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Solving the Problem of Multi-Stakeholder Construction Site Layout Using Metaheuristic Algorithms

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Abstract. Construction site layout planning (CSLP) is crucial to projects' success and implementation. The CSLP has an impact on time, cost, and quality from a project management standpoint. Other than that, CSLP is overshadowed by issues like project management, economic efficiency, and the mitigation of environmental damage, while it can be used to put the aforementioned conditions more effectively. The viewpoint of the stakeholders and their integration with one another, in addition to the elements and characteristics analyzed in putting the site's layout, can directly affect how well CSLP is optimized. In this study, a genetic algorithm was used to analyze the CSLP of a construction project with many stakeholder interactions, and the outcomes were compared with the PSO algorithm. In this instance, combining multiple stakeholders produced better results than combining double and single stakeholders.

Keywords: construction site layout planning; interaction multi-stakeholder; optimization; genetic algorithm; agent-based modeling (ABM)

1. Introduction

The process of governing current management experience with management science and its new methodologies has maintained the culture regulating the projects as traditional and has led the workshop issues of recent decades to stay unaddressed, even with the emergence of novel manufacturing technologies in the workshops. The process of governing current management experience with management science and its new methodologies has maintained the culture regulating the projects as traditional and has led the workshop issues of recent decades to stay unaddressed, even with the emergence of novel manufacturing technologies in the workshops [33-35].

Mahmodabadi et al. were able to resolve one of the most important issues facing construction workshops, with the use of the harmony search algorithm, one of the latest optimization models. In addition to aiding in the resolution of such issues, this move brings modern science closer to the demands of the world. Distrust between workshop managers and the modern science of construction management must be broken down throughout the nation's workshops [14]. The three components of space, time, and equipment have not been successfully combined by static layout models or common

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construction workshop layout methods. They provided a dynamic layout model using the harmony search algorithm that arranges in accordance with the equipment's time distribution schedule and the potential for shifting the equipment over time. One feature of the structure of this model is the suitable and logical adaptation of harmony vectors to the topic of dynamic arrangement. The dynamic arrangement problem from the prior research by Afshar and his colleagues was solved with the aid of this algorithm to compare the performance of the model, and the outcomes were then compared with the findings from earlier models. The model demonstrates that the harmony search algorithm can successfully implement dynamic arrangements [13]. The factors that will cause the project to fail if they are not properly managed include failing to pay attention to the project's feasibility research before initiating it, adverse risks at the beginning and end of the project, contracts' correct knowledge, and the project team's expertise. The two components examined in this research are thus drawn from the risk management of projects, which is how the team's correct design, the project's key individuals, and earlier the feasibility and necessity of performing it in crucial projects are extremely important in the country [25]. By taking into account total cost reduction, A. ghadiri et al. modeled safety objective functions (owing to potential risks originating from hazardous sources and interaction flows) connecting temporary facilities [5]. A combined WOA-CBO algorithm was suggested for the construction site layout planning problem. The CSLP method and how it is set up in construction projects is crucial and has a direct impact on time and cost. To accomplish this goal, it should be done by cutting costs and time and improving safety [41, 42]. To improve the solutions, reliability, and convergence speed in the new approach, which is known as the WOA-CBO algorithm, this study tries to increase the improvement of the WOA corpus by hybridizing it in some concepts of particle collision optimization (CBO). He suggested that the goal of optimization CSLP is in construction projects [9) (or other hybrid algorithms such as [23], [24)). They looked at simulation and agent-based modeling in construction. Due to its distinctive system modeling characteristics and recent developments in computational capabilities, agent-based modeling (ABM) has grown in popularity in the field of construction research, which has resulted in a notable increase in the number of publications on the subject. To confirm the usefulness of the developed model in addressing CSLP-CMLP and CSLP-SP interactions, a case study was taken into consideration. This study added to the body of knowledge by increasing academics' familiarity with ABM in the context of construction from a particular perspective: 1) a theoretical perspective; and 2) a practical perspective by analyzing industry-oriented studies and offering recommendations to improve its application in real construction[10). To select the optimal dam noise design in terms of health impact, productivity, and cost aspects, Choi et al. employed an automated decision-making model. They did this by employing three objective functions in trade along with mathematical calculations. In addition, they presented the established methodology to enhance the urban sound environment, which secures the profitability of construction companies and can be applied to construction projects, along with the case study's viability.

Travel distance, which is frequently employed in safety and cost objective functions, is the primary ideal parameter in construction site layout planning (CSLP) as an optimizatio problem[l9]. This is done by applying fuzzy graph theory to optimize travel distance while taking behavioral uncertainty into account. According to UAV-based 3D reconstruction for site mapping and layout planning in petrochemical development, the majority of current site layout planning methods optimize construction facilities from 2D space, which makes it challenging to assure the safety of large-scale lifting. In this study, site mapping and layout planning are done using unn1anned aerial vehicles and 3D reconstruction. The primary goal of this study is to improve facility layout planning through the use of real-time 3D spatial information as a constraint [28]. Agent-based decentralized optimization was used to study the impact of multi-stakeholder interactions in site layout construction planning. The study's main goal was CSLP-CMLP/SP combined optimization. The cost has been minimized in this study while taking the objective function into account. And one of its primary drawbacks is the proper coordination with the CSLP policy; in this regard, 5 main components were taken into account for the objective function [26].

Workshop equipment layout design is a crucial step in the construction planning process. Despite receiving little attention, this activity significantly affects project objectives, especially in large projects. Managers and engineers will pay greater attention to this issue if they consider the economic consequences of improper arrangement of workshop equipment, as well as the reasons why designing the arrangement of workshop equipment is necessary. Three of the four steps of planning the layout of the workshop equipment are proposed in the research that was done. That the third step in setting up the workshops for optimal efficiency, "determining the size and shape of the common facilities," is the subject of the research [20]. Genetic algorithms work in optimizing the layout of the site and to solve the problems of the construction site layout planning by considering a set of predetem1ined facilities and a set of specific locations by determining the restrictions and requirements for achieving satisfactory results.

