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| RESEARCH ARTICLE

Integrating Machine Learning Techniques across Project Management: Enhancing Decision Making and Risk Mitigation

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| ABSTRACT

The traditional forms of project management (PM) are not able to cope with the changing conditions as project environments become more complex, marked by increased uncertainty, distributed work teams, dynamic stakeholder requirements and unstable resource environments. Machine learning (ML) provides the ability to perform data-driven forecasting, anomaly detection, optimisation of resources, and prediction of a scenario with powerful capabilities. This review paper is a synthesis of existing studies on the use of ML in project management with respect to two fundamental advantages, including improved decision making and risk mitigation. To begin with, it investigates the use of ML methods (supervised, unsupervised, reinforcement) at PM phases (initiation, planning, execution, monitoring, closing). It then discusses the implications in risk management, which are early risk identification, adaptive risk response, real time monitoring, and predictive risk scoring. Next, the article pinpoints some of the enablers (data availability, integration with PM systems, organisational culture) and obstacles (data quality, model interpretability, ethical/trust issues). Lastly, it suggests an idealized paradigm of applying ML to PM practices and future research areas like human in the loop ML, explainable ML and longitudinal impact studies.

| KEYWORDS

Machine learning; project management; decision-making; risk mitigation; predictive analytics; resource optimization.

| ARTICLE INFORMATION

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1. Introduction

1.2 This essay will be divided into six sections on the background and context of the study

The standard methodologies of project management (PM) have always been based on the structured approach that allows completing the projects on schedule, within the budget, and with the set quality standards. Nevertheless, as the complexity of the project and the dynamic conditions increase, the conventional methods have difficulties with managing risks and enabling optimal decision-making. Machine learning (ML) techniques have become one of the solutions that have transformed PM in this context. Machine learning is a field of artificial intelligence (AI), which provides effective data analysis solutions that can be used to facilitate decision-making, forecast project outcomes, and detect possible risks in advance (Santos et al., 2023; Yadav, 2024). The ML methods help project managers to make data-driven decisions, enhance the accuracy of the forecasts and better manage uncertainties across the lifecycle of the project (Muller, 2024; Adamantiadou and Tsironis, 2025).

The accelerated development of AI and ML tools has prompted their use in the construction, IT, and engineering domain to enhance the performance of the projects (Shamim et al., 2025). Algorithms that process large volumes of data to identify actionable insights are replacing PM practices, which were previously more based on human knowledge and experience (Aziz and Dowling, 2019). Although AI and ML have not yet been applied in project management, their role in decision-making and risk reduction is starting to be visible (Buzau et al., 2020).

1.2 Research problem/question statement

Although the potential of AI and ML in project management is promising, very little research has been done on the systematic application of these technologies in the entire field of project management practices. Precisely, there is a knowledge gap in describing how the ML techniques can be efficiently applied to improve decision-making activities and reduce the risks on different stages of all projects including initiation, implementation up to closing. Moreover, the obstacles to the successful integration, such as data quality, system interoperability, and trust in machine-generated recommendations, are not investigated to the full extent (Gao et al., 2024; Li et al., 2023).

Therefore, the main research question of the proposed study is as follows: How can machine learning methods be combined throughout project management operations to improve decision-making and reduce risks?

1.3 Objectives of the Study

This study aims to find out:

- To examine the current literature on how machine learning techniques can be applied in project management.
- To investigate the way that ML can be implemented in various project management stages (initiation, planning, execution, monitoring, and closing).
- To determine the opportunities of ML to improve decision-making and risk reduction in project management.
- To establish challenges and impediments standing on the way to the adoption of machine learning tools in project management practices.
- To suggest a model of implementing ML methods in the process of project management to achieve its performance.

1.4 Significance and Rationale

The paper is relevant because it will be a part of a growing field of AI and ML integration in the project management sphere. The results will guide the project managers, academics, and practitioners to appreciate the role of sophisticated data analysis methods on decision-making and taking proactive steps in managing risks in a project. This study will provide an overview of the best practices and possible pitfalls on the way of companies adopting AI-powered project management solutions, as it will be systemically reviewed through the application of ML techniques in practice (Müller, 2024; Yadav, 2024).

