Neural Network Algorithm Optimization for Financial Budget of Universities

Abstract: Efficient budget management is crucial for the successful execution of construction projects. To achieve this, the design of a Construction Project Audit Budget Management System based on combinatorial optimization offers significant advantages. Combinatorial optimization techniques focus on finding optimal solutions from a vast number of possible combinations, making them well-suited for complex budget management scenarios. This system employs advanced algorithms to analyze and optimize various factors such as resource allocation, cost estimation, risk assessment, and scheduling. This paper focused on the construction of the Project Fuzzy Audit System in China. The developed model computes total investment decision, preliminary design, design, contracting, completion, acceptance and other stages of the investment/cost, namely investment estimation, budget estimate, control price, contract price and settlement price. According to the project total investment/cost control needs in China Project. The constructed model uses the combinatorial Optimization model for the estimation of the investment estimation of the Construction Project for the cost index. Through the Fuzzy Audit System new method abolishes the "maximum price" in the bidding document with the limit as the unit, and gradually terminates the preparation of the budget quota, highlighting the market price, so there is an urgent need for a set of cost index in line with the actual needs. The results demonstrated that with the fuzzy Audit system new method abolishes the "maximum price" in the bidding document with the limit as the unit, and gradually terminates the preparation of the budget quota, highlighting the market price, Through analysis it is concluded that with fuzzy based optimization model effectively accumulate fast and accurate calculation of the Project cost.

Keywords: combinatorial optimization, construction project, Fuzzy Optimization, Project Management, Market Price, Budget

I. INTRODUCTION

The Project Audit Budget Management System is a comprehensive solution specifically designed for the construction industry to effectively monitor and control project budgets [1]. This system provides a streamlined approach to budget management, enabling project managers and stakeholders to track expenses, allocate resources efficiently, and ensure financial accountability throughout the project lifecycle. By integrating advanced analytics and reporting capabilities, the system allows for real-time visibility into budgetary performance, identifying potential risks, and facilitating informed decision-making [2]. With its user-friendly interface and customizable features, the Project Audit Budget Management System offers a robust and reliable platform to optimize financial planning, mitigate cost overruns, and enhance overall project success in the dynamic construction industry [3]. The Project Audit Budget Management System is an advanced software solution developed specifically for the construction industry, aimed at improving the management of project budgets [4]. Construction projects often involve complex financial considerations, with multiple stakeholders, resources, and expenses to be tracked and controlled [5]. This system offers a comprehensive approach to budget management, providing a centralized
One of the key features of this system is its ability to track and analyze expenses in real-time. It enables project managers to record and categorize costs, whether they are related to labor, materials, equipment, subcontractors, or any other aspect of the project [7]. With this data in a centralized database, the system provides a holistic view of the project's financial health. The system also facilitates effective resource allocation. It allows project managers to allocate budgets to various activities, departments, or phases of the project, ensuring that financial resources are optimally distributed [8]. This feature helps in identifying areas of overspending or underspending, enabling timely adjustments to be made to keep the project on track. Financial accountability is a crucial aspect of project management, especially in the construction industry [9]. The Project Audit Budget Management System ensures transparency and accountability by generating detailed financial reports and audits. These reports provide stakeholders with clear visibility into the project's financial performance, highlighting any deviations from the allocated budget [10]. With this information, project managers can take proactive measures to mitigate risks and make informed decisions regarding budget adjustments or corrective actions [11]. Moreover, the system's advanced analytics capabilities help identify potential risks and cost overruns early on. By analyzing historical data and comparing it to real-time project data, the system can provide valuable insights into trends, patterns, and potential budgetary issues [12]. This proactive approach empowers project managers to address financial challenges promptly, minimizing the impact on the project's overall timeline and success. The Project Audit Budget Management System also offers a user-friendly interface, making it accessible to all stakeholders involved in the project [13]. It can be customized to align with specific project requirements, ensuring flexibility and scalability. Additionally, the system can integrate with other project management tools and software, facilitating seamless data exchange and enhancing overall project efficiency [14].

Fuzzy logic plays a crucial role in the Project Audit Budget Management System within the construction industry, offering a valuable framework for handling uncertain and imprecise information [15]. Its application in the system allows for a more nuanced assessment of project risks, considering the likelihood and impact of various factors in a flexible and adaptive manner. Through incorporating fuzzy sets and rules, resource allocation decisions become more robust, taking into account multiple criteria and constraints [16]. Additionally, fuzzy logic aids decision support by leveraging expert knowledge and heuristics, providing intelligent suggestions and recommendations based on the project's budget status [17]. Furthermore, through forecasting and predictive analysis, fuzzy logic enables project managers to anticipate future budget trends and proactively address potential cost overruns. With the integration of fuzzy logic enhances the Project Audit Budget Management System's ability to handle uncertainty, support decision-making processes, and improve the overall management of construction project budgets [18].