They suggested a management framework for stakeholders as well as an agent-based model approach for assessing urban demolition waste. In recent decades, the amount of construction and demolition (C&D) waste has grown dramatically in tandem with the construction industry's explosive growth. Getting accurate data on waste quantities is essential because demolition waste is recognized as a significant stream of C&D waste. An agent-based model with interaction with the stakeholders involved in them was taken into consideration in this study for the best management of construction waste and its recycling [31].

A crucial resource for planning facilities and roads for large-scale engineering construction projects, such as dams, tunnels, and airports, is available space in addition to materials, machinery, and humans [8]. The effort required to manage the site space available to support construction operations is known as construction site layout plam1ing (CSLP), and it has been the subject of extensive research [2]. Research on the effects of proper site layout has highlighted its com1ections to direct costs, safety, and security [2,21-22, 38-40]. To implement CSLP, it is necessary to define the objects, sites, and planning goals as well as to select practical problem-solving approaches. In this paper, the CSLP problem has been developed using a location optimization and on-site route planning model to predefined temporary facilities locations and effective road planning in place [29]. A site layout planner (LaP) is hired to design the layout plan for the project managers and/o

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general contractors as many factors such as site sun-oundings and transportation requirements need to be simultaneously incorporated to optimize the CSLP. Due to the NP-Hard nature of CSLP problems, no established solution method can quickly determine the ideal site layout. However, several CSLP methods and approaches have been created from a single LaP standpoint as a result of technological advancements. The present CSLP solution methods frequently include expert experience[8], the adaptation of existing layouts to a targeted example[22], GIS-aided techniques[2-21], knowledge-based systems[2], CAD-supported tools[17, 36], mathematical model-oriented solving methods[19-27], and heuristics and meta-heuristics[8, 37]. The solution methods are chosen depending on the project-specific surroundings and requirements. Mathematical solutions are frequently utilized to transform the practical aspects of CSLP into mathematical models, where the CSLP objectives are modeled as objective functions, site layout designs are decision variables, and practical restrictions or requirements are model constraints. For instance, Hammad et al. created a mixed integer programming model to minimize the interactive CSLP costs between any pair of facilities [6]. and Song developed a multi-objective model to simultaneously locate facilities within the construction site and optimize the CSLP costs and interactive distances [28], while Huang and Wong developed a mixed model to solve a phased CSLP problem [11]. Large-scale construction companies (like China Datang Corporation) have created hierarchical systems in which specialized stakeholders are included to concurrently conduct multiple project tasks, interacting with architectural design, planning, and construction. This has been done in response to the increased focus on heavy engineering construction projects. For instance, during the construction design and planning phase, participants from different businesses involved in the same project, such as contractors and subcontractors, come together to make decisions about things like the heavy tower crane layouts, and materials, equipment, and transportation route designs that attempt to optimize objective values [27]. LaP has been hired to design a site layout for feasible construction [27], which is typically overseen by project owners and general contractors.

A safety manager (SaM) [3] or security officer [21] is needed to oversee occupational health and safety measures put in place to prevent accidents and make sure site security planning (SP) is implemented. A logistics planner (LoP) is also necessary to plan the material supply channel for logistics planning of building materials (CMLP).

Therefore, a wide range of stakeholders works together on the CSLP system to account for overall construction costs and project length, guarantee quality, and reduce the environmental effect. As with CSLP problems, there has been considerable research on optimizing materials supply channels [4-29] and designing appropriate security plans [57-3].

The optimization of multi-stakeholder structures in constrnction systems has drawn more academic interest. Depending on whether subsystem optimizations involve a single decision maker or several, structures can be classified as concentrated, decentralized, or mixed. For instance, Said and El-Rays develop centralized mathematical-matisse optimization models for integrated site layout designs and transport/storage materials [21-22], as well as site layout and project scheduling problems [7-8]. A centralized model fior

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material procurement and site layout optimization was developed by RazaviAlavi and AbouRizk [18]. From the viewpoints of two stakeholders, Xu and Li develop a decentralized mathematical model to optimize site layout planning and security planning problems [12]. Xu and Zhao used a decentralized bi-level model to model the interactions and interdependencies between both the site layout planner and the material supplier using a decentralized bi-level model [30]. Furthermore, the results of our earlier research [29] were optimized for a decentralized integrated site layout planning and material logistics planning problem. Even though these earlier approaches acknowledged the important role that constrnction project interactions play in the development of the optimal site layout plans and overall best solutions, there hasn't been much research specifically on these multi-stakeholder interactions. Consequently, it is now important to design a specialized method of resolving these intrinsic structures while taking into account each operation inside the multi-stakeholder system. Therefore, in this paper, to examine the effects of multi-stakeholder interactions on-site layout plans, a multi-stakeholder structure consisting of the LaP, LoP, and the SaM, in which the LaP is the core decision-maker on the upper level, and the LoP and the SaM, who have close connections to the LaP. Different stakeholders are classified into two levels and are deemed independent in the CSLP-oriented multi-stakeholder system.

The performance of the LaP is detem1ined and is impacted by the LoP and the SaM. However, due to each stakeholder's distinct goals and requirements (i.e., the objective functions) as well as inherent limits (i.e., decision variables), mutual influences and limitations are unavoidable. A suboptimal site layout plan might result from neglecting the bi-level multi-stakeholder characteristics and interdependent interactions during site layout optimization, even if mathematical methods have been demonstrated to be suitable for CSLP situations. Agent-Based Modelling (ABM), which enables the model establishment of individual stakeholders (the agents) in a multi-stakeholder system and can model the complex multi-stakeholder interactions in an integrated system [26-32], has been one of the most widely utilized appropriate approaches to address these problems [22-13].

