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Abstract: Planned methods may be developed to improve the efficiency of building construction. The construction business is profoundly impacted by the prevalence of inaccurate cost and schedule prediction. The main strategy to improve the project performance is to evaluate the hybrid sustainable materials using the artificial neural network (ANN) method based on the effective factors in construction projects in Iraq. This strategy needs an effective method to classify the project input representation and specify the accurate activity of each factor. This paper uses a hybrid artificial neural network to correlate and classify the sustainable hybrid of construction projects to evaluate their performance. The contribution of this method is the selection of the Multi-Criteria Decision-Maker method (MCDM) based on time and cost-effective factors correlated with the artificial neural network method. A dynamic selection procedure for project materials may be created using the existing technique as an evolutionary model for successful project completion. The MCDM observed that the appropriate sustainable material was considered as the main factor with a rank of 0.823 for cost effect and 0.735 for time effect and the main influence factor in Iraqi projects was the building height. The results present superior functional cost evaluation results correlated with the selection of hybrid sustainable materials.

1   Introduction

Effective project management ensures that both the needs of the client and the business are satisfied. A successful project accomplishes its goals while staying within its allotted budget and with minimal scope creep. The development of an appropriate model and methodology for cost estimating in construction projects is vital to the success of a project. Users who undertake their own cost estimating may find it difficult to put the results of current studies into reality due to the increased complexity of the cost estimation process [1]. Effective cost management is still the best approach to boosting construction sector efficiency and decreasing the number of abandoned projects and unhappy clients. However, there is still a challenge in determining the best approach to cost control. To rephrase, several elements contribute to the time and money needed for construction projects. The capacity to properly manage costs goes beyond simply keeping track of spending and producing cost reports. The ability to build with nearly flawless digital information and shifts in how businesses are conducted is driving a reaction to the construction industry's various cost control concerns [2]. The Theory of Industrial Evolution simplifies the process of making great decisions by highlighting the significance of four key factors: "Accuracy, Timeliness, Cost, and Completeness". In light of this, the construction sector is currently creating misleading and superfluous data [3]. Yet, the project's finances will decide its major turning points. In the absence of a predetermined budget, it is difficult to determine whether or not the project is making satisfactory progress.

It is possible to estimate the quantity of certain needed components from the blueprints. Even if you have a good strategy in place, you do not need to rely on prior experience to make quantity estimates, provided the ultimate aim or job description is clear. An accurate estimate can only be obtained via the use of all-inclusive price estimating approaches, which in turn need more in-depth instructions and a substantial amount of work [4,5]. Due to the need of accuracy in managing costs, estimation is not always easy. A project manager's timeline has to take into account inflation, interest rates, fixed and variable costs, and overhead [6]. Parametric modelling and program assessment and review are two examples of the more mathematical methods used by certain academic institutions (PERT). You may either use a top-down or a bottom-up strategy. If you have access to price data from the past, the top-down method will work well for you. Decisions are best made by project managers who have worked on many comparable projects. For projects when there is a dearth of prior information, an organization may benefit from bottom-up techniques [7,8]. These approaches use task-specific cost estimates before aggregating them at the project level. Earned Value Management (EVM) is a cost-control method used in the field of project management. It offers an impartial assessment of the state of a project by combining the factors of time, money, and scope [9,10]. Specifications for a project are very in-depth descriptions of the project's tangible parameters.

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Everything from the overall square footage of a structure to its floorplate size, height, interior and external design, floor loadings, heating and lighting requirements, etc., is based on the building's intended use and anticipated occupancy rate. The total amount of money that will be spent on the structure may be divided into five groups: [11].

The specification describes in great detail the tangible features of the project. The quantity of paving material, the number of lanes, the number of bridges, and other elements are all taken into consideration while designing a road. In this regard, it might be useful to have a deeper understanding of the different materials used in the construction of buildings, homes, and other systems. Careful preparation is needed for the last stage of a building's life cycle, which is the processing of its materials. In the planning and creation of any building, the use of composites that are too difficult to deal with should be minimized as much as feasible [12]. Products that may be made from recycled materials without the need for any processing processes in between. Even though they are useless in their present condition, they can still be broken down into usable parts. To avoid downcycling and waste, they should be recycled without degradation in quality. Manufacturers should do more in terms of system integration, prefabrication, and even ongoing responsibility for the performance of their systems, some sources claim, because it is unrealistic to expect tradespeople to understand and properly install the numerous interconnected systems that make up larger commercial buildings [13].

