2Optimization of Quantitative and Qualitative Indicators of Construction Projects with a Project Management Knowledge Approach (Case study: Qucham reservoir dam)

Behzad Espoutin [1], Sina Fard Moradinia [1*]

[1] Department of Civil Engineering, Tabriz Branch, Islamic Azad University, Tabriz, Iran.

ABSTRACT

In recent years, the complexity of project implementation, competitive business environment and limited resources of organizations, has showed 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 has been done on a case-by-case basis on the Qucham reservoir dam. For this purpose, six Metahioristic Optimization algorithms have been 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.

KEYWORDS

Optimization, survival pyramid, metaheuristic algorithms, project management knowledge, Qucham reservoir dam.

* Corresponding Author: Email: fardmoradinia@iaut.ac.ir

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 it is the duty of management accountant to 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, in order 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 with the aim of estimating project duration, optimizing project time and cost, the effect of optimal number of personnel and the effect of optimal personnel training and the effect of activities on another [2]. Most of the researches have used one or at most two methods to investigate the optimization problem, but the innovative aspect of this paper is due to the fact 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 is performed in water projects with a case study on 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 Qucham Dam and then table 1 was prepared, which shows 1 of the 23 chapters used as an example. This table is the 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 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.

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				
0.3	82.9	84	0.2	77	0.3	86	0.5	472,263,732,474	16	2	78.775	531,296,699,033	فصل اول	1
0.25	62.5	65	0.2	60	0.3	63	0.5	708,395,598,711	24	3				

3.Results and Discussion

3.1 Optimization Problem Formulation

In this research, five different modes have been implemented on the problem. For this purpose, each of the time, cost, quality and risk factors are optimized in four modes separately. Finally, all four factors are 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, Equation (1) is used to calculate the objective function:

Equation (1)

$$F(x) = \frac{T-T_{min}}{T_{max}-T_{min}} \frac{C-C_{min}}{C_{max}-C_{min}} \frac{R-R_{min}}{R_{max}-R_{min}} \frac{Q_{min}-Q}{Q_{max}-Q_{min}} \quad (۱)$$

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

Table 2- Optimization results in different algorithms

	Haris Hawks Optimiz ation	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

Also in Figures 1 to 5 below the convergence diagrams show the optimization of all 5 scenarios:

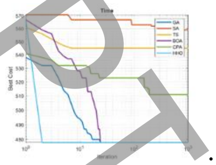

Figure 1. Convergence diagrams for time optimization

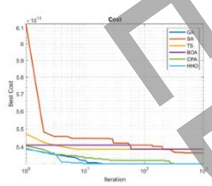

Figure 2. Convergence diagrams for cost optimization

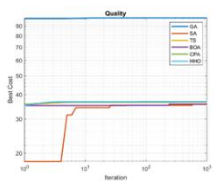

Figure 3. Convergence diagrams for Quality optimization

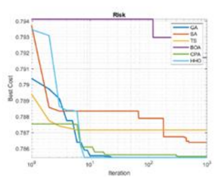

Figure 4. Convergence diagrams for Risk optimization

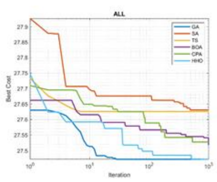

Figure 5. Convergence diagram to optimize all indicators

4.Conclusion

According to the obtained results, it is possible to act on the basis of 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 genetic algorithms (GA) and Harris Hawks (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[2] 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.

5. References

[1] Ahmad Abdullahi, Ali Khozin "Using Genetic Algorithm to Optimize Balance, Time, Price, Quality and Risk in Construction Projects and Investment Projects" - Journal of Accounting and Auditing Studies, Issue 20, 2016, pp. 104-123

[2] Hesham A. Abdelkhalek, Hesham S. Refaie, Remon F. Aziz. "Optimization of time and cost through learning curve analysis". Ain Shams Engineering Journal, 26 December 2019

[3] Holland, J. H. Genetic algorithms. Scientific American, (1992), 267(1), 66-73.

[4] Glover, F., & Laguna, M. Tabu search. In Handbook of combinatorial optimization (pp. 2093-2229). (1998) Springer, Boston, MA.

[5] Van Laarhoven, P. J., & Arts, E. H. Simulated annealing. In simulated annealing: Theory and applications (pp. 7-15). (1987), Springer, Dordrecht.

[6] Arora, S., & Singh, S. (2019). Butterfly optimization algorithm: a novel approach for global optimization. Soft Computing, (2019) 23(3), 715-734.

[7] Kaveh, A., & Zolghadr, ACyclical parthenogenesis algorithm: A new meta-heuristic algorithm. (2017)

[8] Heidari, A. A., Mirjalili, S., Faris, H., Aljarah, I., Mafarja, M., & Chen, H." Harris hawk optimization: Algorithm and applications. Future generation computer systems, (2019)97, 849-872.

[2] The Project Management Body of Knowledge