over many of the work-intensive jobs in construction, as well as replacing manual control for construction vehicle operations (e.g., bulldozers or excavators) that can run manually or autonomously for increased efficiencies [20].

Drones were already making inroads within the construction sector for surveying, progress inspections, and safety checks. Drones can immediately analyze construction site problems and follow up on construction progress due to their real-time aerial photos and data service, which could enhance the safety of construction [21, 22]. Drones can also assist with data collection that would otherwise be done by hand, a process that would reduce labor costs and increase efficiency [24].

Actionable imagery captured by drone missions in record time is great for project managers and stakeholders who must make the right decisions under pressing deadlines. Drones also mitigate construction site inspection-related risks by eliminating the physical presence of workers in unsafe or inaccessible locations [25].

3D printing is one of the most exciting forms of automation in construction at present. It enables components as well as complete buildings to be quickly manufactured by automatic systems that print material in layers, forming structures [26]. The technology has also been applied to develop affordable, eco-friendly housing and infrastructure, and it is even being used to make customized building elements.

Reduction of material waste is one of the most important benefits of 3D printing is the minimized material waste for sustainable construction [27]. On

top of that, you could cut back on the time it takes to construct certain kinds of buildings overseas, saving you money and getting your projects done even faster.

METHODOLOGY

Research Approach

This study is of a mixed quantitative and qualitative design, to investigate the adoption of automation in the construction industry. The first is quantitative by looking for dominant trends and problems as well as the impacts of automation, while the second is qualitative by considering the opinions of the industry professionals on matters of barriers and implementations.

Data Collection

Questionnaire Surveys: A well-structured questionnaire will be developed to collect the information from construction practitioners such as project managers, engineers, contractors, and policy makers. The survey will focus on questions such as the extent of automation use, common challenges, and its influence on efficiency and sustainability.

Sample Selection: Using a stratified random sample approach to reflect all stakeholder groups from government, private sector, and consultants in Pakistan.

Size of the Sample: The research aspires to address 150-200 sample respondents.

Interviews with experts: Semi-structured interviews will be used to generate further understanding about the challenges, opportunities, and effective strategies of automation in the context of industry experts, engineering managers, and decision-makers.

Secondary Data

Document Review: Finished project reports, academic research, governmental reports, and industry white papers will also be used to understand what trends exist, what technological progress has been made, and what policy levels are applicable to construction for this project.

Case Studies: A few projects undertaken in Pakistan through the use of automation will be examined to determine process success and common hurdles.

Data Analysis

Quantitative Analysis

Survey data will be analyzed by statistical packages such as SPSS or Excel.

The automation challenges and benefits will be prioritized using tools like the Relative Importance Index (RII).

Descriptive analysis and correlational analysis will be used to examine the correlation among established variables.

Qualitative Analysis

Interview data will be subjected to thematic analysis to identify common themes emerging in relation to barriers, readiness, and attitudes to the adoption of automation.

The outputs of the case studies will be also synthesized to extract lessons and pinpoint the contextual issues which are specific to the Pakistani construction industry.

Risk Analysis

Techniques such as the Analytic Hierarchy Process (AHP) and risk matrices will help to classify and analyze barriers and risks related to automation implementation in construction work.

From various Internet sources such as online databases and journals, academic papers and

studies were collected to gather relevant information. To provide the theoretical foundation of the study and to identify the gaps in previous knowledge, a literature review was conducted.

Questionnaire Design

Primary data have been collected from construction professionals by way of a pre-tested structured questionnaire in this study. The questionnaire will be developed to 361 evaluate different aspects of automation uptake in the construction industry, with the emphasis on the following respective areas:

1. Demographic Information
2. Level of Automation Adoption
3. Advantages of Automation
4. Challenges and Obstacles to Automation Uptake
5. It affects efficiency and productivity
6. Impact on Safety and Quality
7. Sustainable and Environmental Aspects
8. Future Outlook on Automation

The survey included variables and sub-variables in the survey to gauge the level of responses and experiences of the respondents with automation. Following is a complete summary of the questionnaire.

Questionnaire for Automation Adoption in Construction Industry

Table 1: Questionnaire for Automation Adoption in Construction Industry

Section	Question	Response Type	Scale
Demographics	What is your role in the construction industry?	Multiple choice	Project Manager, Engineer, Contractor, Policymaker, Other
	How many years of experience do you have in the construction industry?	Multiple choice	0-5 years, 6-10 years, 11-15 years, 16+ years
	What type of organization do you work for? (Private, Public, Consultancy)	Multiple choice	Private, Public, Consultancy
	What is the size of your organization? (Number of employees)	Multiple choice	1-50, 51-200, 201+
Level of Automation Adoption	To what extent has your company adopted automation technologies in construction projects?	Likert scale	1 = Not at all, 5 = Fully adopted
	Which of the following automation technologies are being implemented in your projects?	Multiple choice (check all)	Project Management Software, Drones, Robotics, 3D Printing, AI/ML, Other
	How long has your company been using automation in construction?	Multiple choice	0-2 years, 3-5 years, 6+ years
Perceived Benefits	To what extent do you think	Likert scale	1 = Not at all, 5 = Very

of Automation Sub-Variable	automation improves project efficiency?		much
	How much has automation contributed to cost savings in your projects?	Likert scale	1 = No impact, 5 = Significant savings
	To what extent has automation improved construction project quality (e.g., reduced errors, better precision)?	Likert scale	1 = No impact, 5 = Significant improvement
	Has automation improved the accuracy of measurements or designs?	Likert scale	1 = Not at all, 5 = Significantly
	Has automation contributed to faster project delivery?	Likert scale	1 = No impact, 5 = Significant improvement
Challenges and Barriers	What are the main challenges your company faces in adopting automation?	Multiple choice (check all)	High costs, Lack of skilled workers, Resistance to change, Technological limitations, Others
	How would you rate the high initial costs associated with automation technologies?	Likert scale	1 = Very high, 5 = Very low
	How significant is the lack of skilled workforce as a barrier to automation?	Likert scale	1 = Not significant, 5 = Very significant
	How do you perceive resistance to change within your organization regarding automation?	Likert scale	1 = Very resistant, 5 = Very open
	What is the level of technological expertise available in your company for adopting automation?	Likert scale	1 = Very low, 5 = Very high
Impact on Efficiency and Productivity	How has automation affected the efficiency of project scheduling and time management?	Likert scale	1 = No impact, 5 = Significant improvement
	Has automation increased the overall productivity of your workforce (e.g., fewer errors, less rework)?	Likert scale	1 = No impact, 5 = Significant improvement
	Has the implementation of automation reduced the number of working hours required for specific tasks?	Likert scale	1 = No reduction, 5 = Significant reduction
Impact on Safety and Quality	To what extent has automation contributed to improving safety on construction sites?	Likert scale	1 = No improvement, 5 = Significant improvement
	Has automation helped reduce worker injuries by eliminating high-risk tasks?	Likert scale	1 = No reduction, 5 = Significant reduction
	How much has automation helped in improving the quality of work (e.g., precision in material usage, structural integrity)?	Likert scale	1 = No improvement, 5 = Significant improvement
Sustainability and	How much has automation contributed to the environmental	Likert scale	1 = No contribution, 5 = Significant contribution