A large toolbox and an array of methods are at the disposal of those in the building industry. In addition to the time spent working and the task itself, the output accomplished and productivity at the site may be determined via equipment and productivity control. As the overall cost of the project remains unaffected, the primary goal of control is to remove waste in usage. Twenty-five percent of Ugandans live in inadequate housing, but this number might be eliminated if the cost of building homes is reduced by 30 percent via industrialization [14].

Initial price estimates might be affected by factors such as a site's soil and drainage characteristics and access limits. Because of the poor ground conditions, extra manpower is required for excavation, piling, and foundational construction. Damage and breakage during handling, deterioration due to inadequate storage and poorly managed storage conditions, and short shelf life are all potential causes of product waste in storage [15]. Mismanagement, shoddy accounting, and an inability to account for all firm cash all contribute, as does the supervisor's cavalier attitude. Storage on the building site for an extended period of time accelerates the degradation. Requesting, ordering, receiving, inspecting, unloading, handling, storing, and distributing items are the phases when most material is lost [16].

In order to achieve sustainable development, it is necessary to carefully consider environmental implications throughout the design and execution of building projects. There has not been a lot of research into finding a happy medium between time, money, and ecological impact. Decision-making procedures have not been employed in project scheduling issues, despite the fact that using them is necessary when choosing an execution method for a project activity. In most cases, the length of time it takes to finish a project increases in proportion to the size of its budget. The schedule for completing a project depends heavily on the details of that project's design. As a rule of thumb, the time needed to complete a project is directly related to the scope of the task at hand. But this isn't always the case, and in many situations, if substantial additional resources are used, the project's implementation timeline can be accelerated [17].

Price inflation must be taken into account, and the longer it takes to complete construction, the more that inflation must be taken into account. When dealing with matters involving a government agency's financial projections, this is of the highest significance. For a project's final price tag to be accurate before construction starts, all expected expenditures must be accounted for [18].

Sixty percent or more of a building project's cost may be attributable to labour. Workers' contributions to a project's success may be split into "direct" and "indirect" categories. We compare the labour costs of major cities throughout the country. Compiling a list of pricing trends in chosen parts of the nation is necessary for the establishment of cities with economic conditions superior than the capital region [19]. There are flaws in the plans as well as the actual building. The lack of a quality control system and the use of untrained workers are to blame for the building defects. Corrosion and breaks in the reinforcing bars and uneven concrete settling are common problems with older constructions. Repairing and replacing damaged parts of a building is also more costly [20]. Factors affecting preliminary construction cost estimates were identified via a literature review [21]. To effectively manage a large project's budget—which might run into the hundreds of crores or millions of dollars—it is common to use state-of-the-art tools and techniques. Construction management's notoriously high resource requirements are a major roadblock to efficient resource allocation. The amount, quality, price, and availability of imported materials are all important considerations. There is a lack of data that analytically links particle shape and size as they pertain to gradation and the mechanical performance of materials. Substantial, and in some cases catastrophic, effects on the economy result from all of these causes [22].

Therefore, the evaluation of hybrid sustainable materials using artificial neural networks based on successful elements in Iraqi building projects is the primary way to enhance project performance. The project's input representation must be classified in an efficient manner,

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and each factor's precise activity must be specified. In order to correlate and categorize the sustainable hybrid of building projects in this article, and to assess their performance, a hybrid artificial neural network is organized. This technique adds value by choosing the Multi-Criteria Decision Maker method based on variables that are both time and cost-efficient and are associated with the artificial neural network method. In order to provide a dynamic selection process for projects, the present approach is employed as an evolutionary project success model.

2   Methodology

The planned budget is the basis for all financial projections and assessments of the project's performance. The anticipated cost, however, must be evaluated to see whether it can be used to make a fair assessment of the project. This study's results provide an innovative approach to employing artificial neural networks to track the total cost of a project and its construction when hybrid sustainable materials are used (ANN). The approach, in this perspective, was created for the express purpose of monitoring the time and money invested in a certain project. The existing plan will keep tabs on the alterations made to the project for the different kinds of work being done. In order to put the ANN system to the test, we utilized the real building's walls as a test subject. In this investigation, we used a control mechanism to create budget deviations over time based on actual expenditures. The time and effort required to keep tabs on project costs as they are incurred will be reduced by using this technique. Actual expenses were compared to the budgeted targets on a regular basis. Goals may be established on a weekly, monthly, or yearly basis, depending on the scope of the project.