The objectives and variables of multilevel stakeholders can be taken into account in an integrated yet decentralized structure thanks to the widespread usage of two-level mathematical modeling for two-level strnctures [32]. The two-level programming created by Baird was a kind of Stackel berg game whose effectiveness was thus widely developed and proved to be able to meet the problems of the hierarchical structure of construction management, such as constrnction supply chain management [l]. For instance, two-level programming models have been designed to optimize a stone planning problem [4], a transport network planning problem [15], and a vehicle routing problem [13]. A study of these models revealed that they differed significantly from generally used optimization models, in which the lower-level optimization model is constrained by the strict restrictions of the higher-level optimization model. Due to this two-level problem's structure, only a desirable solution that complies with stringent requirements and is acceptable to lower-level stakeholders can be found for high-level stakeholders. In these circumstances, stakeholders at both levels must essentially optimize their respective problems based on known information to achieve an integrated optimal solution.

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The two-level system's complex structures are typically addressed using two-level mathematical models. However, these are often two beneficiaries under the lower-level system in the majority of CSLP-oriented systems. Therefore, a bi-level mathematical model that can structurally model a one leader-two followers multi-stakeholder system is required to develop an effective plan that completely takes into account the interactions of the multi-stakeholders; to the authors' knowledge, no such model has yet been developed for CSLP research.

Therefore, the fundamental concepts of ABM and two-level programming are merged in this study to address complex multi-stakeholder and two-level considerations, which helps close a research gap. To optimize the integrated but decentralized CSLP-CMLP/SP system, a two-level multi-stakeholder model has been developed that has two followers, can adequately express the multilevel stakeholder structure, and can model the effects of multi-stakeholder interactions on a desirable site layout design that is possible for LaP and is acceptable to LoP and SaM in their respective planning processes [26].

The rest of this article is organized as follows. Section 2 provides a description of the CSLP-CMLP/SP model and the contributions made by the cu1Tent research. A case study is constructed in Section 3, where a two-level mathematical model is fomrnlated, and an interactive solution method is designed to look for an optimal integrated solution. The case study results are reviewed in pa1i 4 using comparative tables of the proposed CSLP-CMLP/SP model, and future research conclusions and recommendations are given in part 5.

2. CSLP-CMLP/SP MODEL

This research was performed by using related library resources, papers and interviewing the experts. The infom1ation collection tools were based on preparing a questionnaire adapted from the experts' viewpoints and the existing challenges in the construction projects in the oil and gas industry. The questiomrnire's distribution was accomplished in an electronic (online) manner on the contractor/ managers/ client websites and hard copy.

This model has been developed by Song & et al [26]. In this model, they proposed an agent-based decentralized bi-level mathematical model that incorporates decisions from three stakeholders to examine the CSLP multi-stakeholder interactions. A GA optimization-based solution approach has been created to solve the model and produce CSLP, logistics planning of building materials (CMLP), and security planning solutions (SP) in an integrated CSLP-CMLP/SP system. Next, the outcomes are contrasted with PSO optimization. In particular, the stakeholders are modeled as individual agents with distinct decisions and objective functions, and the bi-level model is simultaneously applied to and dealt with the interdependencies between the layout planner and the other two stakeholders (i.e., the logistics planner and the safety manager). To achieve multi-stakeholder interactions, the individual decisions are updated iteratively into the optimal integrated solution with the fewest possible stakeholder disputes during the construction stage.

Tri-PSO is designed by Song et al., using interaction framework ideas. LoP initially hired PSO to solve the CSLP optimization model, and as a result, a CSLP decision is made. The CSLP decision is transferred to LoP and SaM by ISO. The CMLP optimization problem is the

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addressed with a PSO, and the SP optimization model is solved with a PSO. A CMLP decision and an SP decision into an integrated feasible solution, which is then returned to LaP by ISO. LaP evaluates targets based on CMLP and SP decisions. If the objectives are met, ISO incorporates the relevant CSLP, CMLP, and SP decisions into a possible integrated solution deemed useful for overall project control. To facilitate programming for problem-solving, the conceptual tii-PSO is suggested in Figure. 1.

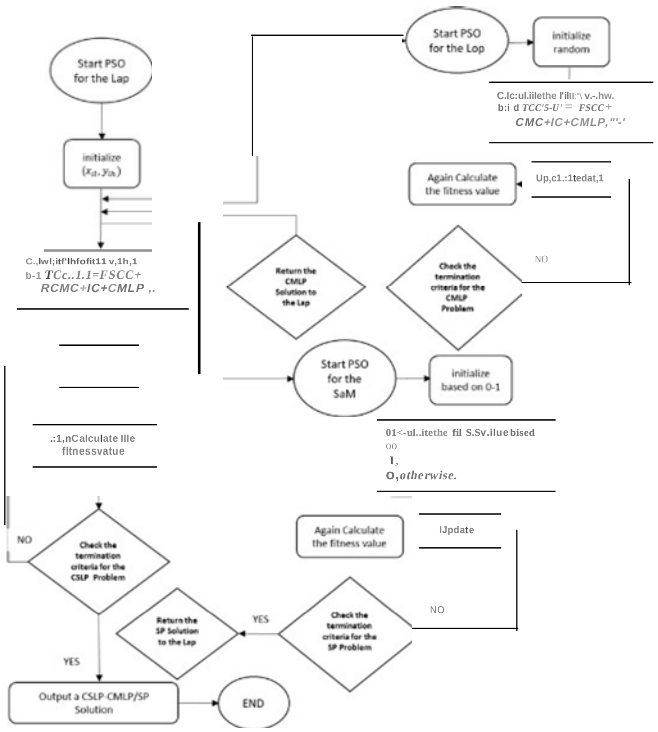

Figure 1. Conceptual tri-PSO flow chart

3. CASE STUDY

The integrated CSLP-CMLP/SP model is used to address multi-stakeholder interactions in site layout designs, supply channels, and security plans for a practical case of constructing a dam base, which is a crucial component for large-scale plant strength. The notional case in the previous research [29] focuses on a particular section of a contract, as depicted in Figure. 2. To finish the project within a given planning period and overlook the project globally, the integrated CSLP-CMLP/SP system is employed to address the CSLP, CMLP, and SP problems simultaneously. Three beneficiaries are placed under contracting for relevant tasks. Project names and engaged bidders won't be disclosed for reasons of confidentiality. Building dam blocks and auxiliary structures is the main task.