The paper on the Fuzzy Audit System with ILP-based Combinatorial Optimization makes several significant contributions to the field of construction industry and budget management. Firstly, the paper introduces a novel approach that combines fuzzy logic principles and ILP-based combinatorial optimization techniques. This integration allows for more accurate and efficient handling of uncertainties, imprecise data, and trade-offs in resource allocation and cost optimization. By incorporating fuzzy logic, the system can effectively model and manipulate uncertain financial information, leading to more informed decision-making processes. Secondly, the
paper presents a comprehensive framework that addresses various aspects of budget management, including resource allocation, task dependencies, risk assessment, budget constraints, and quality metrics. By considering these parameters simultaneously, the Fuzzy Audit System provides a holistic approach to budget management, ensuring that resources are allocated optimally, risks are mitigated, budgets are adhered to, and quality objectives are met. Furthermore, the paper demonstrates the practical implementation and effectiveness of the Fuzzy Audit System through the provision of sample tables and results. By showcasing the system's ability to handle resource allocation, cost optimization, and decision-making in real-world scenarios, the paper offers tangible evidence of its contribution to the construction industry. The proposed system's contribution lies in its ability to improve the efficiency and accuracy of budget management processes. By automating and optimizing resource allocation decisions, the Fuzzy Audit System minimizes costs, maximizes resource utilization, and ensures that projects stay within budgetary constraints. This ultimately leads to improved project outcomes, increased stakeholder satisfaction, and enhanced financial performance. As this paper's contribution lies in presenting a comprehensive framework that addresses the complexities and uncertainties in budget management, leveraging fuzzy logic and combinatorial optimization techniques. The system's practical implementation and demonstrated effectiveness make it a valuable tool for auditors, project managers, and stakeholders in the construction industry, contributing to improved decision-making, cost optimization, and project success.

II. LITERATURE SURVEY

With the fuzzy logic allows the Project Audit Budget Management System to capture the inherent complexity and ambiguity often present in the construction industry. Construction projects involve numerous variables and factors that are difficult to precisely quantify or define. Fuzzy logic accommodates this by enabling the system to work with linguistic variables and fuzzy sets, which can represent and manipulate imprecise information more effectively. In risk assessment, fuzzy logic facilitates a more comprehensive evaluation of project risks. By incorporating fuzzy rules that consider both quantitative and qualitative factors, such as expert opinions and subjective assessments, the system can generate more accurate risk rankings and prioritize mitigation strategies accordingly. This helps project managers allocate resources and implement appropriate measures to address the identified risks. The integration of fuzzy logic within the Project Audit Budget Management System in the construction industry enhances its ability to handle uncertainty, ambiguity, and complexity. By embracing imprecise information and incorporating fuzzy sets, rules, and reasoning, the system becomes more adaptive, robust, and effective in managing project budgets. This contributes to better financial planning, risk management, decision-making, and ultimately, the successful completion of construction projects within budgetary constraints.

In the study by Sari and Latief (2021) [19], the authors explore the use of fuzzy logic and artificial neural networks for estimating safety costs in building construction. The research aims to improve the accuracy of safety cost estimation by considering the uncertainty and imprecision associated with safety-related factors in construction projects. Yevu et al. (2021) [20] present an evaluation model for the influences of driving forces on the application of electronic procurement systems in Ghanaian construction projects. The researchers analyze various factors and their impact on the successful implementation of electronic procurement systems, providing insights into enhancing procurement practices in the Ghanaian construction industry. Charisis, Hadjidimitriou, and Hadjileontiadis (2022)
propose a novel project evaluation approach, called FISEVAL, utilizing fuzzy logic. The study focuses on the i-Treasures project and demonstrates how fuzzy logic can be used to assess and evaluate multiple project dimensions, considering the inherent uncertainty and subjectivity in project evaluations.

Jabbar and Malik (2023) [22] explore the application of fuzzy logic to enhance audit procedures. The research investigates how fuzzy logic techniques can be integrated into audit processes to improve accuracy and effectiveness in detecting anomalies and identifying potential audit risks. Naji, Gunduz, and Naser (2022) [23] develop an adaptive neurofuzzy inference system for assessing change order management performance in construction projects. The study aims to improve the evaluation process of change order management by incorporating both fuzzy logic and neural network techniques to handle uncertainty and complex relationships within the construction context.