2.1 Artificial neural network technique behaviour

An ANN uses a multilayer perceptron application to find meaningful patterns in data rather than more standard statistical approaches like linear regression or bivariate correlation. Multilayer perceptron neurons are made to resemble their biological counterparts [23]. Because of its superior ability to capture both high levels of construction uncertainty and better accuracy, ANN is widely used in the industry. The ANN is maturing into a problem-solving modeller in the building industry. The construction sector has found success in using ANN to problems like as cost prediction, safety, productivity, and risk assessment. While an overview of this application is given, the specifics of how ANN may be used to the building sector are glossed over. Thereafter, the construction industry's future with ANNs is discussed in further detail. This article compares and contrasts ANN estimation and prediction, explores the robustness of ANN models, and considers whether or not they may be combined in a single framework [24]. The 'hardlim' transfer function is used in the perceptron neuron shown below. The sum of the weights assigned to each

external input (w1j) is then sent along to the hard-limit transfer function, which also gets an input of 1 from the bias. For illustration, consider the following example of a transfer function with a hard limit that only ever returns 0 or 1. Every perceptron neuron outputs a 1 if the net input into the transfer function is larger than zero and a 0 otherwise. In order for a perceptron to categorize input vectors, the hard-limit transfer function partitions the input space into two regions. If the net input n is less than zero, the output is zero, and if it is more than zero, the output is one [25].
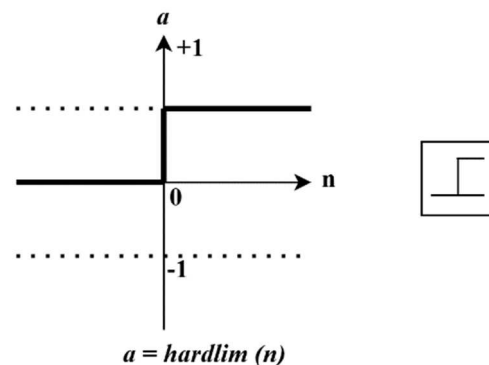
$$a = hardlim(n)$$

Hard-Limit Transfer Function

Figure 1 ANN transfer function

Figure 1 depicts the input space of a two-input hard-limit neuron with weights $w1,1 = 1$, $w1,2 = 1$, and a bias $b = 1$. Classification space is cut in half by the decision boundary line L at $Wp + b = 0$. The bias b rotates this line such that it runs perpendicular to the weight matrix W. The hard-limit neuron will generate a 1 as an output if its input vector is located above and to the left of line L. When input vectors are below and to the right of the line L, the neuron produces a zero. The input space may be classified in a number of ways depending on the values of weight and bias you give it. Unbiased categorization lines will always begin at the point of genesis of hard-limit neurons. By including a bias, the neuron may handle input vector pairs that are not perpendicular to the origin. The accompanying diagram shows how this bias makes it possible to move the decision boundary further from the starting point. The nnd4db sample application may be run. You may change the position of a decision boundary, choose a different set of inputs to classify, and watch as the network learns to accurately categorize those inputs over and over again.

2.2 Many criteria decision making

By breaking down a complex problem into a multi-level hierarchical structure of objectives, criteria, sub-criteria, and alternatives, MCDM help to define the overall choice operation. Using this framework, a good next step can be chosen. Complex, unstructured, and multi-faceted judgments are perfect candidates for MCDM's application. These standards do not describe a linear set of options; rather, they take into account both physiological and

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psychological factors. The subjective assessment of the decision maker may be factored in and quantified using the Many Criteria Decision Making) framework [26]. The MCDM may be built with the help of the following three easy steps:

1) Determine the criteria weights by computing a vector.

2) Compiling a matrix of all conceivable score configurations.

3) Arrange the options in ascending order.

Every step henceforth will be elaborated upon for greater clarity. It's likely that the evaluation criteria will be looked at, and that n options will be graded. As an added bonus, a realistic approach to figuring out whether the findings can be believed will be covered. Simple steps for data collection are outlined for the user, who then inputs that information into the program to get the desired outcomes [27].

Step 1: Define Potential Solutions.
Step 2: To specify the parameters of the issue.
Step 3: Rank the criteria in terms of importance.
Step 4: Find out how the weights compare to one another.

The software tool will use the data to execute the mathematical calculation and give weights to the criteria depending on the data. A person may evaluate their alternatives and choose the one that best fits their needs once the appropriate weighted criteria have been entered into the appropriate places in the equation. [28]. Elewe et al [29] and Abdullah et al [30] presented a new algorithm to apply in solving the complex problems, they used Firefly algorithm and developed this algorithm with using a scanning method. Talib et al [31], Ali et al [32] and bin Hasnan et al [33] used MC-GPSO algorithm to develop a method to solve large scale problems. A very small portion of the overall cost to build a family home out of wood is attributable to transportation [34]. The authors evaluated that legal standards affect the logistics of businesses in order to promote long-term sustainability [35].