The inter-related CSLP, CMLP, and SP subsystems make combinatorial efforts to support the successful completion. To be more precise, the CSLP subsystem facilitates site layout by establishing on-site routes and temporary facilities. The CMLP subsystem transmi

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reasonable materials from material suppliers to structures under construction. The CSLP and CMLP subsystems are connected, according to an earlier study [29]. Additionally, SP a subsystem has been implemented to regulate the level of health and safety in place. Similarly, the current project aims to develop shared physical security measures in facilities that link the CSLP and SP subsystems. Since CMLP and SP subsystems simultaneously influenced CSLP's decision-making, the extent of their influence is crucial for LaP's problem and overall project management. Therefore, the CSLP-CMLP/SP system is optimized using the integrated model, which results in relevant CSLP, CMLP, and SP solutions.

This work's key component is the accessibility of data. A workable solution can be developed by gathering precise data for model constant parameters and the solution approach.

Model parameter settings: The following data needed to be prepared by the LaP, LoP, and SaM stakeholders to achieve an optimal integrated solution. (I) The candidate location matrix (I, I=1,2,... ,L) from the earlier research was used.

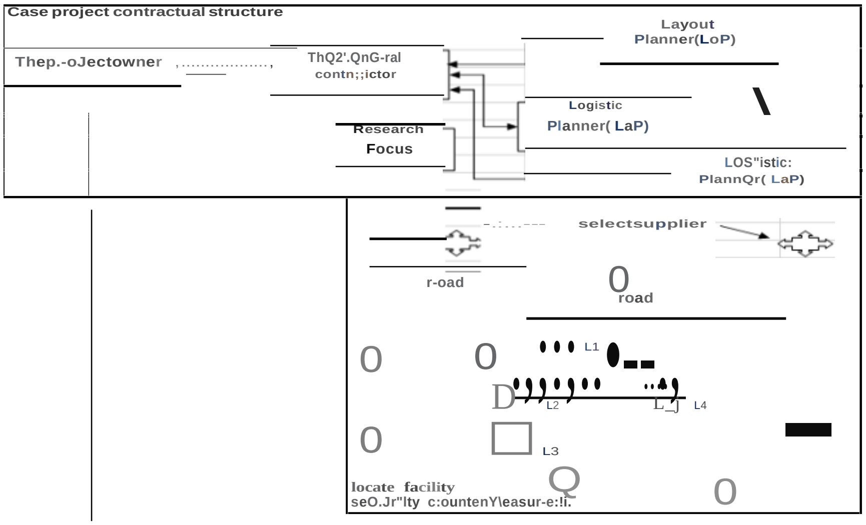

Figure 2. Case project conceptual structure

Parameter settings for the model-solving approach: The tri-PSO was created to solve the bi-level CSLP-CMLP/SP model. The same parameter values, which have been validated in [29], were pre-set for the involved LoP, LaP, and SaM. These values were Pop-size=200, denoting the population size; GN=200, denoting the generation number; ro E [0.2,1.2], denoting an inertia weight; cl =2 and c2=2, denoting the coefficients; and three random numbers, Randl E [0,l],Rand2 E [0,1] and Randab E [0,1]. The parameter combinations were able to arrive at the best solutions for integrated CSLP and CMLP problems based on the results of the prior optimization. However, additional sensitivity analyses are required to further evaluate the efficacy of the parameter combination, including performance on objectives for the relevant stakeholders, the average computing time, and the convergent speed.

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4. DISCUSSION

To find the best solution for said interested stakeholders, the combined CSLP-CMLP/SP and tri-PSO model's variables were adjusted, and then the PSO and GA models were run 50 times. The program has been run 50 times, and it has been discovered that the chosen parameter combinations have a low-perfom1ance variance for the intended purposes, demonstrating its efficacy and stability. In Tables 1 & 2, pa1iial results for 50 runs by PSO & GA algorithms are displayed. For each partial result, a solution can be parsed out to help the stakeholders. The decision variables and target function solutions for the various stakeholders were different, as shown in Tables 1 & 2.

For instance, site layout plans in the second column are decision options for LaP, the decisions in the fourth and sixth columns are decision alternatives for LoP and SaM, and the best solutions came from 50 relevant tri-PSO and GA implementations.The CSLP-CMLP/SP integrated optimal solution with the lowest fitness value (as one of solution 6) was developed for the lap core decision maker for stakeholders involved in the CSLP-CMLP/SP system using Eva Lucien's fitness functions. Figures 3 & 4 (a) illustrates how the optimal solution was broken down into a site layout that reflects the decision of the location facility; the design plan is a supply channel that reflects suppliers, order values, inventory values, production values, and transportation network linking activities; and a security map. To direct the LaP by taking the desires of the LoP and the SaM into account, the genetic algorithm's solution 6 was chosen.

Therefore, the LoP's objective values are 25.036 * 108CNY, the LaP's profits are 0.997 * 108CNY, and the SaM's risk is minimal at 19.02%. Numerous supply channel assumptions were made because the goal of this case study was to evaluate the effects of multi-stakeholder interactions on the site layout plan. As a result, the LoP and SaM solutions were not proven because they lacked applicability.