Environmental Impact	sustainability of your construction projects (e.g., waste reduction, energy use)?	Likert scale	1 = No reduction, 5 = Significant reduction
	Has automation helped in reducing material wastage during construction?	Likert scale	1 = No impact, 5 = Significant improvement
Future Outlook on Automation	To what extent has automation contributed to energy efficiency on your construction sites (e.g., automated lighting, machinery)?	Likert scale	1 = No impact, 5 = Significant improvement
	In your opinion, how likely is it that automation will become fully integrated into construction processes in the next 10 years?	Likert scale	1 = Not likely, 5 = Very likely
	What are your expectations regarding the increased adoption of automation in the construction industry?	Likert scale	1 = Not likely, 5 = Very likely

Level of Automation Adoption

This section examines to what extent construction enterprises have adopted automation. The variable captures the pervasiveness of usage in different technologies (project management software, drones, robotics, etc.) and the length of time they are being used in the industry.

The paper measures three categories of perceived benefits of automation brought to construction projects, including project efficiency, cost reduction, quality enhancement, and project delivery time.

Sub-variable: Impact of automation on measurement or design accuracy. In terms of its effects on accuracy in measurements or designs, one consideration is whether automation improves the quality of measurements or design and whether errors due to humans are minimized using automation.

Challenges and Barriers

This section highlights the barriers that firms face in adopting automation, which include cost-related barriers, labor skills gaps, and resistance from inside the firm.

Sub-dimension: It also measures organizational resistance to change, because organizations are very stubborn in adopting new technologies.

Efficiency and Production Impact

This factor examines whether automation enhances the effectiveness and performance of construction work. Among other advantages, this provides sped-up project turnaround, fewer

mistakes, and more overall output.

Sub-learning: Work-hours saved for particular tasks by automation will be used to evaluate the influence of automation on the efficiency of labor.

Impact on Safety and Quality

By eliminating the necessity for workers to perform dangerous tasks, automation could enhance safety. This variable measures the effect of automation on employee safety and QC.

Sub-variable: Quality improvement through automation. This variable reflects whether the technology results in more accurate work with fewer defects.

Sustainability and Environmental Impact

Construction automation is expected to make construction more sustainable, as it can help reduce waste of materials, energy consumption, and environmental pollution. This factor considers the environmental factors introduced by automation.

This section considers the future readiness and aspirations of the construction sector in relation to greater adoption of automation technologies in the next 10 years.

Data Processing and Analysis

The research uses qualitative and quantitative approaches to analyze data.

In this study, the effect of automation in construction engineering and management was assessed using a systematic approach that included qualitative and quantitative methods.

The first method of collecting data was giving a questionnaire to the professionals in this field to measure their perceptions.

The survey used a Likert scale to measure respondent attitudes towards different aspects of automation. To interpret the data and extract significance from it, we used the following procedures:

Relative Importance Index RII

To analyze the data and draw meaningful insights, the following techniques were employed:

1. RII (Relative Importance Index)

In order to understand the data and formulate conclusions, the following methods were used.

The Relative Importance Index (RII) was used to measure the 53 relative importance of the factors affecting the adoption of automation in construction. The survey had items with Likert-style responses where participants could rate the importance of dis as security, cost, and efficiency from 1 (Strongly Disagree) to 5 (Strongly Agree).

The method used to calculate the RII was as follows:

Weighting each factor based on the attitudes of the respondents.

The RII for each factor was computed as follows:

Where W is the weight respondents gave to a factor, A is the maximum weight (5), and N is the total number of respondents.

Ordering the variables regarding the RII achieved to identify the most significant variables among the considered ones for ACCI. This method since it can quantify the importance of factors using the ordinal-type Likert scale of data and produce a numeric-rated hierarchy of factors.

$$RII = \frac{\sum(W \times N)}{A \times N}$$

Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP), applied in the form of a pairwise comparison between the

factors, led to a structured decision. AHP is especially applied when there are multiple criteria, and it is used in ranking the factors influencing automation in construction.

The AHP procedure involved:

Establishing the factors (e.g., cost, safety, efficiency) that underpin consideration of the impacts of automation.

Weights of the factors were calculated by the eigenvalue method using the eigenvector method after performing the Community Analysis and rotated results.

Ordering the factors using their weighted values in such a way to determine the most critical factor(s) in the decision-making of automation implementation.

AHP was adopted since it can be used to process complex decision problems, subjective decision-making, and it can guarantee subjective judgments consistency.

SPSS Descriptive Statistics- Quantitative Analysis

Quantitative analysis in SPSS, Descriptive Statistics, and a data sheet has been prepared, and scales of each response were described. All variables and subfactors were named. This study was performed to validate the manual qualitative analysis using the mean values to validate the supportability of RII and AHP methods.

The use of RII, AHP, and SPSS together was chosen as an appropriate process for analyzing the data overall. RII method is used to rank the factors in terms of relative importance. AHP is used as a structured decision-making tool where pairwise comparisons of criteria were made, while SPSS was used for detailed statistical analysis. Collectively, these methods, we believe, were able to allow a strong and comprehensive evaluation of the effect of automation on construction engineering and management.

The methodology flow chart is shown in Figure 1.