3   Result and discussion

3.1   Many criteria decision making effective factors results

The construction industry has a poor track record of effectively predicting costs because key elements that affect costs are often disregarded or underestimated. To back up his claims, the author performed research on the Iraqi construction industry and found that the most influential factors include: Successful construction businesses are built on a solid foundation of reliable cost accounting. From Table 1, it was observed that the most influential factor in building time and cost was building heights. In addition, Table 2 exhibits that the used sustainable materials are not appropriate for the project design. The MCDM value varies between 0.823 and 0.735 for cost and time, respectively. As it was seen in Table 2, the geotechnical evaluation of the subsoil at the project site is necessary in order to supply useful input data for the design and construction of foundations for the planned buildings. Recording and collecting data on the project's costs and progress toward completion are crucial to cost management. Figure 2 exhibits the cost vs the number of floor data which also help the construction stakeholders to manage their budget for the project. The system provides an equation to exhibit the cost growth, which helps predict the project's overall cost with a single equation. Furthermore, it necessitates evaluating actual development against projected outcomes. Profit maximization within the allocated time limit while keeping the quality of the work to an acceptable level is the major goal of cost control for any given project.

Table 1 The influencing factors for this research

Influence factors on building cost and time	MCDM	MCDM
Number of floors in the building	0.60	0.65
Type of used walls material	0.63	0.64
Type of slabs	0.65	0.63
Walls materials quantities	0.59	0.57
Slabs materials quantities	0.58	0.55
Project area	0.65	0.66
Building height	**0.70**	**0.70**
Type of external plastering and warping	0.66	0.68
Type of tilling	0.63	0.68
Site position	0.68	0.54
Sites risks	0.66	0.57

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Table 2 The management of sustainable materials

| No	Factors	MCDM of cost	MCDM of time
F1	The used sustainable materials are available near the site	0.719	0.688
F2	**The used sustainable materials are not appropriate for the project design**	**0.823**	**0.735**
F3	The inventory in the work site is not suitable for used materials in the project	0.754	0.707
F4	The used sustainable materials cannot be cheated or replaced	0.723	0.642
F5	The contractor can efficiently deal with the required materials	0.763	0.676
F6	Often the contract is obligated to pay directly	0.792	0.722
F7	The payment is often obligated to purchase	0.775	0.664
F8	The works must be continues as planned for the event of non-payment	0.735	0.638
F9	Purchases are obligated to provide materials with the project even if delay in wage	0.806	0.726
F10	Failure to make payments does not affect the supply of raw materials	0.794	0.657
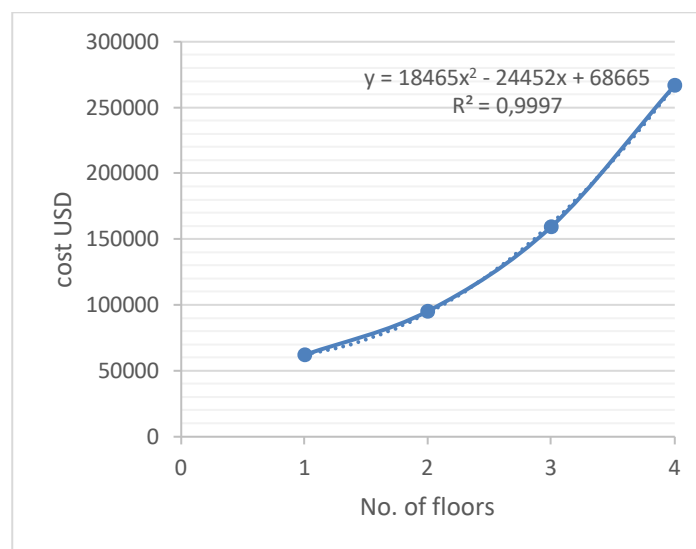
Figure 2 The cost growth in building construction

$$y = 18465x^2 - 24452x + 68665$$
$$R^2 = 0,9997$$

3.2 Artificial neural networks - ANN model results

A computer model that mimics the functions of human brain cells, an artificial neuron network (neural network). "Artificial neural networks" refer to computer systems that use "learning algorithms," or programs that can autonomously make modifications, or "learn," when given with new information (ANNs). This idea was crucial in providing the researcher with the information and computations needed for efficient management of both time and money. In order to achieve the same or comparable effects when applied to artificial intelligence, neural networks, a subset of computer architecture, pulls lessons from the functioning of organic nerve systems. The neural network may be thought of as a mathematical function that takes in a series of inputs and returns a series of outputs that the user specifies. Artificial neural networks' models are consistent with those of biological neural networks. They have an exposed exterior layer, one or more concealed layers, and a concealed interior layer. Input data There is no information unique to the system that can be gathered from the transfer functions. Although they were originally designed for use with a certain kind of connection, they may be modified to work with any link type. The stacked neural network model used in the proposed prediction approach is trained and evaluated using three separate ANN models. The first version of the ANN model for structural analysis takes in four inputs and outputs two. Second, there must be a total of five inputs to the wall but only two outputs. The third model, which we'll call the foundation model, has two outputs and six inputs. Keep in mind that first-generation neural network-based price estimation algorithms suffered from a number of serious drawbacks. optimized performance with three different types of networks.