Wang (2021) [24] conducts research on the influencing factors of financial performance in listed companies using multiple linear regression and a fuzzy logic system. The study explores how fuzzy logic can be utilized alongside traditional statistical methods to analyze and understand the impact of various factors on financial performance. Pan and Zhang (2021) [25] present a critical review of the roles of artificial intelligence (AI) in construction engineering and management. The review highlights the potential applications of AI techniques, including fuzzy logic, in various aspects of construction projects, such as scheduling, quality control, and risk management. Eghbali Amooghin et al. (2023) [26] propose the use of the fuzzy analytic hierarchy process to determine the importance of variables influencing financial reporting quality. The study aims to provide a structured approach to prioritize and assess the significance of different factors affecting financial reporting quality using fuzzy logic-based decision-making.

Wang et al. (2022) [27] propose a Bayesian predictive model for auditing construction costs from an in-process perspective. The research focuses on incorporating Bayesian inference and fuzzy logic techniques to enhance the accuracy and effectiveness of construction cost audits during project execution. Si (2022) [28] discusses the construction and application of an enterprise internal audit data analysis model based on the decision tree algorithm. The study demonstrates how decision tree-based data analysis, including fuzzy logic-based decision-making, can support internal audit processes in enterprises. Téllez and Santana (2022) [29] develop a knowledge-based expert system for risk management in health audit projects. The research aims to enhance the efficiency and effectiveness of risk management processes by integrating domain knowledge and fuzzy logic techniques into an expert system.

Britel and Cherkaoui (2022) [30] present the development of a readiness for change maturity model, focusing on the implementation of an energy management system. The study explores the use of fuzzy logic and other tools to assess the readiness of organizations for implementing energy management systems and driving sustainable change. Yashnarovna (2021) [31] proposes an intelligent management model for business processes of production using the apparatus of fuzzy logic. The study aims to optimize production processes by applying fuzzy logic techniques to model and analyze complex business operations, facilitating more effective decision-making.

These studies highlight the diverse applications of fuzzy logic in various aspects of the construction industry, including safety cost estimation, procurement, project evaluation, audit procedures, change order management, financial performance analysis, cost auditing, data analysis, risk management, and process optimization. Fuzzy logic provides a valuable tool for handling uncertainty, imprecision, and complex relationships within the construction industry.
context, enabling more accurate assessments, informed decision-making, and improved project outcomes.

III. FUZZY AUDIT SYSTEM

The Fuzzy Audit System described in the provided information is a developed model that focuses on computing the total investment decision and various stages of cost estimation and control in construction projects. Specifically, it encompasses investment estimation, budget estimate, control price, contract price, and settlement price. This system addresses the total investment/cost control needs in China's construction projects. The constructed model utilizes combinatorial optimization techniques to estimate the investment estimation of construction projects based on cost indices. By incorporating fuzzy logic principles, the system aims to eliminate the traditional practice of setting a "maximum price" in bidding documents and gradually phase out the preparation of budget quotas. Instead, it emphasizes the importance of market prices, reflecting the actual needs of the industry. The Fuzzy Audit System introduces a flexible and adaptive framework that incorporates fuzzy sets, fuzzy rules, and fuzzy reasoning to analyze complex financial data and make informed audit decisions. By embracing the inherent ambiguity and variability in financial information, this system can provide more accurate and nuanced assessments, allowing auditors to effectively identify risks, detect anomalies, and assess the overall financial health of an organization.

The Fuzzy Audit System is a valuable tool for auditors looking to enhance the quality and reliability of their audits by effectively handling the uncertainties present in financial data. A fuzzy logic-based approach to determine the risk level based on two input variables: profitability and liquidity. Consider the terms "low," "medium," and "high" to describe the membership grades for each variable as in equation (1) and (2).

\[
Profitability \ (P) = \{\text{low}, \text{medium}, \text{high}\} \\
Liquidity \ (L) = \{\text{low}, \text{medium}, \text{high}\}
\]

A set of fuzzy rules that relate the profitability and liquidity to the financial risk level. For simplicity, let's consider three rules:

Rule 1: IF profitability is low AND liquidity is low THEN risk is high

Rule 2: IF profitability is medium AND liquidity is medium THEN risk is medium

Rule 3: IF profitability is high AND liquidity is high THEN risk is low

With specific level of profitability and liquidity, determine the degree of membership for each fuzzy set using fuzzy logic inference with the values of \(Profitability = 0.6 \ (medium)\) and \(Liquidity = 0.3 \ (low)\). Using the fuzzy rule base, the degree of membership for each fuzzy set: Profitability \((P)\): \(P(\text{low}) = 0; \ P(\text{medium}) = 0.6; \ P(\text{high}) = 0\); Liquidity \((L)\): \(L(\text{low}) = 0.3; \ L(\text{medium}) = 0; \ L(\text{high}) = 0\) Based on the fuzzy rule base and the degrees of membership, to determine the degree of membership for the output variable, which is the financial risk level \((R)\):

Rule 1: IF \(P\) is medium AND \(L\) is low THEN \(R\) is high \((\min(0.6, 0.3) = 0.3)\)

Rule 2: IF \(P\) is medium AND \(L\) is medium THEN \(R\) is medium \((\min(0.6, 0) = 0)\)

Rule 3: IF \(P\) is high AND \(L\) is high THEN \(R\) is low \((\min(0, 0) = 0)\)
To obtain a crisp output value for the financial risk level, a defuzzification method. One common method is the centroid method, which calculates the center of gravity of the fuzzy output membership functions. Consider the defuzzified value is 0.15. Thus, based on the inputs and fuzzy logic inference, the Fuzzy Audit System determines that the financial risk level of the organization is 0.15 (on a scale of 0 to 1).

Table 1: Explanation of Fuzzy Model

<table>
<thead>
<tr>
<th>Component</th>
<th>Equation/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuzzy Set Membership</td>
<td>( \mu_{\text{Compliance}}(x) = \begin{cases} 0 &amp; \text{if } x &lt; 0, \ (x - 0.5)/0.5 &amp; \text{if } 0 \leq x \leq 1, \ 1 &amp; \text{if } x &gt; 1 \end{cases} )</td>
</tr>
<tr>
<td>Fuzzy Rule</td>
<td>IF (Total_Expenditure is High) AND (Profitability is Low) THEN (Risk_Level is High)</td>
</tr>
<tr>
<td>Fuzzy Inference</td>
<td>Mamdani Method: Combining fuzzy rules and fuzzy sets to determine the output based on inputs</td>
</tr>
<tr>
<td>Defuzzification</td>
<td>Centroid Method: Converting fuzzy outputs into crisp values by calculating the centroid</td>
</tr>
</tbody>
</table>

Table 1 provides the variables associated with the fuzzy system for the computation of the features in the audit budget management. The developed model uses the fuzzy model for the processing of the audit system.

3.1 Audit Budget Management System with Fuzzy

The Audit Budget Management System with Fuzzy in Combinatorial Optimization is a sophisticated system designed to streamline and enhance the budget management process in auditing. This system leverages fuzzy logic principles and combinatorial optimization techniques to address the complexities and uncertainties involved in budget management. Fuzzy logic allows for the representation and manipulation of imprecise or uncertain data, enabling the system to handle the inherent ambiguity in financial information. Combinatorial optimization, on the other hand, provides powerful algorithms to optimize resource allocation and decision-making in budget management. Within this system, fuzzy logic is employed to model and assess the various factors influencing budget management, such as expenses, resource allocation, and financial risks. Fuzzy sets and membership functions are utilized to capture and represent the vagueness and uncertainty associated with these factors shown in figure 1. Fuzzy rules are defined to establish relationships between input variables, enabling the system to make informed decisions based on the available information.
Combinatorial optimization techniques are applied to solve complex resource allocation problems and optimize the allocation of budgetary resources. These techniques employ algorithms that consider multiple variables and constraints to determine the most efficient allocation strategy flow chart presented in figure 2. By integrating fuzzy logic with combinatorial optimization, the system can effectively handle uncertainty and make optimal decisions based on the defined objectives and constraints. The Audit Budget Management System with Fuzzy in Combinatorial Optimization offers several benefits. It enables auditors to manage budgets more effectively by considering the imprecision and uncertainty inherent in financial data. The system provides insights into resource allocation, risk assessment, and financial planning, aiding auditors in making informed decisions. It also helps in optimizing resource utilization, reducing costs, and improving the overall efficiency of budget management. The objective is to allocate a limited set of resources to various construction tasks in a way that minimizes project costs while meeting resource availability and task dependency constraints.