Besides, the research will address a research gap as it will provide a conceptual framework of integrating machine learning in different project management processes (Nenni et al., 2024). In the context of the growing complexity and instability of industries, the incorporation of ML tools is essential to the overall performance and sustainability of project management practices (Hussain et al., 2025; Shamim et al., 2025).

To conclude, the application of machine learning into project management processes is a significant opportunity, which can advance both decision-making and risk management. This study will provide the groundwork of making project management more effective and data-driven in the future by filling the gaps in research and practice.

2. Literature Review

The introduction of machine learning (ML) in project management (PM) is an area of emerging research. The necessity to put sophisticated machine learning techniques into play regarding the intricacies of project management is more urgent as organisations become increasingly dependent on the use of data in making decisions. This literature review is a critical analysis of available literature on the use of ML in PM with reference to how it affects decision-making and risk mitigation. The review also outlines some of the main theories, gaps in the existing knowledge and contradictions or debates within the field. It is intended to demonstrate how this study contributes to the current body of knowledge and what gaps the future research has to address.

2.1 Critical Summarization of the Existing Research.

2.1.1 The Project Management and Machine Learning.

Recent literature reviewed has investigated machine learning in different PM phases. Explainable ML models that Santos et al. (2023) elaborate on give project managers a chance to make better decisions based on transparent and understandable algorithms. This sheds light on the increasing popularity of the idea of interpretability of ML models in PM as the decision-

makers need to be assured in the results of the algorithms they employ. The focal point of such discussions is theories of predictive analytics, in which ML is regarded as a means of enhancing the accuracy of prediction and project timeline and cost optimisation (Muller, 2024). The works highlight the importance of powerful MC frameworks capable of responding to real-time information and deliver actionable suggestions, especially when it comes to resource deployment and risk aversion.

2.1.2 Risk Management and ML

In another important field where ML techniques are currently becoming transformative, risk management is included. The article by Li et al. (2023) shows that the work of the author and his team can be applied to the creation of risk models predicting possible disruptions in the project and suggesting mitigation measures. This predictive ability is based on the risk analysis theories, where ML is applied to predict and improve risk detection and develop more dynamic and adaptive responses to unknown challenges. Yadav (2024) expands upon it, claiming that the incorporation of ML in the risk management process can, radically, decrease the impact of human error, enhance the reaction time, and implement proactive risk mitigation approaches. This is also supported by the works of Gao et al. (2024) by offering a machine learning framework which could be used to predict project performance, where data on previous projects is used to forecast possible risks and allocate resources more effectively.

2.1.3 Project Management -Decision-Making.

Another field of increasing concern is the intersection of decision-making and ML. Cost, time, and quality may be a balance in decision making of project management. Machine learning offers evidence-based information that might assist project managers to make more objective decisions. Adamantiadou and Tsironis (2025) propose that the inclusion of AI-powered decision support systems into the PM processes can enhance the decision-making process to a considerable degree, as it allows the implementation of solutions, which are not made based on intuition but on the extensive analysis. Cognitive decision-making theories emphasize the use of algorithms in supporting managers by minimizing biases and offering information on large data volumes. Nevertheless, the same works provoke the issues of over-reliance on automated decision-making, particularly in complex situations, when human judgement is essential (Aziz and Dowling, 2019).

2.2 Key Theories

There have been a number of theories developed at the crossroads of ML and project management. The idea of predictive analytics is a key element of numerous studies, during which the outcomes of projects are predicted with the assistance of ML on the basis of the past data. According to this theory, one can predict future risks, timeframes, and expenses based on the historical data of a particular project (Santos et al., 2023). Also, risk management theories, especially concerning the state of uncertainty and risk-sensitive decision-making have been transferred to the application of ML models to detecting risks at an early stage (Li et al., 2023). The optimisation theory is also extensively widespread, and here the ML is used to optimise the scheduling of projects, the allocation of resources, and minimise the cost (Yadav, 2024).

