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Optimization of Quantitative and Qualitative Indicators of Construction Projects with a Project Management Knowledge Approach (Case study: Qucham Reservoir Dam)

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ABSTRACT: In recent years, the complexity of project implementation, competitive business environment, and limited resources of organizations have shown the need to pay attention to project management in achieving project goals. Therefore, in the implementation process, employers seek to increase quality, reduce execution time, costs, and risk, which are their main goals. In this research, optimization between the components of the survival pyramid including time, cost, quality, and risk in construction projects are done on a case-by-case basis on the Qucham reservoir dam. For this purpose, six Metahioristic optimization algorithms are used, which are three classical algorithms (genetics, Tabu search, and simulated annealing) and three new algorithms (butterfly, cyclical parthenogenesis, and harris hawk). In four cases, each component of the survival pyramid is optimized separately, and finally, all four cases are examined simultaneously. Coding related to objective functions and optimization algorithms has been done in MATLAB software. The results indicate the proper performance of the genetic algorithm. Also, in optimizing the quality index, only the genetic algorithm has given the best optimal answer, and in the combined optimization, considering all the indicators simultaneously, the genetic algorithms and the Harris hawk have given the best solution.

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1- Introduction

Optimization means balancing time, cost, quality, and risk to create the best level of satisfaction for customers and end-users and to obtain the most optimal level of value for each organization. Reducing risk, cost, and execution time as well as increasing its quality are different goals of managers that do not align with each other, and management accountants must help production engineers solve the problem of time, cost, risk, and quality balance in investment plans and construction projects. In recent years, the complexity of project implementation, competitive business environment, and limited resources of organizations highlighted the need to pay attention to project management in achieving project goals. Therefore, with the advancement of science, the existence of meta-heuristic optimization algorithms to present new models in line with this goal is fruitful. Various researches have been done on optimization between time and price or time, cost, and quality. Abdullahi and Khozin used a genetic algorithm to optimize the components of the survival pyramid including time, quality, and risk in construction projects and investment projects, to balance time, cost, quality, and risk [1]. Hisham et al. attempted to optimize time and cost through learning curve analysis of all personnel and their number and to estimate project duration, optimizing project time and cost, the effect of optimal personnel training, and the effect of activities on another [2]. Most of the researchers have used one or at most two methods to investigate the optimization problem. But the innovative aspect of this paper is that six metaheuristic optimization algorithms have been used in this regard, and this leads to a kind of ranking and comparison of how it works between classic and modern algorithms, which is also the main goal of the present study as optimization.

2- Methodology

In this section, cost, time, risk, and quality optimization are performed in water projects with a case study on the Qucham reservoir dam located in Kurdistan province. For this purpose, six metaheuristic optimization algorithms have been used, which are three classical algorithms (genetic algorithm (GA), Tabu search (TS) and simulated annealing (SA)) and three new algorithms (butterfly optimization algorithm (BOA), cyclic parthenogenesis algorithm (CPA) and harris hawks optimization (HHO)). In four cases, each component of the survival pyramid is optimized separately, and finally, all four cases are examined simultaneously. Coding related to objective functions and optimization algorithms in MATLAB software has been done using pseudocodes of each algorithm. Preliminary data were extracted from the final status of the construction of the Qucham dam and then, Table 1 was prepared, which shows 1 of the 23 chapters used as an example. This table is the

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Table 1. Technical data related to Qucham dam.

Technical data of the sample (Qucham Reservoir Dam) - Dam construction price list														
Risk	Final Quality	Quality Indicator 3		Quality Indicator 2		Quality Indicator 1		Price of each Implemetaion	Implementation Time	Implementation Choice	Effect Percentage	Total Price (Rials)	Activity Description	No
		Implementation Choice	Effect Percentage	Implementation Choice	Effect Percentage	Implementation Choice	Effect Percentage							
0.45	98.4	98	0.2	96	0.3	100	0.5	413,230,765,915	14	1	78.775	531,296,699,033	فصل اول	1
0.3	82.9	84	0.2	77	0.3	86	0.5	472,263,732,474	16	2				
0.25	62.5	65	0.2	60	0.3	63	0.5	708,395,598,711	24	3				

basis of the present research. In completing this table, the experiences of various elite people and experts in this field have been used. According to this table, all the chapters of the price list related to the construction of the Qucham dam are divided into 3 modes of execution times (which include execution in minimum, maximum and average time) based on the opinions of elites and experts in this field. Also, each chapter is randomly written in 3 types of quality indicators with different percentages, and the final quality in each line is obtained from the total percentage of the effects of those 3 quality cases and also for each chapter, the risk percentages are randomly selected based on the opinions of elite and experts in this field.