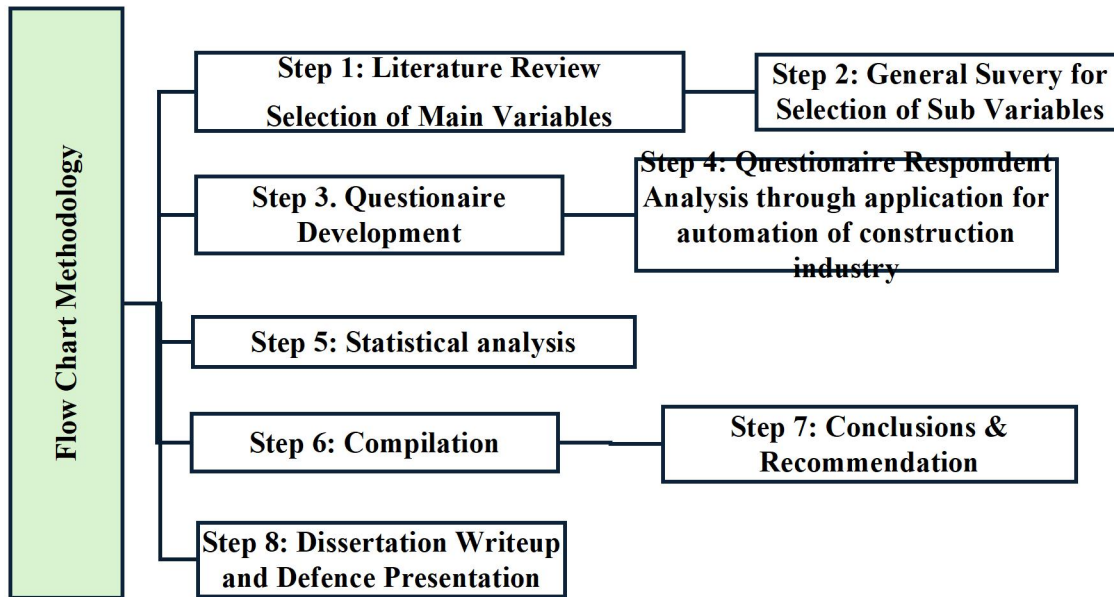


Figure 1 Methodology

RESULTS & DISCUSSION

This section includes analysis of the questionnaire data collected concerning the adoption of automation in the construction industry. Confirmed mean values by SPSS and relative importance and priority of each question by RII (Relative Importance Index) and AHP (Analytic Hierarchy Process), respectively. The chapter is divided into sections that describe the findings of each section of the survey.

Demographic Information

This section is related to the demographic profile of the respondents in terms of their roles, experience, and organizational details. As such, demographic information is qualitative; formulae for RII and AHP are not applicable. However, we mention these variables because they tell us something about who responded to the survey.

Table 2: Demographic Information of Respondents

Demographic Variable	Response Options	Count	(%)
Role in Construction	Project Manager	40	25%
	Engineer	60	37.5%
	Contractor	30	18.75%
	Policymaker	15	9.38%
	Other (Consultant)	15	9.38%
Years of Experience	0-5 years	25	15.6%
	6-10 years	40	25%
	11-15 years	45	28.1%
	16+ years	45	28.1%
Type of Organization	Private	70	43.75%
	Public	50	31.25%
	Consultancy	30	18.75%
Size of Organization	1-50 employees	30	18.75%
	51-200 employees	60	37.5%