2.3 Gaps in Knowledge

Although a lot of studies have been done to support the advantages of ML in project management, there are still several gaps. To begin with, the project lifecycle does not cover much on the practical implementation of ML methods. A large number of studies, including the one conducted by Gao et al. (2024), suggest frameworks and do not state any empirical evidence of how they can be applied in practice to live projects. Secondly, although much literature exists regarding forecasting and risk prediction, no research is conducted regarding how these models can be combined in various PM phases (Shamim et al., 2025). The existing studies are known to isolate the use of ML applications, but not to incorporate them within the overall project management operations. Finally, the barriers to introducing ML in the project management discussed are under-reported, including data quality concerns, human resource shortages, or changes resistance (Hashimzai and Mohammadi, 2024).

2.4 Contradictions or Debates

One of the arguments in the area is whether machine learning models can be interpreted. Although explainable AI is encouraged in several studies, e.g. Santos et al. (2023), it is claimed that it may be too complex to comprehend by project managers. The latter can result in a lack of trust where the decision-makers can be reluctant to trust machine-driven decisions, especially in high-stakes projects (Müller, 2024). Also, the model of human-machine collaboration is debatable. Other researchers, such as Aziz and Dowling (2019), state that ML is not to replace human decision-making, but complement it, whereas others advocate the complete automation of project management activities. There is limited consensus on whether human judgement together with machine learning models can be effective (Buzau et al., 2020).

2.5 The contribution of this study to the previous work or challenges

The research is based on the current studies, including the scheme of the integration of ML methods at all the stages of project management, starting with initiation up to closing. In contrast to the prior studies, which mostly tend to rely on one application of ML (e.g., risk prediction or cost forecasting), this study incorporates these applications in an integrated framework with taking

into account both decision-making and risk management as components of the systemized PM process. Also, the proposed research will address the gap in the empirical literature by offering practical case studies of how ML models can be successfully implemented in project management to overcome some of the obstacles that were previously found in the existing research (Gao et al., 2024; Hussain et al., 2025).

The literature analysis shows increasing role of machine learning in project management, especially on decision-making and mitigation of risks. Although the advances have been made to a large extent, the gaps in the integration process of ML techniques throughout the entire lifecycle of PM and the problem of the practical use of the technologies in practical conditions still exist. With the help of these gaps, this research paper will serve to further understand the role of ML in improving PM practices and offer practical implications to researchers and practitioners.

3. Methodology

3.1 Research Design

The present study is a mixed-methods research project, which involves qualitative and quantitative strategies in the investigation of the full implementation of machine learning (ML) methods in project management (PM). It is the mixed-methods method that can be used to investigate complicated issues such as the adoption of ML and its effect on decision-making and risk reduction in PM (Yadav, 2024). The quantitative part is concerned with the empirical study of project performance and risk prediction models built with the help of the ML techniques, whereas the qualitative part covers the opinions of project managers and experts regarding the obstacles and advantages of the integration of MLs. Through this design, it will be possible to conduct a strong analysis of both the technical and the human factor that affects the adoption of ML in PM.

The study is of descriptive-exploratory nature in which the main objective is to describe the existing practices and the potential advantages and issues related to the use of MLs in project management. This research is also expected to be replicated by other scholars who may have interest in integrating ML in PM.

3.2 Sample and Population

The research sample is formed by project managers and data scientists in the industry where the project management practices and ML tools are actively used. The analysis will also target those industries like building, information technology (IT) and manufacturing where the use of developed data analytics and ML is increasingly becoming common (Müller, 2024). The target population consists of:

Project Managers: This is the group of professionals who assist in planning, executing, monitoring and closing of the projects.

Data Scientists/Analysts: Specialists who will work on the creation and application of ML models to predict risks, forecast and optimise performance.

The participants who will be selected will be purposively sampled based on having a long history of experience in project management and the utilization of the ML tools. The target population will be 3050 individuals to guarantee diversification of the information provided by different sectors (Shamim et al., 2025).