3- Results and Discussion

3- 1- Optimization Problem Formulation

In this research, five different modes were implemented on the problem. For this purpose, each of the time, cost, quality, and risk factors were optimized in four modes separately. Finally, all four factors were considered simultaneously. The value of the objective function in each case is calculated as follows:

First mode: time optimization (T), second mode: cost optimization (C), third mode: quality optimization (Q), fourth mode: risk optimization (R), and fifth mode: optimization of time, cost, quality, and risk simultaneously. In this mode, Eq. (1) is used to calculate the objective function:

$$F(x) = \frac{T - T_{min}}{T_{max} - T_{min}} \frac{C - C_{min}}{C_{max} - C_{min}} \frac{R - R_{min}}{R_{max} - R_{min}} \frac{Q_{min} - Q}{Q_{max} - Q_{min}} \quad (1)$$

Table 2 shows the optimization results for all indicators and algorithms.

Also, in Figs. 1 to 5 below the convergence diagrams show the optimization of all 5 scenarios:

Table 2. Optimization results in different algorithms.

	Haris Hawks Optimization	Cyclic Parthenogenesis Algorithm	Butterfly Optimization Algorithm	Simulated Annealing	Tabu Search	Genetic Algorithm
Time index (days)	478		478			478
Cost index (Rials)	530,773,130,016	30,773,130,016				530,773,130,016
Risk index	0.7855					0.7855
Quality index						99.11
A total of 4 indicators	27.47					27.47

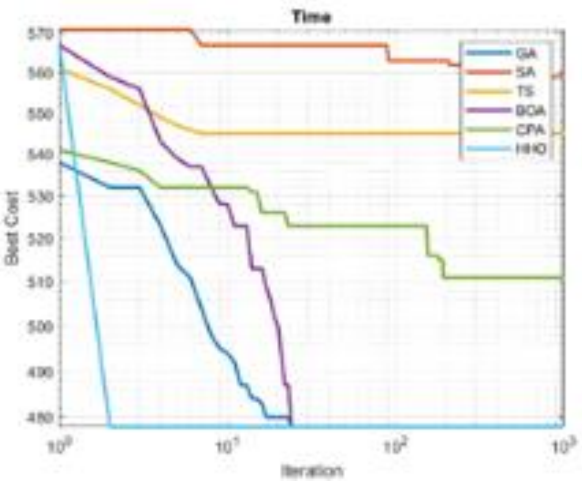

Fig. 1. Convergence diagrams for time optimization.

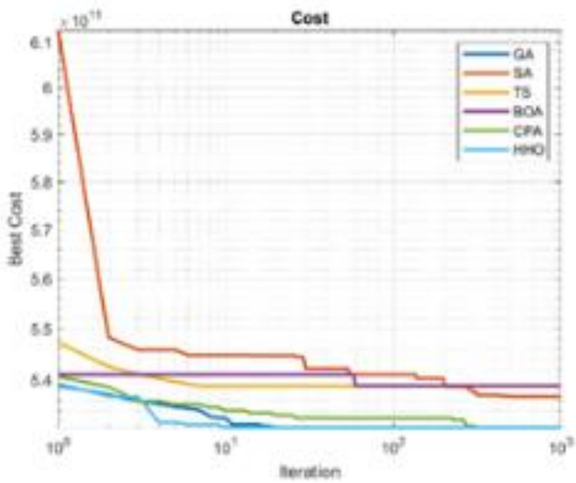

Fig. 2. Convergence diagrams for cost optimization.