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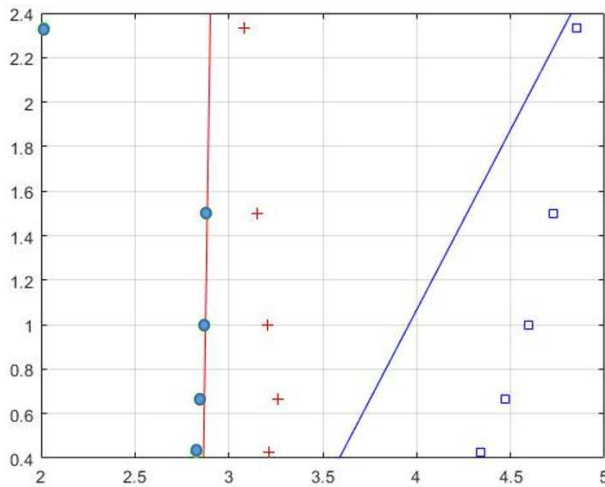Halah Waleed Albasri, Sepanta Naimi

Figure 3 The ANN classification results

The current system was designed, built, and put into place to capture all data required for each project. A sample set of real-world inputs is collected from the data's rightful owner and organized for use as a model. The purpose of this stage is to assess the program's infrastructure and decide whether or not it can support a reliable method of data monitoring. Materials chosen for construction will be heavily influenced by the building code, which specifies the required levels of durability for various building components.

$$y = x^2 - 1.32x + 3.72 \qquad (1)$$

If the right materials are used during construction, the building's functionality will improve. A three-story skyscraper in Baghdad, Iraq, was under dispute. We are concentrating our efforts on figuring out what happened to the old structure.

Table 3 The building cost results using the developed function

No of floors	Area	Cost USD
1	100	34,000
1	150	64,600
1	200	75,140
1	300	107,780
2	100	50,800
2	150	96,520
2	200	112,268
2	300	161,036
3	100	87,600
3	150	166,440
3	200	193,596
3	300	277,692
4	100	144,400
4	150	274,360
4	200	319,124
4	300	457,748

Cost model testing, as was previously said, is to determine whether the finalized model is effective and if the targeted degree of generality was achieved. By iterative development influenced by earlier advice, the ideal model was developed to provide more accurate cost projections with no loss of accuracy.

Table 4 The ANN hybrid material selection for sustainable building construction

No of floors	area	cost USD	ANN material results
1	100	34,000	BLOCK_THRMI STON
1	150	64,600	BRICK_BLOCK
1	200	75,140	BRICK_BLOCK
1	300	107,780	BRICK_BLOCK

By taking this approach, the model was able to generate more accurate cost projections without compromising accuracy. Better cost estimates could be made using this strategy. The results of the system's calculations are provided in the Tables 3 and Table 4 and the Figure 3, depending on the preexisting framework.

5 Conclusion

This research aimed to give a novel cost estimation method and selection of sustainable building projects in Iraq by developing a model employing sustainable materials. The main objectives of the present research are starting with finding the effective factor in building cost and time. The MCDM presented using appropriate sustainable materials for the project design as the main factor with a rank of 0.823 for cost effect and 0.735 for time effect. The second step is to investigate the main influence factor in Iraqi projects and the MCDM observed the building height as the main effective influence factor in the present work. Based on the presented results, the ANN trained to specify the suitable hybrid materials that can be used as suitable sustainable materials. the following steps and procedures were taken:

a) A questionnaire survey, expert interviews, and an exploratory review of existing research were used to ascertain the cost-effective components of building projects. Most Common Differential Mean and the Mean for the Most Important Factors.

b) There were a number of stages involved in creating an ANN model, the first of which was deciding on the program that would be used to construct the model. The flexibility of Microsoft Excel was a major factor in our decision to adopt it as our main cost estimating tool, along with its user-friendliness and capacity to extract data. Initially, the data sets were encoded before being analyzed.

c) It is possible that the ANN method may provide accurate cost estimates for projects.

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