While a review of the case project's computational findings showed that none of the three stakeholders could reach specific decisions, it did demonstrate that the model was able to explain the relationships among the tasks of site layout design, material supply channel planning, and security planning tasks. For instance, Tables 1 & 2 shows that when CMLP or SP decisions and objective function values were different, CSLP decisions and objective function values changed correspondingly. This clearly demonstrates that CSLP decisions were simultaneously influenced by CMLP and SP activities and that understanding the effects of multi-shareholder interactions is essential to successful site layout planning. To minimize any conflicts once construction proceeded, the CMLP and SP requirements were taken into account throughout the CSLP design and planning stage. Even though LoP and SaM make decisions based on CSLP decisions, the optimality of CSLP solutions often requires compromises to meet the supply of materials and security demands. For instance, decisions on CMLP production quantity and SP's combined anti-security measurement are influenced by the size and location of tempora1y processing centers.

In this section, additional discussions are provided to enhance the perfonnance and confirm the viability of the proposed CSLP-CMLP/SP model.

Numerous studies from the standpoint of system engineering have been conducted on construction site layout planning problems and other optimization problems. Due to the conelation between site layout planning and many other pre-planning tasks, the proposed

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CSLP-CMLP/SP system advances CSLP research by modeling the effects of multi-stakeholder interactions on a feasible site layout plan from a high-level coordination and control perspective. The CMLP and SP optimizations were added as hard constraints into the CSLP-CMLP/SP model by including the effects of the multi-stakeholder interactions, which compromised the overall site layout plan's optimum. However, these possible CSLP-CMLP and CSLP-SP decision conflicts can be efficiently managed by selecting sub-optimal solutions for some or all of the involved stakeholders. LaP-LoP and LaP- SaM disputes or lawsuits can often be avoided by taking into account potential CSLP-CMLP and CSLP-SP conflicts during the planning stage.

Table 1: Fifty solutions for the CSLP-CMLP/SP model.(Data based on the base article) [26]

Solution no.	CSLP solutions		CMLP solutions		SP solutions	
	Site layout plan	*TCcsLP*(CNY)	Supply channel	*TEcmP(CNY)*	Security plan	*TRsp* (%)
1	Site_Layout_l	26.533 • 108	Supply_Channel_l	0.815 • 108	Security_PIan_l	17.05
2	Site_Layout_2	26.937 * 108	Supply_Channel_2	0.873 * 108	Security_PIan_2	20.33
3	Site_Layout_3	25.335 * 108	Supply_Channel_3	0. 755 • 108	Security_PIan_3	18. 75
4	Site_Layout_4	27.89 • 108	Supply_Channel_4	0.903• 108	Security_PIan_4	19.35
5	Site_Layout_5	25.755 * 108	Supply_Channel_5	1.014 • 108	Security_Plan_5	23.45
6a	Site_Layout_6a	24.735 • 108 a	Supply_Channel_6 a	0.956* 108a	Security_Plan_6 a	17. 75a
7	Site_Layout_7	24.997 * 108	Supply_Channel_7	0.895• 108	Security_PIan_7	**24.53**
46	Site_Layout_46	28.557 * 108	Supply_Channel_46	0.897 * 108	Security_PIan_46	25.95
47	Site_Layout_47	28.975 * 108	Supply_Channel_47	0. 795 • 108	Security_PIan_47	26.37
48	**Site_Layout_48**	**26.85S°108**	Supply_Channel_48	0.813• 108	**Security_Plan_48**	23.7S
49	Site_Layout_49	27.951*108	Supply_Channel_49	0.955 * **108**	Security_PIan_49	20.31
50	Site Layout SO	25.755 * 108	Supply Channel 50	1.037 * **108**	Security Plan SO	25.35

Table 2: The results of table 1 are based on the information of this paper in the genetic algorithm (GA)

Solution oo.	CSLP solutions		CMLP sol«ions		[illegible]	
	Site layout plan	*TCcsLP(CNY)*	**S,W**cllawel	*rFc:M,.P (CNY)*	**Sectdyplan**	*1'Rsp* (%)
	Sile_U1yo111_ l	25.873 •10^{8}	*Supply_C/1<11",el_ l*	1.012 • lo"	*Securih·_Plan* I	22.17
2	*Sile_U1yo111_2*	26.236 • 10^{8}	*Supply_ Clwm1N!l_ 2*	0.894 • 10^{8}	*Securil)·_Pltn1_ 2*	21.09
3	*SilP_ IA7Yo1.1t_3*	28.'136 • lo"	*Suppfv_Chmmel_3*	0.896 • to"	*Security_Pim,_ 3*	23.17
4	*Site_layout _4*	25.234 .,0^{8}	*Supp v_Chmmel_4*	0.923 • 10^{6}	*Security_Pkn, _4*	19.76
5	*Site_ lnyout_5*	25.756 • lo"	*Supp,v_Clwmnel_5*	1.003 • 10^{8}	*Secnrif)•_Pim,_5*	22.56
6	*Site_f.0·0111_* 6	27.871* 10•	*S11pp{v_Cha,mel_ 6*	0.872 * 10^{8}	*Seeuriry_Pim,_ 6*	18.31
7	*Site Layout 7*	27,098 • 10•	*Suppfv Cha,mcl 7*	0.976 * 10^{9}	*Security Plan 7*	19.78
8	*Site_Layout_8*	26.120 • 10•	*S11ppfv_Chm111e/_8*	1.023 • 10^{9}	*Security_Plan_8*	24.32
9	*Sile_Layo111_9*	25.876 *10•	*Suppfv_Cl,nnnel_9*	0.876 * 10B	*Security_PInn_ 9*	20.44
10	*Sile_L<lyout_ 10*	25.139• 10^{8}	*S11pp,v_Cha1111el_ 10*	0.987 • 10"	*Security_Plan_10*	19.87
11•	*Sile_ l<ryo111_* llb	25.036 ' lo"b	*Supply_ Channel_* 11•	0.997 • 108b	*Security_P Ian_* 11h	19.02 b
32	*Site layout 46*	27.913 • JO"	*Suppfv Channel 46*	0.975 • tO"	*Security Plan 46*	24.8
ll	*Site —1 1*	29.234 • 10^{8}	*C/,a1111el _!1*	0.868 • 108	*Security Pinn.£*	lliJ.
34	*Sile_ Layout_48*	28.432 • 10^{8}	*Supply_Channel_48*	0.789• 10,	*Securil)·_Plcm_48*	24.92
48	*Sile_ l<,youl_48*	25,107 • 10.	*Supply_ Chmmel_48*	0.899 • 10,	*Security_Pkm_48*	22.09
49	*Sile_Lc,yo111_49*	27.112 * 10^{8}	*Supp(v_Chcmnel_49*	0.899 • lO'	*Secuntv_Pkm_49*	20.76
50	*S11e /J,r()11/* 50	26.106. 10°	*Supp v Clv11mel 50*	1.038 • 1<>"	*Seruritv Pita,* 50	2:5.21