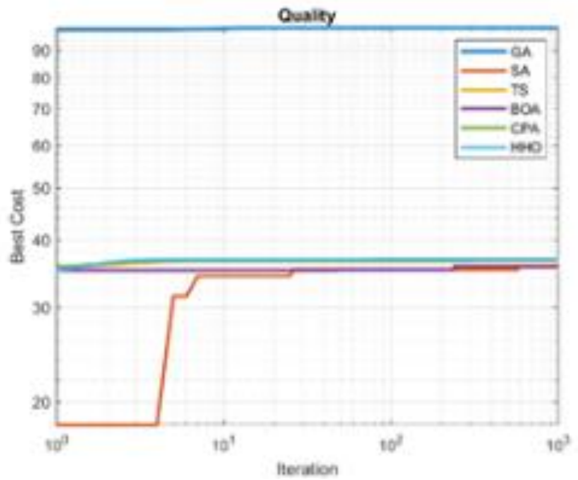

Fig. 3. Convergence diagrams for quality optimization.

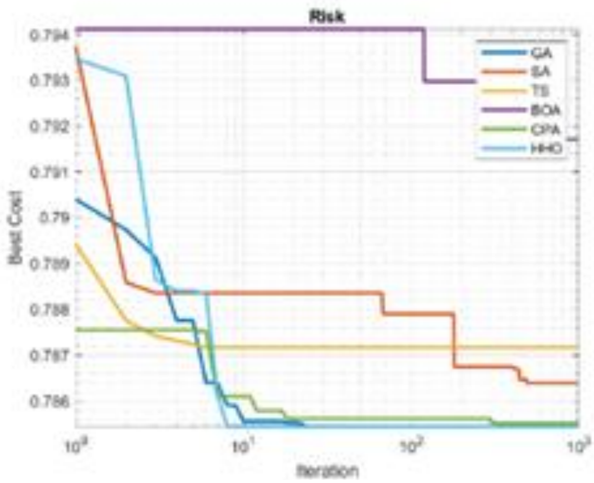

Fig. 4. Convergence diagrams for risk optimization.

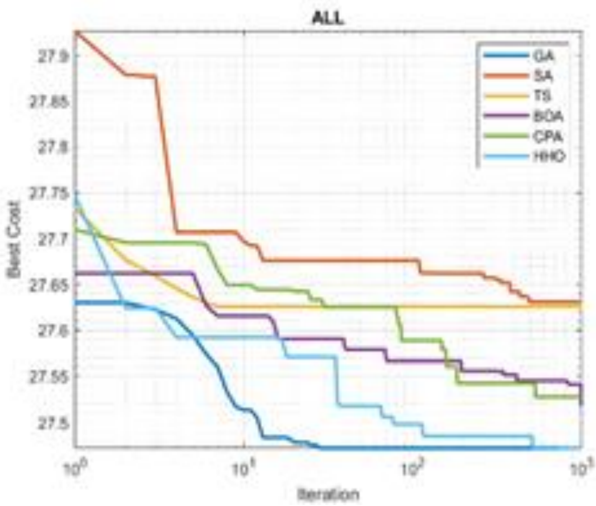

Fig. 5. Convergence diagram to optimize all indicators.

4- Conclusion

According to the obtained results, it is possible to act based on project management based on planning, guiding, and controlling resources to achieve specific goals in other development projects, and in this way, Optimization of time, cost, quality, and risk indicators is considered. Therefore, according to the proposed model, in addition to increasing the quality, the executive operations of the projects can be considered simultaneously with reducing their risk, cost, and time. According to the results of this study, it can be acknowledged that the proposed objective function and GA and HHO can be used as a suitable model for other organizations to optimize the quantitative and qualitative indicators of the construction industry or other water projects. According to these results, the two algorithms GA and HHO can provide better and more appropriate models used in optimizing other construction projects and especially similar water projects should also be used. Also, considering the conditions of the country's construction projects and project management, especially the PMBOK discussion in terms of project resource management knowledge and project stakeholder management knowledge, the effect of payments and project financing by the employer can be optimized. Cost, time, quality, and risk indicators were considered.

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