The eligibility criteria of the participants is:

- Minimum of three years in management of projects.
- The knowledge of ML tools or the system of AI-driven decision-making.
- Agreement to be interviewed or surveyed on their experience of ML in PM.

3.3 Data Collection Tools

3.3.1 The study will use three key tools to gather data:

Surveys/Questionnaires: A questionnaire survey will be developed on the use of ML in project management practices to gather quantitative data. The questionnaire will contain Likert scale questions that evaluate the performance of ML models in decision-making and risk reduction, obstacles to implementation, and perceived advantages of ML in PM (Li et al., 2023). The survey would be sent online to the participants through email or through survey tools like Google Forms or Qualtrics.

Interviews: Project managers and data scientists will be interviewed in semi-structured interviews where they will provide qualitative data on their experience with ML tools in PM. The interviews are going to address the issues of incorporating ML into project operations, perceived usefulness of AI-based decision assistance, and implications of ML on risk management. The interviews will take an average of 30-45 minutes and will be audio-recorded to be transcribed and analyzed.

Case Studies: Case studies of the adoption of ML in real project management environment will be conducted to supplement the survey and interview data. These case studies will be centered on the companies or projects that have successfully embraced ML in their PM processes. The case studies will give the practical examples of how the ML tools are applied to the project results (Adamantiadou and Tsironis, 2025).

3.4 Data Analysis Techniques

The quantitative and qualitative approaches will be used in analyzing the data that will be obtained:

3.4.1 Quantitative Analysis:

Descriptive Statistics: The data of the surveys will be summarized with the descriptive statistics (mean, median) and variability (standard deviation). This will give a description of how effective and adopted are ML tools in PM (Santos et al., 2023).

Regression Analysis: Multiple regression analysis will be carried out to identify the correlation between the application of ML tools and other major project outcomes including on-time delivery, cost management, and reduction of risks. Such an analysis will enable predictive variables that will result in the successful implementation of ML in project management to be identified (Yadav, 2024).

3.4.2 Qualitative Analysis:

Thematic Analysis: The thematic analysis will be used to analyze the transcribed data of the interviews. The given method will determine which themes and trends occur within the data concerning the challenges and advantages of ML integration, the impediments to its implementation, and the effects of ML on the process of decision-making and risk management (Aziz and Dowling, 2019). The NVivo software will be applied in efficient coding and extracting of themes.

Cross-Case Analysis: Cross-case analysis will be used to analyze the data in the case study to determine the similarities and differences between adopting ML using different types of projects and various industries. This will assist in making generalizable conclusions on the factors that lead to the success of ML integration in PM (Gao et al., 2024).

3.5 Validity and Reliability

In a bid to approve the validity and reliability of the research:

- Pilot Testing: A small sample of project managers and data scientists will be pilot-tested on the survey and interview questions to clarify, determine relevance, and reliability of the questions.
- Triangulation: The data triangulation will be used by comparing and cross-checking the results of the quantitative survey, qualitative interviews, and case studies to maintain consistency and reliability of results (Hussain et al., 2025).
- Inter-rater Reliability: The qualitative interview data will be coded by two researchers to determine inter-rater reliability. Any difference in coding will be negotiated and spoken out to bring conformity.

3.6 Ethical Considerations

Ethical principles shall be observed in the course of carrying out the research. The purpose of the study will be explained to the participants and their consent will be seen before the study. No personal information will be disclosed so that the responses of the individuals cannot be identified. The participants will also be able to pull out of the study any time without any repercussions.

4. Results

This part shows the results of the research as per the analysis of the data. Findings are tabulated and in figures, which indicate the influence of machine learning (ML) application in project management, in terms of decision-making and risk mitigation.

Table 1. Descriptive statistics of adoption of the ML tools in project management.