b Represents the best solution and the underlined is the worst solution.

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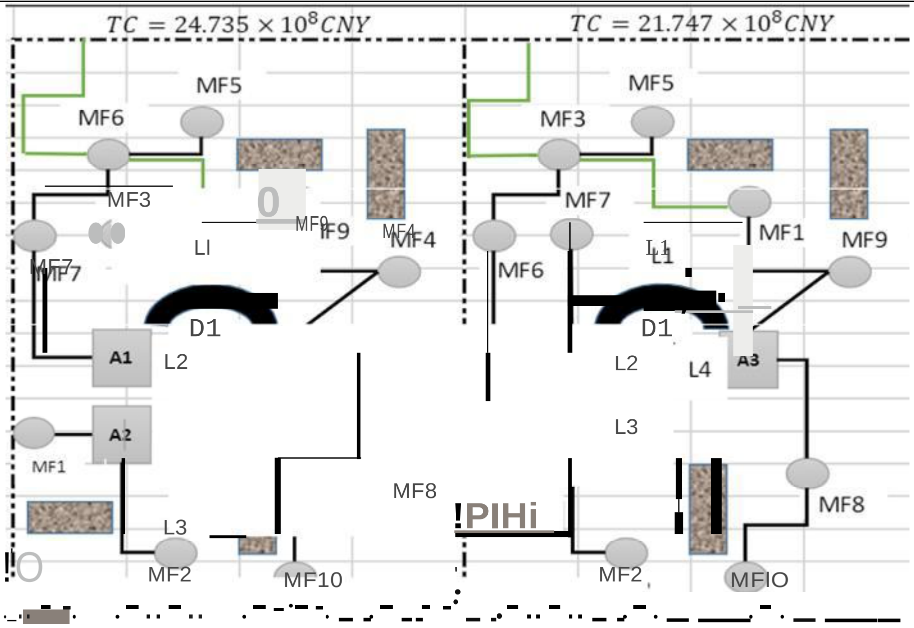
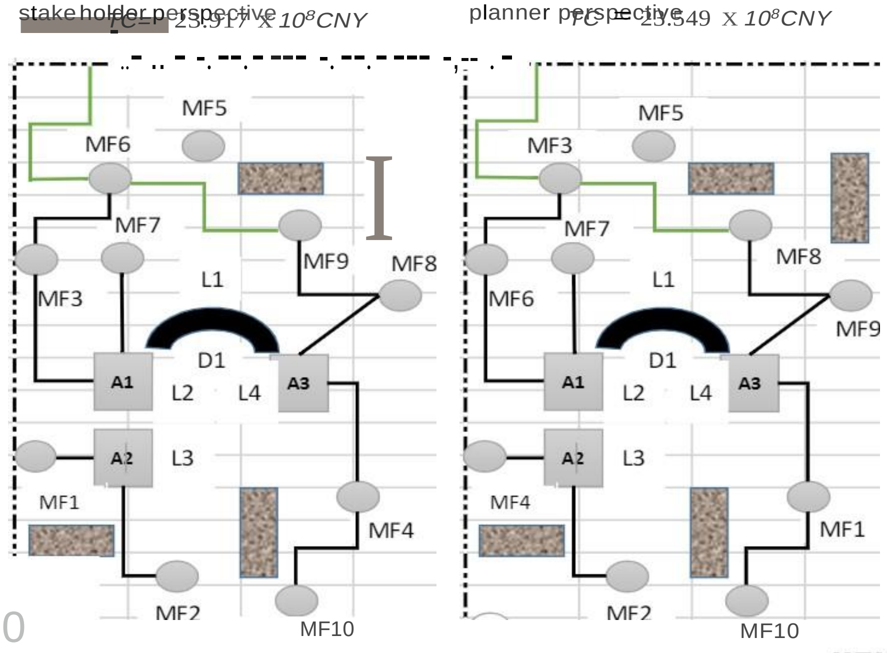