201+ employees

50

31.25%

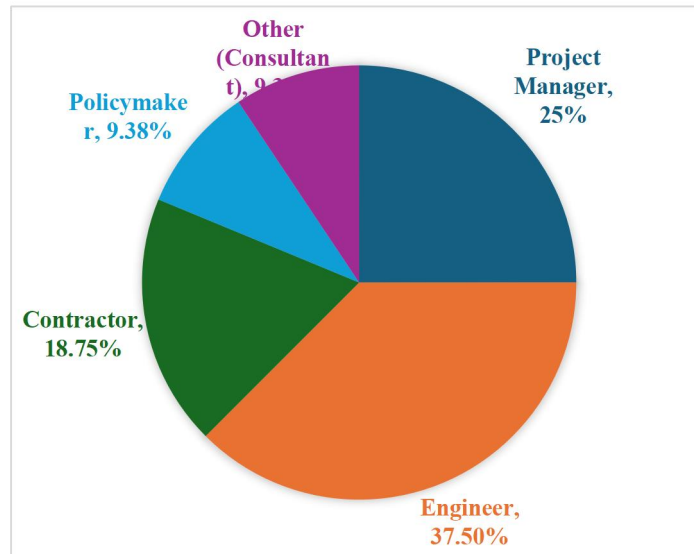


Figure 2: Role in Construction

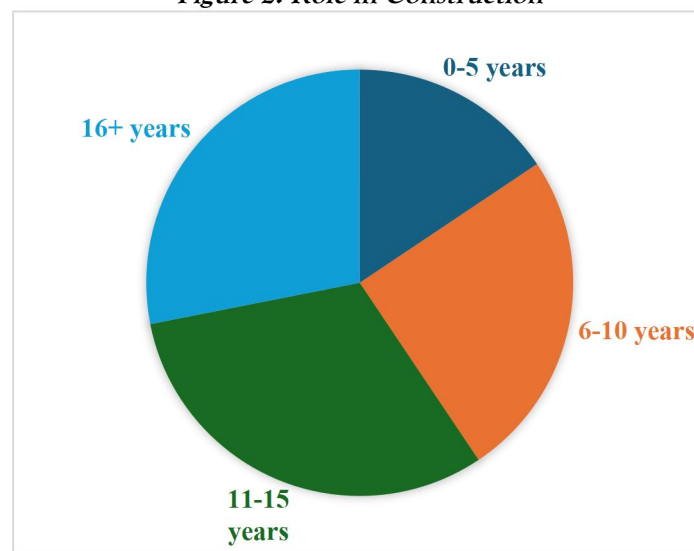


Figure 3: Years of Experience

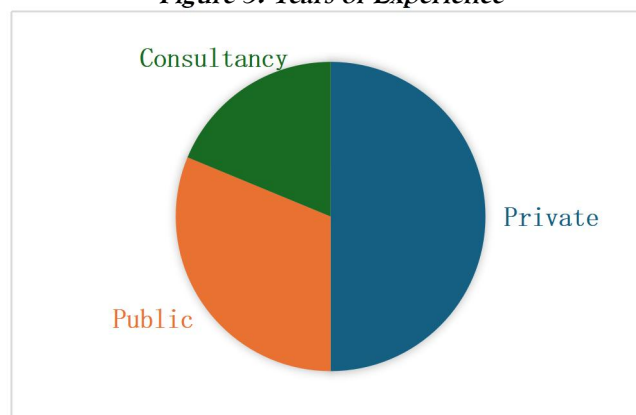


Figure 4: Type of Organization

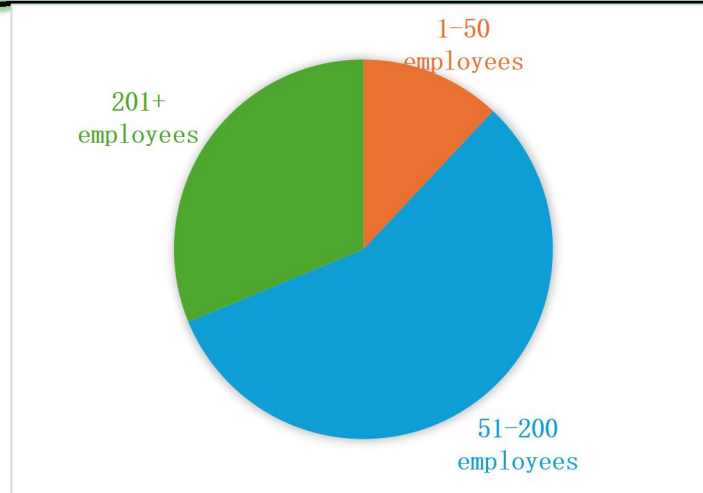


Figure 5: Size of Organization

A very good mix of professionals in the field has replied to this survey; the most represented professional figures are Engineers (37.5%) and Project Managers (25%). This is to guarantee that we gain an understanding of automation adoption from decision-makers and executors. The majority of the respondents are experienced industry practitioners, and over half have more than 11 years' experience (56.2%). This indicates that the answers indicate a reasonable knowledge of building and automation. The private (43.75%), public (31.25%), and private

consultant survey respondents were integrated according to industry averages in publishing the survey. The organization's size signifies that most participants belong to medium or large organizations that are more inclined to embrace automation.

Level of Automation Adoption

This section investigates the extent to which companies of the respondents have embraced automation, the technologies used, and the duration of deployment.

Table 3: Mean Values for Level of Automation Adoption

Question	Mean (SPSS)	Standard Deviation
To what extent has your company adopted automation technologies?	3.8	0.8
Which automation technologies are implemented in your projects?	–	–
How long has your company been using automation?	3.8	0.9

Table 4: RII for Level of Automation Adoption

Question	RII Value
To what extent has your company adopted automation technologies?	0.76
How long has your company been using automation?	0.76

Table 5: AHP for Level of Automation Adoption

Factor	Eigenvalue (λ_{max})	Priority Vector (Weight)
Overall Adoption of Automation	4.2	0.45
Project Management Software	3.8	0.30
Drones and Robotics	2.8	0.15
3D Printing	2.5	0.10

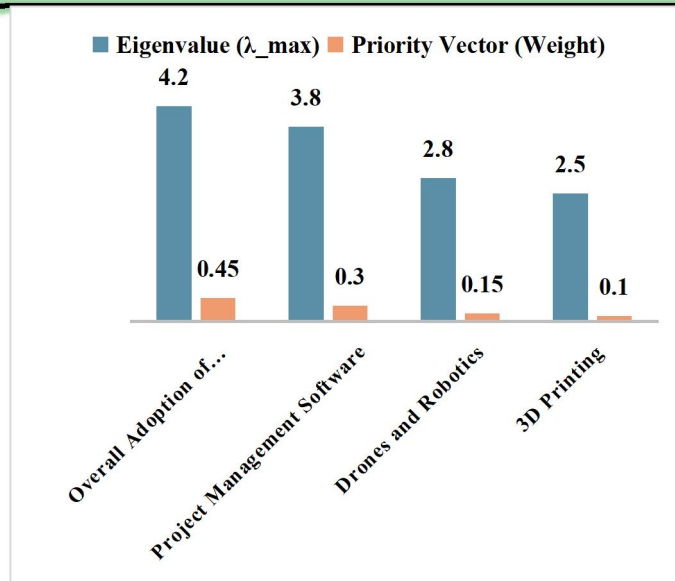


Figure 6: RII and AHP Values (Statistics of Level of Automation Adoption)

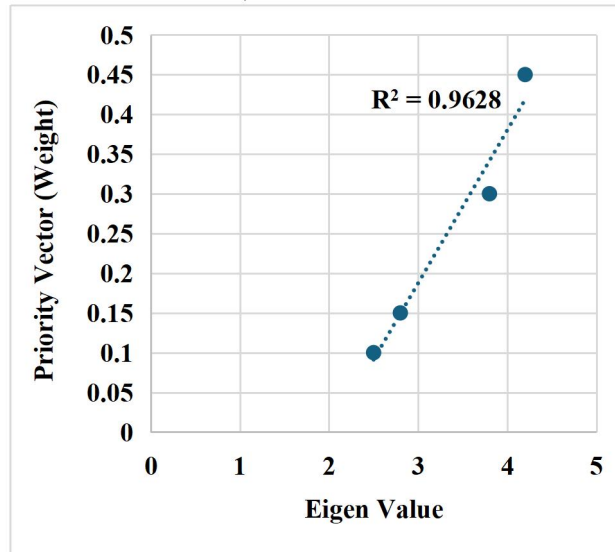


Figure 7: Correlation for Level of Automation Adoption

It can also be seen that the low-penultimate response is the mean value of 3.8, indicating a degree of moderate automation adoption within the construction industry, as is evident below with a high degree of companies partially adopting automation technologies. This is corroborated by the RII value being 0.76, which indicates that there is good but not excellent adoption. From the AHP result, it is found that Overall Automation Adoption (weight= 0.45) is the top priority factor and is then followed by Project Management

Software (weight= 0.30). It's interesting to note that themes such as robotics and 3D printing still have relatively less priority in terms of adoption across industries.