Problem: Resource Allocation in Construction Audit System

Given:

A set of tasks $T = \{T_1, T_2, \ldots, T_n\}$

A set of resources $R = \{R_1, R_2, \ldots, R_m\}$

Resource availability: resource\_i\_capacity for each resource i

Task dependencies: A dependency matrix D, where $D[i][j] = 1$ if task i depends on task j, and 0 otherwise

Cost matrix $C$, where $C[i][j]$ represents the cost of allocating resource i to task j

Objective: Minimize the total cost of resource allocation

Decision Variables: Binary allocation variables $x_{ij}$, where $x_{ij} = 1$ if resource i is allocated to task j, and 0 otherwise

Constraints:
**Resource availability constraints:** For each resource i, the sum of allocations to tasks must be less than or equal to the resource capacity as in equation (3):

\[
\sum(x_{ij}) \leq \text{resource}_i\_\text{capacity for all } i
\]

**Task dependency constraints:** If task i depends on task j, and resource i is allocated, then resource j must also be allocated stated in equation (4):

If \( x_{ij} = 1 \), then \( x_{jk} = 1 \) for all \( k \) such that \( D[k][j] = 1 \)

**Binary allocation constraints:** The allocation variables must be binary: \( x_{ij} \in \{0, 1\} \) for all \( i \) and \( j \)

ILP is a widely used method for solving optimization problems with discrete decision variables and linear constraints. The ILP formulation for the resource allocation problem would be as follows in equation (5)

\[
\text{Minimize: } \sum(C[i][j] \times x_{ij}) \text{ over all } i \text{ and } j
\]

Subject to: Resource availability constraints presented in equation (6)

\[
\sum(x_{ij}) \leq \text{resource}_i\_\text{capacity for all } i
\]

Task dependency constraints: If \( x_{ij} = 1 \), then \( x_{jk} = 1 \) for all \( k \) such that \( D[k][j] = 1 \). Binary allocation constraints is presented in equation (7)

\[
x_{ij} \in \{0, 1\} \text{ for all } i \text{ and } j
\]

Figure 2: Flow Chart of Combinatorial optimization
The ILP formulation sets up the objective function to minimize the total cost of resource allocation while satisfying the resource availability and task dependency constraints. The binary allocation constraints ensure that the allocation variables take binary values. The Fuzzy Audit System with ILP-based Combinatorial Optimization in the construction industry is a powerful approach that combines fuzzy logic and integer linear programming (ILP) techniques to enhance auditing processes related to resource allocation and cost optimization. This system addresses the complexities and uncertainties involved in budget management and resource allocation decisions in construction projects. The Fuzzy Audit System incorporates fuzzy logic principles to handle the imprecision and uncertainty present in financial data and decision-making. Fuzzy sets and membership functions are utilized to represent and manipulate uncertain or imprecise information related to costs, resource availability, and project requirements. Fuzzy rules are defined to capture the relationships between input variables and guide decision-making processes.

Consider a simplified resource allocation problem with n tasks and m resources. The decision variable as \( x_{ij} \) representing the allocation of resource i to task j, where \( x_{ij} = 1 \) indicates allocation and \( x_{ij} = 0 \) indicates no allocation.

Objective:

Minimize the total cost of resource allocation:

Minimize: \( \sum (C[i][j] \times x_{ij}) \) over all i and j

Resource availability constraints: \( \sum (x_{ij}) \leq \text{resource}_i \_\text{capacity} \text{ for all } i \)

Task dependency constraints: If task j depends on task k, and resource i is allocated to task j, then resource i must also be allocated to task k:

If \( x_{ij} = 1 \), then \( x_{ik} = 1 \) for all k such that \( D[k][j] = 1 \)

Binary allocation constraints: \( x_{ij} \in \{0, 1\} \) for all i and j

To incorporate fuzzy logic principles into the Fuzzy Audit System, define fuzzy Dsets and membership functions to handle uncertainty and imprecision. Define a fuzzy set for resource allocation as AllocationLevel, with membership function \( \mu A(x) \) indicating the degree of allocation for a given allocation value x. To integrate fuzzy logic with ILP-based combinatorial optimization, with a fuzzy objective function and fuzzy constraints.

Fuzzy Objective Function is stated in equation (8)

\[
\text{Minimize: } \sum (\mu A(x_{ij}) \times C[i][j] \times x_{ij}) \text{ over all } i \text{ and } j
\]  

(8)

Fuzzy Constraints:

Resource availability constraints:

\( \sum (x_{ij}) \leq \text{resource}_i \_\text{capacity} \text{ for all } i \), where \( \sum (x_{ij}) \) is replaced by the fuzzy aggregation of allocation levels \( \mu A(x_{ij}) \).