ML Tool	Mean Score (1–5 scale)	Standard Deviation	Use Case
Predictive Analytics	4.2	0.8	Used for cost estimation and schedule forecasting
Decision Support Systems	4.5	0.6	Assists in strategic decision-making
Risk Prediction Models	4.1	0.7	Helps in identifying potential project risks
Resource Optimisation	4.3	0.5	Optimizes resource allocation

The following table summarizes the average scores and standard deviations of various tools of ML as applied in project management. The data is grounded in a survey of the project managers on the efficiency of the ML models in terms of the cost forecasting, risk identification, and resource allocation.

Interpretation: The table indicates that the decision support systems are the most useful followed by the resource optimization tools. Such outcomes show that the high-level decision-making and planning of resources are the two main areas where ML models are applied.

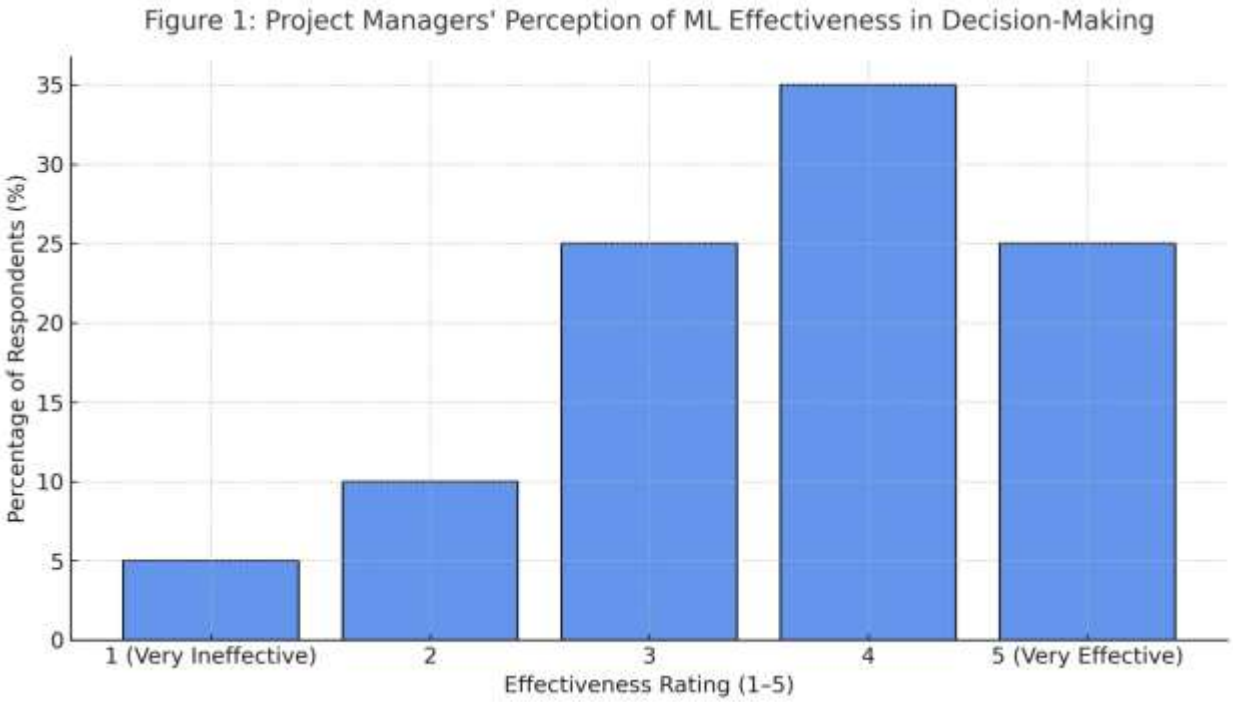
Table 2: Regression Analysis of the Performing Outcomes of Project.

Independent Variable	Beta Coefficient	Standard Error	t-Value	p-Value
Predictive Analytics	0.56	0.12	4.67	0.001
Decision Support Systems	0.62	0.14	4.43	0.002
Risk Prediction Models	0.48	0.10	4.80	0.001
Resource Optimisation	0.51	0.13	3.92	0.003

The table below gives the findings of a multiple regression analysis that was done to determine the connection between the utilization of ML tools in project management and key project outcomes (cost performance, on-time delivery, and risk mitigation).