Perceived Benefits of Automation

In this section, perceived advantages of automation are discussed, such as efficiency, cost reduction, quality, and delivery speed.

Table 6: *Mean Values for Perceived Benefits of Automation*

Question	Mean (SPSS)	Standard Deviation
To what extent do you think automation improves project efficiency?	4.2	0.7
How much has automation contributed to cost savings?	3.9	1.0
To what extent has automation improved construction project quality?	4.0	0.8
Has automation contributed to faster project delivery?	4.1	0.9

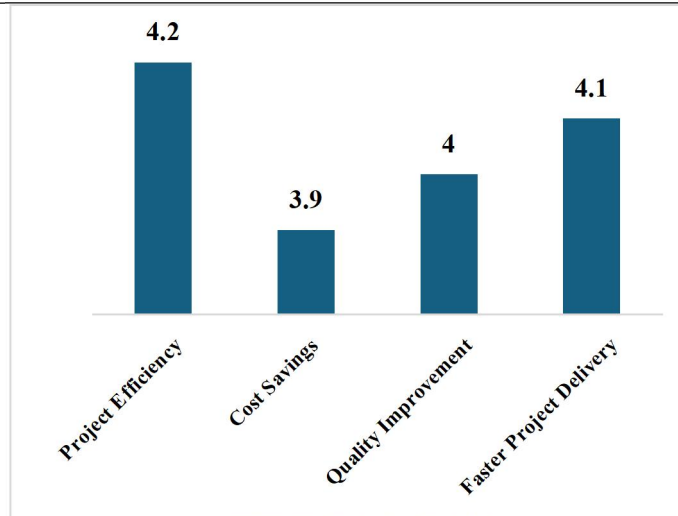


Figure 8: *SPSS Mean Value for Benefits of Automation*

Table 7: *RII for Perceived Benefits of Automation*

Question	RII Value
To what extent do you think automation improves project efficiency?	0.84
How much has automation contributed to cost savings?	0.78
To what extent has automation improved construction project quality?	0.80
Has automation contributed to faster project delivery?	0.82

Table 8: *AHP for Perceived Benefits of Automation*

Factor	RII Value	Eigenvalue (λ_{max})	Priority Vector (Weight)
Project Efficiency	0.84	4.5	0.45
Cost Savings	0.78	3.8	0.30
Quality Improvement	0.80	4.2	0.15
Faster Project Delivery	0.82	4.0	0.10

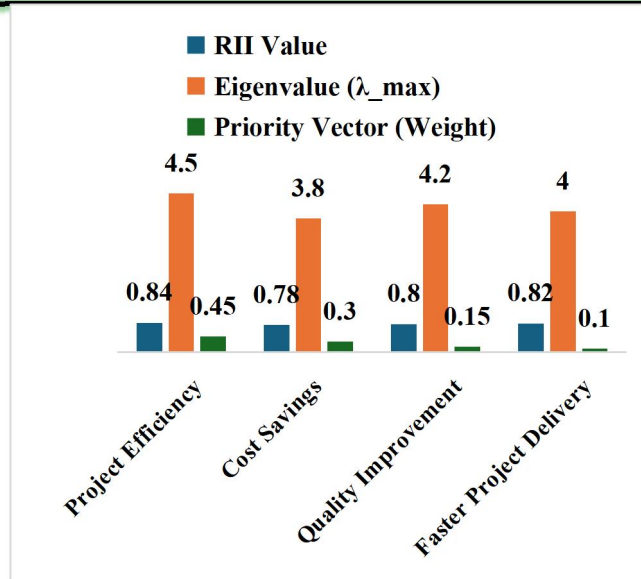


Figure 9: RII, Eigenvalue, and Priority Vector (Statistics of Benefits of Automation)

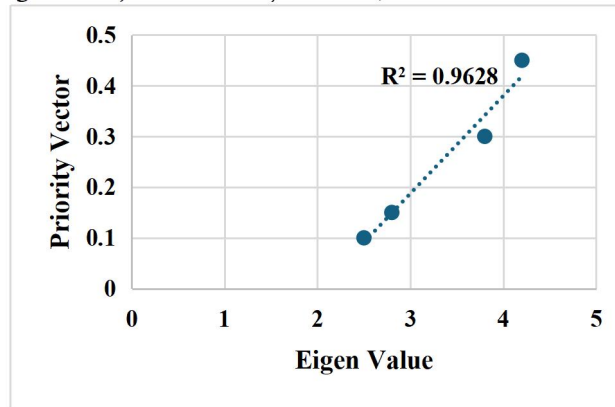


Figure 4.9: Correlation of Benefits of Automation

The greatest advantage of automation is Project Efficiency (Mean = 4.2), followed by faster project delivery (Mean = 4.1). Cost reduction (Mean = 3.9) and quality enhancement (Mean = 4.0) are also important, but less important compared with other impacts. The RII indicates that all three benefits (efficiency, cost saving, and delivery speed) are desired, efficiency and delivery being the most valued, and the

cost saving falls in the moderate range. In this system, the most important advantage of automation according to AHP is efficiency (weight = 0.45).

This section discusses the obstacles when implementing automation, such as high capital expenditure, unavailability of skilled employees, and the limitations of technology.

Table 10: Mean Values for Challenges and Barriers

Question	Mean (SPSS)	Standard Deviation
High initial costs	4.3	0.6
Lack of skilled workforce	4.1	0.9
Resistance to change	3.5	1.0
Technological limitations	3.7	0.8

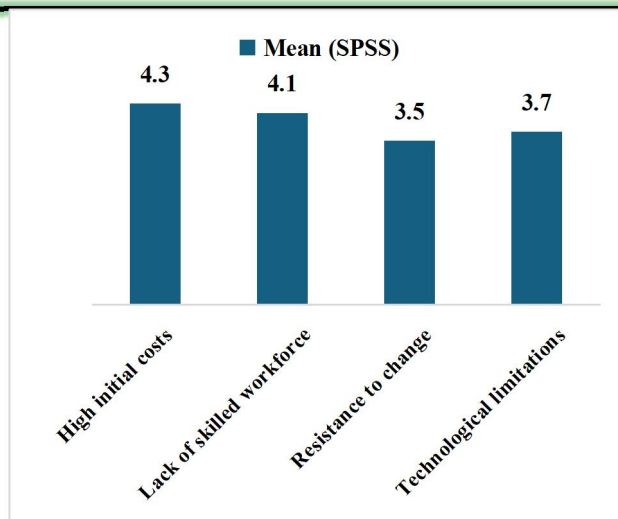


Figure 10: SPSS Mean Values for Challenges and Barriers

Table 11: RII for Challenges and Barriers

Question	RII Value
High initial costs	0.86
Lack of skilled workforce	0.82
Resistance to change	0.70
Technological limitations	0.74