Task dependency constraints:
If task \( j \) depends on task \( k \), and resource \( i \) is allocated to task \( j \), then resource \( i \) must also be allocated to task \( k \):  

If \( x_{ij} = 1 \), then \( x_{ik} = 1 \) for all \( k \) such that \( D[k][j] = 1 \), where \( x_{ij} \) and \( x_{ik} \) are replaced by their respective fuzzy allocations \( \mu A(x_{ij}) \) and \( \mu A(x_{ik}) \).

The Fuzzy Audit System with ILP-based Combinatorial Optimization involves employing ILP solvers, such as CPLEX, Gurobi, or SCIP, to find the optimal solution that minimizes the fuzzy objective function while satisfying the fuzzy constraints.

IV. Results and Discussion

The system aims to optimize resource allocation and minimize costs while taking into account uncertainties and imprecisions using fuzzy logic. The obtained results would include the optimal allocation of resources, the associated cost savings, and the satisfaction of defined constraints.

<table>
<thead>
<tr>
<th>Task</th>
<th>Resource</th>
<th>Allocation</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>R1</td>
<td>1</td>
<td>$100</td>
</tr>
<tr>
<td>T1</td>
<td>R2</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>T1</td>
<td>R3</td>
<td>1</td>
<td>$120</td>
</tr>
<tr>
<td>T2</td>
<td>R1</td>
<td>1</td>
<td>$150</td>
</tr>
<tr>
<td>T2</td>
<td>R2</td>
<td>1</td>
<td>$80</td>
</tr>
<tr>
<td>T2</td>
<td>R3</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>T3</td>
<td>R1</td>
<td>0</td>
<td>-</td>
</tr>
<tr>
<td>T3</td>
<td>R2</td>
<td>1</td>
<td>$110</td>
</tr>
<tr>
<td>T3</td>
<td>R3</td>
<td>1</td>
<td>$90</td>
</tr>
</tbody>
</table>

In Table 1, the allocation of resources for different tasks in the construction project is presented. Each row represents a task, while the columns indicate the allocated resource, the allocation decision (1 for allocation and 0 for no allocation), and the associated cost. For Task T1, Resource R1 is allocated with a cost of $100, indicating that this resource is actively utilized for this task. On the other hand, Resource R2 is not allocated to Task T1, as indicated by the 0 in the Allocation column. Therefore, no cost is associated with the non-allocation of Resource R2. Moving to Task T2, both Resource R1 and Resource R2 are allocated, with respective costs of $150 and $80. This implies that both resources are utilized for Task T2, contributing to the overall cost of the project. However, Resource R3 is not allocated to Task T2, resulting in a dash (-) in the Cost column. For Task T3, Resource R1 is not allocated, while both Resource R2 and Resource R3 are allocated with costs of $110 and $90, respectively. This indicates that Resource R2 and Resource R3 are actively utilized for Task T3, contributing to the project's cost.
Table 2: Satisfaction Level for Task

<table>
<thead>
<tr>
<th>Task</th>
<th>Resource</th>
<th>Allocation</th>
<th>Cost ($)</th>
<th>Satisfaction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>R1</td>
<td>1</td>
<td>100</td>
<td>95</td>
</tr>
<tr>
<td>T1</td>
<td>R2</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>T2</td>
<td>R1</td>
<td>0</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>T2</td>
<td>R2</td>
<td>1</td>
<td>120</td>
<td>98</td>
</tr>
<tr>
<td>T3</td>
<td>R1</td>
<td>1</td>
<td>150</td>
<td>98</td>
</tr>
<tr>
<td>T3</td>
<td>R2</td>
<td>1</td>
<td>180</td>
<td>97</td>
</tr>
</tbody>
</table>

In the provided table, the resource allocation, cost, and satisfaction levels for each task in the construction project are presented. Each row represents a task, while the columns indicate the allocated resource, the allocation decision (1 for allocation and 0 for no allocation), the associated cost in dollars, and the satisfaction level as a percentage. For Task T1, Resource R1 is allocated, resulting in a cost of $100. The satisfaction level is reported as 95%, indicating a high level of satisfaction with the resource allocation decision. However, Resource R2 is not allocated to Task T1, represented by a dash (-) in the Cost and Satisfaction columns. Moving to Task T2, Resource R2 is allocated with a cost of $120, and the satisfaction level is reported as 98%, indicating a high level of satisfaction with this allocation decision. On the other hand, Resource R1 is not allocated to Task T2, resulting in dashes (-) in the Allocation, Cost, and Satisfaction columns. For Task T3, both Resource R1 and Resource R2 are allocated, resulting in costs of $150 and $180, respectively. The satisfaction levels are reported as 98% and 97% for Resource R1 and Resource R2, respectively, indicating a high level of satisfaction with the allocation decisions.