(a) The site layout plan from a multi-stakeholder perspective

(b) The site layout plan from a singular planner perspective



(c) The site layout plan from a bi-stakeholder perspective

(b) The site layout plan from a bi-stakeholder perspective

Senario 1

Senario 2

▨ denote obstacles

Figure 3. CSLP solutions by PSO algorithm

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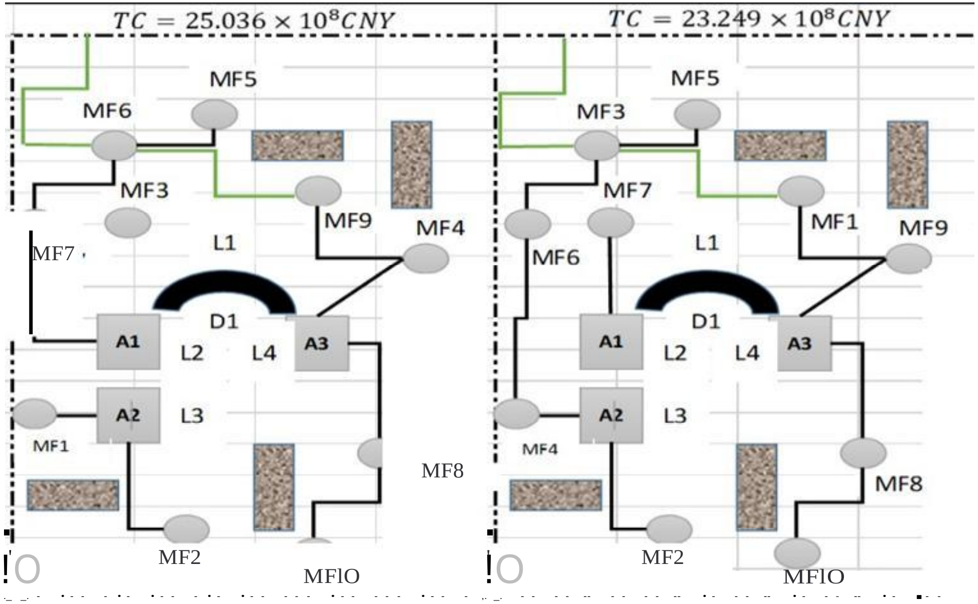

(a) The site layout plan from a multi-stakeholder perspective

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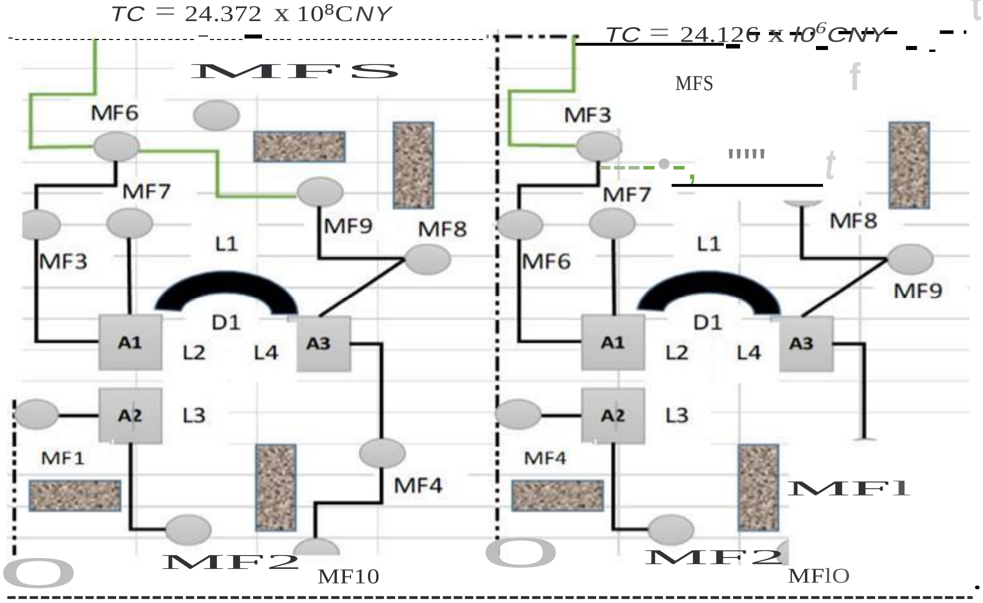

(c) The site layout plan from a bi-stakeholder perspective

(b) The site layout plan from a bi-stakeholder perspective

Senario 1

Senario 2

▨ denote obstacles

Figure 4: CSLP solutions by genetic algorithm(GA)

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To better match the situation and create feasible approaches, the majority of the prior CSLP research has been carried out from a single layout planner's or project manager's perspective. The results, however, validated the need to integrate CSLP and other pre-planning tasks into centralized and decentralized practical projects when [29] and [18] concentrated on the interactions of the two stakeholders. Motivated by ABM and modified deccan optimization, recent research has integrated multi-stakeholder interactions to validate the benefit of the proposed CSLP-CMLP/SP model in addressing practical problems related to LaP, LoP, and SaM. Additionally, computational analysis was carried out to assess site layout planning from the perspectives of a single planner, two stakeholders, and several stakeholders. The first step was changing the integrated CSLP-CMLP/SP model to a single planner perspective to achieve the optimal solution for comparison. As a result, the two CMLP and SP problem hard constraints were eliminated from the model, which meant that the effects of the LoP and SaM activities were no longer taken into account. The decision variables and corresponding objective functions were then produced by solving the model using a reduced version of the tri-PSO & Ga algorithms, which used the same parameter combinations. The layout plan is depicted graphically in Figures 3 & 4 (b) for the choice variables, and Tables 3 & 4 displays the LaP values for various scenarios for objective function values in two alternative algorithms.

The CSLP problems were then evaluated from a bi-stakeholder point of view by integrating the CSLP-CMLP and CSLP-SP, which was comparable to the study focus in [29], and two comparison scenarios were created. To assess the extent to which the CMLP influenced the CSLP decisions, the CMLP optimization model constraint was kept but the SP optimization model was dropped. To determine how much the SP influenced the CSLP decisions in practical situations, the SP optimization model constraint was kept and the CMLP optimization model was dropped.