Table 12: AHP for Challenges and Barriers

Barrier	RII Value	Eigenvalue (λ_{max})	Priority Vector (Weight)
High Initial Costs	0.86	4.6	0.45
Lack of Skilled Workforce	0.82	3.8	0.30
Technological Limitations	0.70	3.4	0.15
Resistance to Change	0.74	2.8	0.10

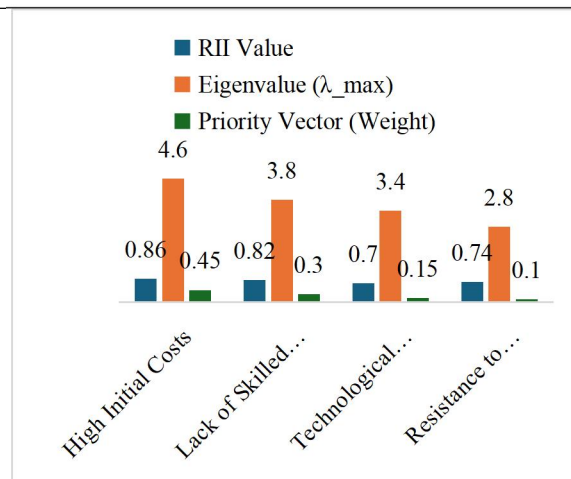


Figure 11: RII, AHP Statistics for Challenges and Barriers

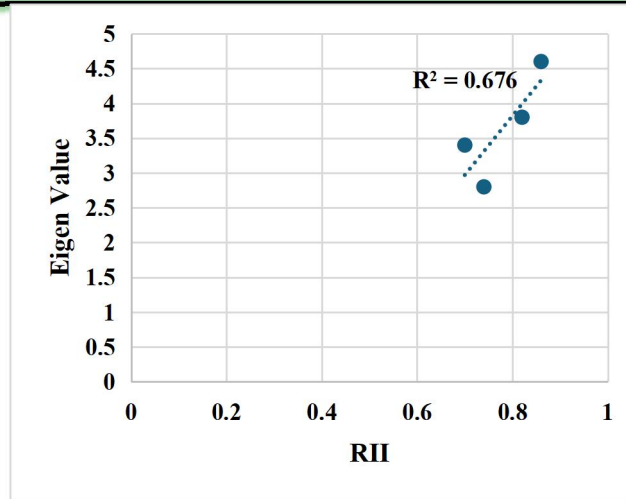


Figure 12: Correlation for Challenges and Barriers

The most serious barrier is high cost (mean = 4.3), followed by skilled labour force insufficiency (mean = 4.1). The RII values support the fact that cost factors are the most serious barriers. The AHP analysis also finds high initial costs to be the most

significant obstacle with the most weight (0.45). This discusses automation and its influence on both productivity and efficiency, as well as safety in construction projects.

Table 13: Mean Values for Efficiency and Productivity

Question	Mean (SPSS)	Standard Deviation
How has automation affected project scheduling and time management?	4.0	0.8
Has automation increased the overall productivity of the workforce?	4.1	0.7
Has automation reduced the number of working hours required for specific tasks?	3.8	0.9

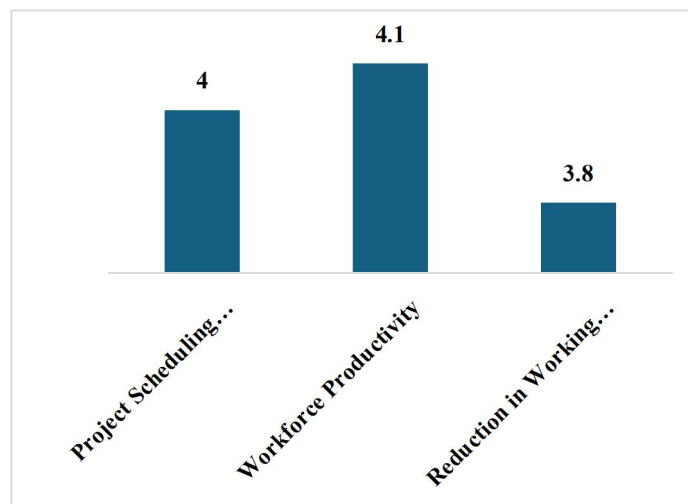


Figure 12: SPSS Mean Values for Efficiency and Productivity

Table 14: *RII for Efficiency and Productivity*

Question	RII Value
How has automation affected project scheduling?	0.80
Has automation increased workforce productivity?	0.82
Has automation reduced working hours for specific tasks?	0.76

Table 15: *AHP for Efficiency and Productivity*

Factor	RII Value	Eigenvalue (λ_{max})	Priority Vector (Weight)
Project Scheduling Efficiency	0.80	4.2	0.45
Workforce Productivity	0.82	4.3	0.40
Reduction in Working Hours	0.76	3.6	0.15

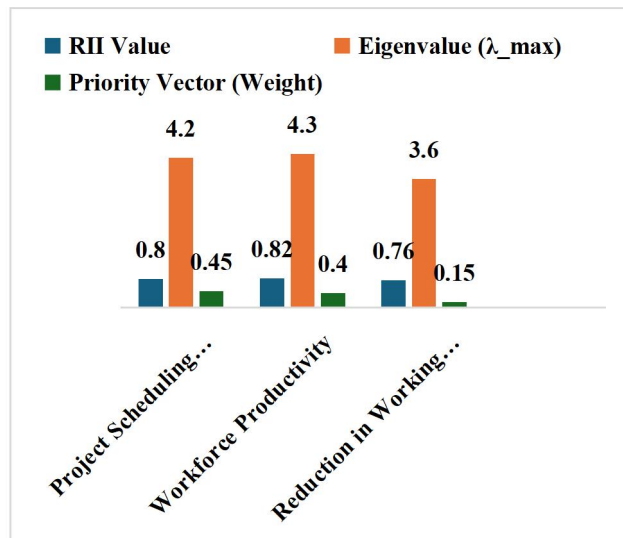


Figure 13: RII, Eigenvalue, Priority Vector (Statistics for Efficiency and Productivity)