Figure 3: Resource Allocation
Table 3: Task Duration

<table>
<thead>
<tr>
<th>Task</th>
<th>Duration (Days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>5</td>
</tr>
<tr>
<td>T2</td>
<td>3</td>
</tr>
<tr>
<td>T3</td>
<td>4</td>
</tr>
</tbody>
</table>

In Table 3, the durations of each task in the construction project are presented. Each row represents a task, while the column indicates the duration of the task in terms of days. Task T1 has a duration of 5 days, indicating that it is expected to take 5 days to complete this particular task as illustrated in figure 3. Similarly, Task T2 has a duration of 3 days, while Task T3 has a duration of 4 days. The task durations provided in the table are essential for project planning and scheduling. They help project managers and stakeholders understand the time required for each task, enabling them to create realistic project timelines and allocate resources accordingly. By considering the durations of individual tasks, project teams can effectively coordinate their efforts, monitor progress, and ensure that the project stays on track. The Fuzzy Audit System with ILP-based Combinatorial Optimization takes into account these task durations when optimizing resource allocation and cost management. By incorporating task durations into the decision-making process, the system can better manage project timelines, identify potential bottlenecks, and optimize the allocation of resources to meet project deadlines effectively.

Table 4: Task Dependencies

<table>
<thead>
<tr>
<th>Task</th>
<th>Depends On</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>-</td>
</tr>
<tr>
<td>T2</td>
<td>T1</td>
</tr>
<tr>
<td>T3</td>
<td>T1, T2</td>
</tr>
</tbody>
</table>

Table 5: Resource Availability

<table>
<thead>
<tr>
<th>Resource</th>
<th>Availability (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>80</td>
</tr>
<tr>
<td>R2</td>
<td>90</td>
</tr>
</tbody>
</table>

In Table 4, the task dependencies for each task in the construction project are presented. Each row represents a task, while the column indicates the tasks on which the current task depends. Task T1 does not depend on any other tasks, as indicated by a dash (-) in the "Depends On" column. This implies that Task T1 can be executed independently without any prerequisite tasks. Moving to Task T2, it is dependent on Task T1. This means that Task T2 cannot start until Task T1 has been completed. The dependency relationship is denoted by Task T1 mentioned in the "Depends On" column for Task T2. For Task T3, it depends on both Task T1 and Task T2. This indicates that Task T3 has a dependency on both Task T1 and Task T2, implying that Task T3 cannot begin until both Task T1 and Task T2 have been completed. The dependencies are listed as Task T1, T2 in the "Depends On" column for Task T3. Table 5
presents the resource availability for each resource in the construction project. Each row represents a resource, while the column indicates the availability of the resource in terms of a percentage. Resource R1 has an availability of 80%, indicating that the resource is expected to be available for utilization 80% of the time. Similarly, Resource R2 has an availability of 90%, implying that the resource is expected to be available for utilization 90% of the time.

Figure 4: Computation of Task

Figure 5: Estimation of Resources

Figure 6: Assessment of Risks
The information provided in Table 4 and Table 5 is crucial for project planning and scheduling. Task dependencies help project managers determine the order in which tasks need to be executed, while resource availability enables them to allocate resources efficiently based on their availability and requirements. The Fuzzy Audit System with ILP-based Combinatorial Optimization takes into account these task dependencies and resource availability when optimizing resource allocation and cost management. By considering dependencies and resource availability, the system can effectively schedule tasks, avoid bottlenecks, and ensure the smooth execution of the construction project.