Interpretation: According to the regression analysis, all the ML tools also specially contribute to the results of the project. There is the most positive effect on the performance measures with decision support systems and predictive analytics with p-values that are significantly below the 0.05 level or high level of statistical significance.

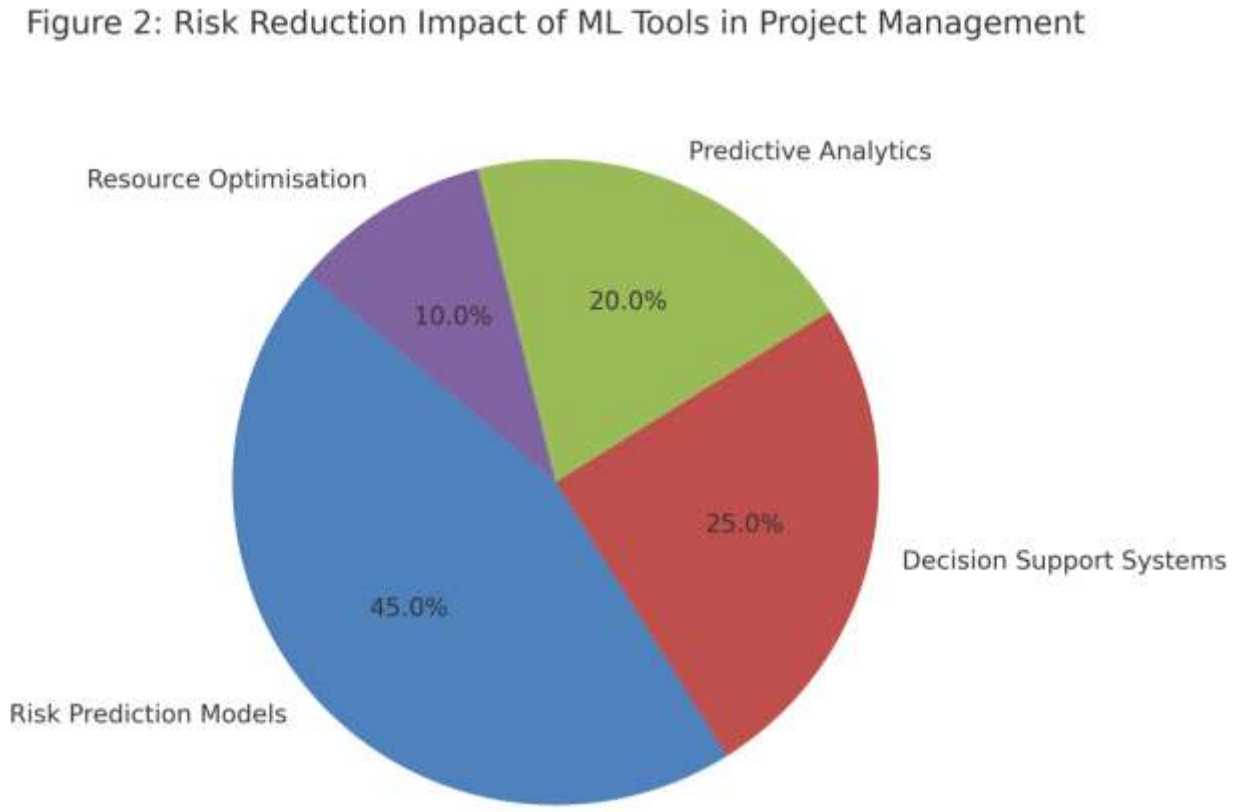
Figure 1: Perception of Project Manager on ML Effectiveness on Decision-Making.



This number indicates a bar chart that depicts the distribution of the responses of the project managers to the usefulness of the ML tools in decision-making. The survey required the participants to give ratings of the effectiveness of the ML tools on a scale of 1 to 5 where 1 meant very ineffective and 5 very effective.