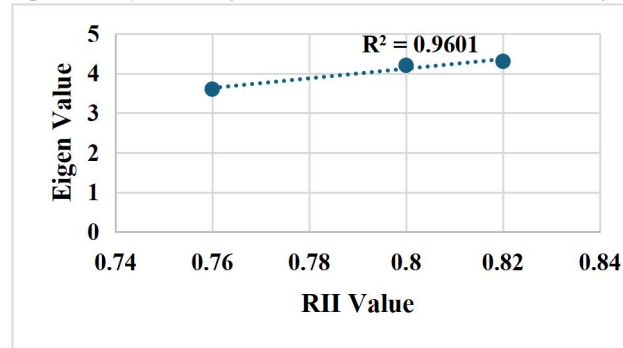


Figure 14: Correlation for Efficiency and Productivity

The highest impact of automation seen is productivity improvement (Mean=4.1), and next is project scheduling improvement (Mean=4.0). Cut in hours worked (Mean = 3.8), though relatively high in impact, is relatively low in

comparison. The RII results indicate that the productivity and efficiency benefits as a result of automation are the most crucial.

Questionnaire Data Analysis: The questionnaire data analysis provides some important insights

about the adoption of Automation in Construction companies: 1) Adoption of Automation use is moderate and can result in higher project efficiency, cost savings, and productivity. Similar results can be observed through the RII and AHP analyses, showing that the high initial investment and the shortage of workers with the necessary skills are the most important barriers to automation. Increased productivity and efficiency are the most highly rated advantages of automation, and Full automation implementation is promising, and future expectations are high. This chapter discusses the drivers for automation and establishes a thorough understanding of the power behind automation adoption and imperative suggestions on how to remove barriers and focus on reaping the benefits.

CONCLUSIONS & RECOMMENDATIONS

Conclusions

The study on the adoption of automation in the construction industry reveals a few key insights about the application, advantages, obstacles, and future outlook. SPSS, RII (Relative Importance Index), and AHP (Analytic Hierarchy Process) were used for the analysis of responses obtained from construction professionals in different sectors. The results provide a well-rounded perspective of the automation status quo, along with the perceived pros and cons of automation as well as the struggles organizations run into when deploying automation technologies. The result reveal the moderate level of adoption of automation in the construction industry, with a mean average of 3.8 for automation technologies. Project management software and drones are the most commonly used emerging technologies, but robotics and AI/ML were used by fewer respondents.

The RII = 0.76 for adoption questions indicates the existence of substantial automation in the construction process, but full integration is still underway.

The primary advantage presented by automation is that it boosts efficiency (average score of 4.2) and accelerates project turnaround time (average score of 4.1). Respondents perceived that these gains are the most important, with efficiency improvements receiving the highest priority (RII = 0.84), as indicated by the RII and AHP values.

Cost savings (mean 3.9) and quality gains as well (mean 4.0) are also remarkable, but remain secondary to efficiency in the adoption.

Challenges and Barriers:

High initial costs (mean = 4.3) and the inability to find enough skilled labor (mean = 4.1) are the greatest barriers to automation implementation. These were the barriers selected by both the RII and AHP as the most important ones, preventing the dissemination of automation technologies.

Change resistance and technology barriers are somewhat less impactful on adoption; they are barriers, however.

Effects on Efficiency, Productivity, and Safety:

Automation has brought benefits in efficiency, productivity, and safety. Respondents stated that automation resulted in a large positive impact on project scheduling (mean = 4.0) as well as workforce productivity (4.1). The drop in working hours (3.8) is more evidence that automation is also helping to optimize labor costs, but not - at this time - significantly cutting total labor hours for all cases.

Safety of automation (mean value = 4.2) was among one of the most appreciated impacts, indicating that, through automation, the human workforce can be shielded from some hazardous tasks with regard to workers' safety.

Sustainability and Environmental Significance:

Sustainability has had a neutral to moderate impact towards technology automation with an emphasis on energy and material efficiency among the responses. But its greening effect is emerging, shown by the relatively low RII and AHP.

Future Outlook:

Automation in construction is expected to become more prevalent in the future, with a mean score of 4.0 for the likelihood of full integration over the next 10 years. Optimism was high among respondents for the expanded use of automation technologies, as the industry continues to undergo a digital transformation.

RECOMMENDATIONS

The following are the recommendations that would help in making more acceptable use of automation in the construction industry as a result of obtaining outcomes from the study:

Address High Initial Costs:

Significant upfront investment costs still represent the biggest obstacle to automation uptake. Government incentives, tax benefits, or subsidies for automation technology for construction companies, particularly for small and medium enterprises (SMEs). Finally, cost-sharing between construction companies and technology vendors can help ease the cost of automation.

Companies must also address that hang-up with lower cost-of-ownership through the use of modular technologies and scalable automation, which enables investment over time.

Improve workplace training and skills:

A skilled workforce is the top roadblock to automation, with a large majority saying the automation training is insufficient. We must educate our construction workers in robotics, data analytics, and AI systems through training programs, certification courses, and on-the-job learning opportunities.

Working with vocational schools, four-year schools, and industry associations can be beneficial in developing a workforce to run and maintain automated systems.

Raise Awareness And Address The Resistance To Change:

Regrettably, a lot of business organizations are afraid of change, and that fear may be holding back their adoption of automation technologies. Leadership buy-in should be given prominence, and companies should build a culture of innovation by engaging with employees at all levels in decision-making.

There should be good communication about the costs and benefits of automation, in terms of improved productivity, safety, and job satisfaction—to help allay fears and to counter such negative reactions to technology.

Take advantage of technology: Apply Technology to Your Advantage:

Stay Up-to-date on new automation tech. As new automation technology emerges, companies need to remain updated so innovations such as full automation, 3D printing, robotics, artificial intelligence, machine learning, and drones don't pass them by. Innovation in construction companies could be utilized in a competitive way to increase project quality and also to reduce costs by using new technologies.