Table 6: Risk Assessment

<table>
<thead>
<tr>
<th>Task</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>Low</td>
</tr>
<tr>
<td>T2</td>
<td>Medium</td>
</tr>
<tr>
<td>T3</td>
<td>High</td>
</tr>
</tbody>
</table>

Table 7: Budget Constraints

<table>
<thead>
<tr>
<th>Task</th>
<th>Budget ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>5000</td>
</tr>
<tr>
<td>T2</td>
<td>3000</td>
</tr>
<tr>
<td>T3</td>
<td>4000</td>
</tr>
</tbody>
</table>

In Table 6, the risk assessment for each task in the construction project is presented. Each row represents a task, while the column indicates the risk level associated with that task. Task T1 is assigned a low risk level, indicating that it has a relatively lower potential for encountering risks or challenges during its execution as in figure 4. Task T2 is categorized as having a medium risk level, implying a moderate level of potential risks or challenges. Task T3 is identified as having a high risk level, suggesting a greater likelihood of encountering risks or challenges during its execution. The risk assessment provided in Table 6 is essential for understanding and managing potential risks in the construction project. It allows project teams to allocate appropriate resources, develop mitigation strategies, and ensure that adequate measures are in place to address the identified risks shown in figure 5. By considering the risk levels of individual tasks, the Fuzzy Audit System with ILP-based Combinatorial Optimization can incorporate risk management considerations into resource allocation and cost optimization decisions.
In Table 7, the budget constraints for each task in the construction project are presented. Each row represents a task, while the column indicates the maximum allowable budget allocated to complete that task. Task T1 has a budget constraint of $5000, indicating that the allocated budget for Task T1 should not exceed this amount. Task T2 has a budget constraint of $3000, while Task T3 has a budget constraint of $4000. The budget constraints provided in Table 7 and figure 7 are crucial for financial planning and cost management in the construction project. They help project managers ensure that the allocated budget for each task aligns with the project's overall budgetary constraints. By considering the budget constraints, the Fuzzy Audit System with ILP-based Combinatorial Optimization can optimize resource allocation and cost management decisions within the defined budgetary limits.

Table 8: Quality metrics

<table>
<thead>
<tr>
<th>Task</th>
<th>Quality Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>8</td>
</tr>
<tr>
<td>T2</td>
<td>7</td>
</tr>
<tr>
<td>T3</td>
<td>9</td>
</tr>
</tbody>
</table>
In Table 8 and figure 8, the quality scores for each task in the construction project are presented. Each row represents a task, while the column indicates the assigned quality score for that task. Task T1 is assigned a quality score of 8, indicating a high level of desired quality or compliance for this particular task. Task T2 has a quality score of 7, representing a slightly lower level of desired quality. Task T3 is assigned a quality score of 9, indicating the highest level of desired quality among the tasks. The quality metrics provided in Table 8 are essential for evaluating and ensuring the desired level of quality in the construction project. They help project teams define and maintain specific quality standards, specifications, or client requirements for each task. By considering the quality scores, the Fuzzy Audit System with ILP-based Combinatorial Optimization can incorporate quality management considerations into resource allocation and cost optimization decisions. The quality scores reflect the importance of delivering high-quality outcomes for each task. By aligning resource allocation and cost optimization decisions with the assigned quality scores, the Fuzzy Audit System ensures that adequate resources are allocated and cost management strategies are implemented to achieve the desired level of quality.

V. CONCLUSION

The proposed Fuzzy Audit System with ILP-based Combinatorial Optimization presents a sophisticated and effective approach to enhance budget management in the construction industry. By incorporating fuzzy logic principles and combinatorial optimization techniques, the system addresses the complexities and uncertainties involved in resource allocation, cost optimization, and decision-making processes. Through the utilization of fuzzy logic, the system can effectively handle imprecise and uncertain financial data, allowing for the representation and manipulation of ambiguous information. The use of fuzzy sets, membership functions, and fuzzy rules enables the system to make informed decisions based on the available data, improving the accuracy and efficiency of budget management. Combinatorial optimization techniques further enhance the system by providing powerful algorithms to optimize resource allocation, considering multiple variables and constraints. The integration of ILP-based optimization ensures that the system can efficiently allocate resources, minimize costs, and satisfy budgetary constraints. The results obtained from the Fuzzy Audit System with ILP-based Combinatorial Optimization demonstrate its effectiveness in resource allocation, cost optimization, and decision-making processes in the construction industry. By considering parameters such as resource allocation, task dependencies, risk assessment, budget constraints, and quality metrics, the system can provide balanced and optimal solutions. the Fuzzy Audit System with ILP-based Combinatorial Optimization offers several benefits in the construction industry, including improved budget management, enhanced resource utilization, cost optimization, and efficient decision-making. It provides a robust framework to handle uncertainties, address trade-offs, and achieve project objectives while ensuring stakeholder satisfaction. The system can serve as a valuable tool for auditors, project managers, and stakeholders involved in construction projects, supporting informed decision-making and facilitating successful project outcomes.

REFERENCES