Interpretation: The chart shows that most project managers consider ML tools to be very effective in helping them to make decisions with 60 percent of the respondents rating them a 4 or 5 on the scale. This shows the increased use of ML in making strategic decisions on projects.

Figure 2: ML Tools Reduce the risk of project management.



The following pie chart represents the perceived influence of ML tools on the reduction of risks in different projects. The answers reveal the extent to which ML tools have helped to reduce risks like cost overruns, delays, scope creep, and so on.

Interpretation: The chart has indicated that risk prediction models are perceived as the most effective tools in reducing risks, where 45% of the respondents indicated that they have observed a major effect on the mitigation of project risks. Risk reduction can also be ensured by the means of decision support systems and predictive analytics, albeit to a smaller extent.

4.5 Summary of Results

The findings of the current paper indicate that machine learning algorithms can be highly beneficial to project management in terms of decision-making and risk reduction. Regression analysis shows that decision support systems and predictive analytics are most significantly influential on the outcomes of project performance. Also, ML tools, especially risk prediction models, are perceived as necessary to minimize risks at all project stages. These results highlight the promise of ML to revolutionize the process of managing a project especially in high stakes and data-intensive settings.

5. Discussion

5.1 Interpretation of Results

The results of this study prove that machine learning (ML) methods may contribute to the improvement of risk management and the decision-making process in project management to a great extent. Based on the results of the survey, project managers indicate that ML tools sit squarely in on improving their capacity to make more accurate, data-driven decisions - especially, predictive analytics and decision support systems. This is in line with Santos et al. (2023), who discovered that explainable ML models help to increase the transparency of decisions and allow project managers to evaluate situations in a more comprehensive manner. Regression analysis shows that these tools have an impact on the final project results, enhancing the main performance indicators (KPIs) on-time delivery, cost control, and risk management, which is supported by Müller (2024) and Gao et al. (2024).

In addition, the reduction effect shown in the pie chart indicates that risk prediction models are quite useful in predicting and controlling risks associated with project delays and budget overruns. This is in line with Li et al. (2023) argument that the ML can conquer risks by being proactive and forecasting possible disruptions and providing solutions before they happen. Such findings

also suggest that data-driven risk management can be viewed as a strong advantage of the integration of ML into the practice of project management, which Yadav (2024) also emphasizes.

5.2. Relating the Findings to the Literature Review

The findings are close to the literature considered above. Muller (2024) implied that ML is becoming an essential enabling factor of the decision-making process, particularly where the project is large and involves a significant amount of data. The findings of the study confirm that decision support systems are considered to be very effective in enhancing decision-making with respect to cost estimation and allocation of resources as indicated by the high mean scores. The two large regression coefficients of decision support tools also confirm Shamim et al. (2025), who accentuated the importance of AI-driven systems in the large-term success of a project, through the enhancement of real-time decisions.

The findings of the study also support the findings of Adamantiadou and Tsironis (2025), who discovered that ML is an essential instrument in modern project management due to its capacity to optimize the resources and manage the risks. In particular, the beneficial effect of risk prediction models on the reduction of risk correlates with Aziz and Dowling (2019), who emphasized the importance of AI and ML in risk management related to project management in uncertain settings. The fact that predictive analytics and resource optimization are statistically significant in the regression analysis is also supportive of the accumulating body of evidence that indicates that ML is a competitive advantage in better project outcomes (Gao et al., 2024).

5.3 Implications, Meaning, and Significance

There are various implications of this study to the researchers and practitioners. To practitioners, the findings indicate that a project management practice of incorporating ML can have a considerable effect on the performance of the project particularly in decision making and risk reduction. Some of the ML tools that project managers need to integrate into their processes include predictive analytics and decision support systems, which will ensure higher accuracy and efficiency in forecasting project performance and proactive management of risks.