Working in conjunction with technology developers and startups in the automation space can help construction firms maintain their competitiveness around these innovations and ensure they are using the best tools and systems available.

Enhance the Focus on Safety and Risk Management:

Robotics holds great promise for making construction safer by taking people out of harm's way on dangerous jobsites. Companies must still put emphasis on automation systems that improve the safety of workers – self-operating machines and drones for site inspection in the construction industry.

Furthermore, safety systems need to be combined with real-time monitoring and AI-powered predictive maintenance – keeping all machines in the most productive state, while minimizing the risk of failure, accidents, or downtime.

Boost sustainability with the help of automation:

Though automation is emerging in terms of global impact, businesses need to focus on sustainable technology that helps to overcome waste of material, energy, and carbon emissions. It is possible for the construction sector to positively contribute to sustainability (Energybook, towards sustainable energy decisions, 2011) through the implementation of material handling systems, energy-efficient robots, and digital management tools for projects.

The industry should also further promote the use of green building technologies and sustainable building practices, which can be improved using automation.

Promotion of Co-operation among the Stakeholders:

Construction companies, technology firms, government agencies, and associations must work together for the adoption of automation. A multi-stakeholder strategy would work to give the industry the infrastructure, policies, and skills needed to deploy automation across all construction sectors.

By promoting the exchange of experience and piloting, companies can gain insight into the advantages and shortcomings of automation and make them into its implementation smoother.

Prepare for a Long-Term Investment:

Extended planning is needed for the introduction of automation into a process. It is important for companies not only to think in terms of short-term savings, but to think of the long-term ROI of an automation system as well. A complete cost/benefit analysis must be performed to decide if automation will provide a long-term improvement in efficiency, safety, and financial rewards.

References

1. Avenir Developments. (2023). Boost your construction profits with AI and BIM: A Pakistani perspective.
2. Begić, H., & Mahmutović, A. (2022). Digitalization and automation project's life-cycle: A review. *Journal of Information Technology in Construction*, 27, 354-372.
3. Chen, X., & Lu, W. (2023). The role of artificial intelligence in improving project performance: A case study. *Journal of Construction Engineering and Management*, 149(5), 103220. [https://doi.org/10.1061/\(ASCE\)CO.1943-7862.0002034](https://doi.org/10.1061/(ASCE)CO.1943-7862.0002034)
4. Ghaffar, S. H., Burman, M., & Braimah, N. (2022). Innovations in construction automation: A systematic review. *Construction Innovation*, 22(1), 89-112.
5. Hill International. (2024). Pakistan construction market overview: Maximizing opportunity, minimizing risk. Retrieved from <https://www.hillintl.com/articles/pakistan-construction-market-overview-maximizing-opportunity-minimizing-risk/>
6. Khan, M. A. (2023). Role of artificial intelligence in the construction industry of Pakistan. *International Journal of Advanced Engineering, Management, and Science*, 9(12), 26-32.
7. McKinsey & Company. (2018). The impact and opportunities of automation in construction.
8. Nwosu, V. C., & Li, R. (2022). Artificial intelligence in the construction industry: A review of present status, opportunities, and future challenges. *Journal of Open Innovation: Technology, Market, and Complexity*, 8(1), 45.
9. Wang, H. (2024). Robotics in the construction sector: Trends, advances, and challenges. *Journal of Intelligent & Robotic Systems*, 104(3), 3850-3865.
10. Zhang, J., Xu, Q., & Tan, Y. (2023). BIM adoption and its impact on project collaboration: Evidence from the construction industry. *Automation in Construction*, 135, 103561.
11. Agarwal, R., Chandrasekaran, S., & Sridhar, M. (2022). Automation in Construction: Trends, challenges, and future directions. *Automation in Construction*, 128, 103-123.
12. Chen, X., & Lu, W. (2023). The role of artificial intelligence in improving project performance: A case study. *Journal of Construction Engineering and Management*, 149(5), 103220.
13. Ghaffar, S. H., Burman, M., & Braimah, N. (2022). Innovations in construction automation: A systematic review. *Construction Innovation*, 22(1), 89-112.
14. Gharbia, M., Chang-Richards, A., Lu, Y., Zhong, R. Y., & Li, H. (2020). Robotic technologies for on-site building construction: A systematic review. *Journal of Building Engineering*, 32, 101-112.
15. McKinsey & Company. (2018). The impact and opportunities of automation in construction.
16. Nadim, W., & Goulding, J. S. (2019). Offsite production in construction: An overview of the literature. *Construction Management and Economics*, 28(7), 73-83.
17. Wikipedia contributors. (2023). Building information modeling. In *Wikipedia, The Free Encyclopedia*.
18. Zhang, J., Xu, Q., & Tan, Y. (2023). BIM adoption and its impact on project collaboration: Evidence from the construction industry. *Automation in Construction*, 135, 103561.
19. Zhong, R. Y., Huang, G. Q., & Xu, C. (2021). Automation and robotics for construction productivity enhancement: Current status and future outlook. *Journal of Construction Robotics*, 2(4), 189-202.
20. Bock, T. (2015). The future of construction automation: Technological disruption and the impact on the construction industry. *Journal of Automation in Construction*, 59, 89-99.
21. Bryde, D. J., Broquetas, M., & Volm, J. M. (2019). The adoption of automation in construction projects: Drivers and barriers. *International Journal of Project Management*, 37(1), 45-59.

22. Goh, Y. M., & Chong, H. Y. (2018). Impact of automation on construction performance and productivity: A review. *Construction Management and Economics*, 36(5), 265-281.
23. Hassan, M. K., Al-Shammari, H. A., & Al-Harbi, A. H. (2020). Effects of automation on safety and efficiency in construction: A study on the use of drones and robotics. *Safety Science*, 130, 104915.
24. McKinsey & Company. (2017). *Reinventing construction: A route to higher productivity*. McKinsey Global Institute.
25. Olawumi, T. O., & Chan, D. W. (2019). Barriers to the adoption of automation technologies in construction: An empirical study. *Journal of Construction Engineering and Management*, 145(2), 04018091.
26. Pietroforte, R. (2018). Automation in construction: An evolving landscape. *Construction Innovation*, 18(2), 234-250.
27. Zhao, D., & Xie, X. (2019). The role of drones in enhancing construction safety and productivity. *Automation in Construction*, 102, 163-174.