Table 3: Results for the different planner perspectives. (Data based on the base article) 26

	Pm			
	Si.gular pa.pcctivc	Bi-slakdioldcrpaspcctivc		Muli-stalo:holdcrpcnpcctfyc
		Sccmrio I	Sccmm2	
TCCSLP	21.747• 10'cNY	23.917• 10'cNY	23.549• *Hl'CNY*	24.735 .,,,.*CNY*
Vaialiom to CSLP from amulHlakchold«pem,ectiyc	+1208%	+3.31%	+4.79'/4	

CNY i< th: basic Clffl>)CY ri ofth: People's **Rq,mlic**of Cima

Table 4: Results for the different planner perspectives. (The information of this paper in the genetic algorithm(GA))

	Pm lives			
ObjcclM:s	SiJ\wrpmpa:tM:	llHlakcboldcrpaspcctivc		lalu:ooldctpaspcctivc
		Sccoariol	Sccoario2	
TCCSLP	23.249 •10'CNf	24.372'10'CNf	24.126•10'*CNY*	25.036 HO'CNf
Vanalilns to CSI.P from amiti-slakeholderpaspective	+7.14'/4	+2.65%	+3.63%	

CNYistbe basic cJmDCylllll oftbe People's Repli>licofChina.

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The model was rather quiet, and the results were worse than the single planner's point of view because only CMLP or SP were taken into account as beneficiaries in the two-stakeholder optimization system. These results, however, are believed to be more applicable than those from a single point of view because they reflect the situation more accurately. Both the site layout plan that takes the CMLP constraint into account and the site layout plan that takes the SP constraint into account is presented in Figures 3 & 4 (c) (d). Tables 3 & 4 show the first scenario that takes into account the CSLP-CMLP problem and the second scenario that takes into account the CSLP-SP problem for the values of the LaP objective function. The site layout plans were not the same, and the objective function values for the multi-stakeholder perspective were 2.65% higher than the bi-stakeholder perspective for scenario 1, 3.63% higher than the bi-stakeholder perspective for scenario 2, and 7.14% higher than the single planner perspective. The results indicated were related to the genetic algorithm. In terms of PSO, the prior one is comparable. These findings led to the following conclusions.
(1) The site layout plan's optimality was compromised by the failure of the involved stakeholders (i.e., one or more) to arrive at individually best solutions, as shown by the fact that both the CSLP decisions and the corresponding objective functions vaiied under the various scenarios. (2) The CSLP-costs increased as the number of stakeholders expanded, which meant that the LaP had to make more compromises to meet the demands of the stakeholders. (3) The bi-stakeholder results for Scenario 1 and Scenario 2 showed that the LoP and the SaM impact degree on the LaP varied; hence, more study is required that focuses more on the crncial factors while attempting to simultaneously solve CSLP and other pre-planning tasks. The aforementioned data are included separately in the basic article generated from the PSO results as well as in the genetic algorithm results table. The results of genetic algorithm and analysis of points a to dare shown in tables 2 and 4 in Figure. 4.

The site layout plans generated from the single- and bi-stakeholder viewpoints were sub-optimum compared to those produced from the multi-stakeholder analysis, according to the practical analysis and discussion. The objective function values were inferior but better suited for practical projects when taking into account the growing effects of the interdependent stakeholders. The case study began with the assumption that possible conflicts during the constrnction stage might be avoided if the interdependencies were purposefully addressed in the planning stage, and that neglecting this conflict resolution would result in an over-optimistic site layout plan. The proposed CSLP-CMLP/SP is focused on correlating, coordinating, and managing the high-level pre-planning tasks to resolve conflicts before the start of construction. However, the rise in stakeholder numbers was accompanied by a rise in computational complexity, indicating that more research was required to detennine the multi-stakeholder numbers without compromising the benefit of multi-stakeholder interaction research and further escalating computational complexity.

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5. Conclusions

CSLP, as one of the most significant problems, calls for the best project management. One of the topics that are covered in project management knowledge is stakeholders and their management. In this study, stakeholder interactions and the CSLP optimal detem1ination were examined. The objective of this study was to use meta-hemistic algorithms to optimize the results of interactions between va1ious stakeholders and the CSLP and to compare the outcomes. The various stakeholders were first modeled as individual factors in a layout optimization model with the corresponding layout cost, profit, and safety level optimization objectives. The p1incipal decision-maker was the LaP, who determines the facilities candidate locations and plans the onsite transport network to reduce CSLP. The LoP designed the materials supply channel to optimize profits, while the SaM designed the safety and health security plan to reduce facilities attacks.

Additionally, the LoP, LaP, and SaM decisions were combined into a bi-level mathematical model with one upper-level decision-maker and two lower-level decision-makers by linking the respective decisions. Multi-stakeholder dependency models were also examined concurrently to measure the interaction between the two stakeholders, CSLP-CMLP and CSLP-SP, and then the multi-stakeholder interaction and its impact were compared with earlier findings.The complexity of the model necessitated an examination of the metaheuristic GA algorithms and a comparison of their results with those of earlier studies using random data. In identical circumstances, PSO's results were more optimal than GA's. The efficiency of the proposed agent-based decentralized model has been verified in accounting for the multi-stakeholder interaction effects, optimizing the LaP total layout costs, the LoP profits, and the SaM safety levels concurrently, and providing a practical integrated solution.

As stated in the introduction and main text, it's critical to focus on the project's most crucial success factors and optimize the project's effectiveness. The findings of this study demonstrated the benefit of integrating many stakeholders to locate a single stakeholder and two beneficiaries in the most advantageous manner. The fonnation of projects on the path to success might result from the combination of a few stakeholders, particularly in significant and essential projects.

As can be observed from this study, various algorithms for a simple paper were examined and yielded noteworthy results. For further study, new stakeholders will be added to the review modes in addition to CSLP, CMLP, and SP, and they will also be examined in other executive projects. Furthermore, a cooperative system might be developed as an application of the decentralized bi-level model to manage the pre-planning tasks generally. A filtration mechanism might be designed to identify stakeholder numbers based on the influence degree because raising the stakeholder numbers may be more practical but more problematic to solve.

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