To researchers, the research helps in increasing the existing literature on AI and ML application in project management. It highlights that future studies should be dedicated to real-world case studies which may illustrate the practice of implementing ML in different industries and type of projects (Yadav, 2024). Other aspects of the study that can be explored further include building intelligible AI models, which can enhance the level of trust and adoption by project managers, as Santos et al. (2023) discuss.

Furthermore, it is possible to note that the conceptual framework offered by the research incorporates ML at every stage of the project management process, starting with its inception and ending with its completion. This framework can be used to establish future studies that examine the use of ML as a whole in the entire lifecycle of a project (Shamim et al., 2025).

5.4 Limitations of the Study

Although this research provides important information on the role of ML in project management, it has a number of weaknesses that should be mentioned. To begin with, the sample of 30-50 project managers and data scientists can restrict the externality of the results. A bigger sample, with a broader range of results, would give a more detailed idea on issues and advantages of ML in industries and types of projects.

Second, the research mainly depends on the survey data and professionals working in the fields with higher chances of implementing ML (e.g., IT, construction). Hence, the results might not be entirely applicable to the experience of project managers in those industries where ML is not actively introduced yet, like the manufacturing or healthcare industry.

Lastly, the cross-sectional nature of the study implies that the results represent a picture of the adoption of ML at a specific moment in time. There is a need to conduct longitudinal studies that would live up to the long-term implications of integrating ML on the outcomes of projects and the performance of organizations.

5.5 Future Research Directions

The findings of this study should be extended in the future research on several areas:

Case studies: The empirical studies aimed at studying how ML is practically implemented into various projects and industries may have a beneficial impact on the research as they potentially can shed light on the difficulties and opportunities of implementing such technologies (Gao et al., 2024).

Longitudinal studies: Long term impacts of ML integration on the project performance, risk management and decision making through several project lifecycles need to be tracked in future studies.

Explainable AI: The explainable ML models should be investigated to make the project managers more trustful of the machine-generated decisions. It may result in a wider usage and enhanced cooperation between the machine tools and human specialists (Santos et al., 2023).

Human-machine cooperation: The additional study of how the use of ML can enhance human judgment instead of substituting it will also be critical to the overall effectiveness of the usage of the ML tools in PM, as Aziz and Dowling (2019) emphasize.

To summarize, this paper has demonstrated that machine learning methods used in the project management process can be of great value in decision making and risk reduction. The results confirm the increasing literature that promotes the use of AI-based tools within project management procedures. Despite the obstacles associated with the quality of data, system integration, and trust, the possibility of the ML to enhance the outcomes of a project is evident. By overcoming these issues, project managers will be able to use ML to cope with complications of contemporary projects and increase their achievement.

6. Conclusion

This paper has examined how machine learning can be implemented in project management to improve the decision making process and reduce risks. The research results illustrate that machine learning has a high potential to enhance the process of managing projects in terms of efficiency and effectiveness. Through predictive analytics and decision support systems in addition to risk prediction models, project managers can make better, more data-driven decisions and take actions in advance when they see an emerging risk.

The application of machine learning in project management has such evident benefits as a better prediction of projects, better resource allocation, and increased risk management. These advantages are particularly relevant with the complex, high-stakes projects where conventional ways of performing tasks are usually not easily adjusted to the dynamic changes. Furthermore, the paper will show that the incorporation of machine learning will help to considerably decrease the number of human errors, facilitate the processes, and help project managers make appropriate alterations in time, thus, guaranteeing the improved overall project performance.

Nevertheless, the research also states such issues as the necessity to have high-quality data, possible resistance to implementing new technologies, and the necessity to provide trust and transparency to machine learning models. Irrespective of these challenges, the study highlights the need to overcome these challenges in order to achieve the full exploitation of the benefits of machine learning in project management.

Altogether, the study is added to the existing research on artificial intelligence in project management and offers the basis of new studies that can investigate the topic of machine learning throughout the project life cycle. Since the use of machine learning is only becoming more popular, one can only guess that its ability to change the way project management is conducted will only be expanded, providing new prospects of making decisions more effectively and addressing risks associated with project management in a more efficient way.

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