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*Research Article*

# GA-GDEMATEL: A Novel Approach to Optimize Recruitment and Personnel Selection Problems

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The complexity of human resource management (HRM) requires an integrated method of subjective and objective evaluation rather than intuitive decisions such as multicriteria decision-making (MCDM). This study proposes a hybrid Genetic Algorithm and Decision-Making Trial and Evaluation Laboratory (GA-GDEMATEL)-based grey theory systems approach to solve personnel selection problems in a real-case study from a Vietnamese agriculture manufacturing and services corporation. First, the GDEMATEL approach is deployed to investigate the causal relationship between the proposed criteria and determine the subjective weights of recruitment criteria. Second, the GA model utilizes selection, crossover, and mutation with a new objective function of Minimizing Distance to Ideal Solution (MDIS) to find the optimal solution for robust recruitment based on GDEMATEL weights. Notably, the GA-GDEMATEL could be exploited effectively in a short time to optimize personnel selection in "deep and wide" aspects. Moreover, the study's findings on recruiting evaluation and selection problems provide a support model and new research perspectives to the literature and help managers achieve the best solution by dealing with qualitative and quantitative criteria more effectively.

## 1. Introduction

*1.1. Human Resource Management (HRM).* Human resource management (HRM) has traditionally been characterized as a composite of organizational practices, rules, and procedures to manage all personnel involved in driving business performance and establishing a competitive advantage, typically carried out by a human resource (HR) department. The result of effectively managing human resources is an enhanced ability to attract and retain qualified employees motivated to perform. The results of having the right employees motivated to perform are numerous. They include greater profitability, low staff turnover, higher product quality, lower production costs, and more rapid acceptance and implementation of corporate strategy [1, 2]. Labor markets have become more demanding since organizations require qualified, motivated employees due to technological advancements and globalization. HRM is therefore concerned with attracting, hiring, retaining, and growing a workforce that meets the organization's needs. Based on internal estimates, business-relevant insights, and obstacles, long-term human resource needs are matched with supply prospects [2, 3].

Indeed, external recruiting is essential when current employees cannot fill existing positions. Personnel selection aims at assessing whether applicants possess the knowledge, skills, and abilities required to function effectively in a particular field. To do this, the selection approach often comprises a wide range of examinations. In fact, it is an intricate organizational function that specifies the flow of candidates into and out of an organization to increase productivity [4]. Consequently, personnel selection is perceived as a critical activity in organizations that serve the company's goals at various levels. The agriculture sector is possibly the key to addressing poverty, economic and political stability, and rapid economic growth [5].

In the last decades, the Vietnamese agriculture sector has achieved remarkable progress, from being driven by hunger to being a leading exporter of coffee, cashew nuts, and rice. Following the government's Agricultural Restructuring Plan (ARP), the sector expects to generate more additional value while minimizing the use of human resources and intermediary inputs. Accordingly, many agricultural businesses reform the sector by mechanizing the farming process and applying advanced technologies for increased productivity. Human resource development is critical to the success of agricultural and rural development in general and the production, processing, and distribution of food crops and commodities in particular. Even if all other vital components, such as land, water, production inputs, and finance—are available, only a minor impact can be achieved without skilled farmers, trained employees, good administrators, and support staff [6]. However, there is a shortage of high-skilled agricultural labor. This is due in part to farmers' low adaptation to new technologies. When businesses advertise in labor markets to attract candidates with the required qualities, the recruiting process is often referred to as personnel assessment and selection issues. Potential candidates may be from inside or outside the organizations. In a competitive working environment, many of the most successful and distinguished organizations have been endorsed for their personnel's capability and skills. Proper personnel selection influences a sustainable working environment directly or influences it through intermediaries. In a nutshell, this research study addresses the following questions:

(i) What are the critical criteria affecting personnel selection in the agricultural sector?

(ii) What are the prominent criteria that need to be addressed?

(iii) What are the cause-effect relationships and weights of the identified criteria?

(iv) How to rank and select the best candidate among many applicants?

Accordingly, various studies have shown that the primary factors influencing a professional's performance are physical, social, cognitive, behavioral, working environment, and external factors. Indeed, the personnel selection problem's difficulty and critical task necessitate using a robust and analytical systematic approach. In real-world situations, most problems have more than one choice criterion. As a result, multicriteria decision-making (MCDM) approaches have been proposed to handle complicated issues. It is stated that researchers prioritized MCDM over the other alternative methods due to its potential to promote transparency [7, 8]. The goal of MCDM is to identify overall preferences among various solutions. MCDM approaches can outrank alternatives or decide the final decision, depending on the purpose [9–13]. MCDM methods have been applied for solving many problems in various industries, such as hotel and hospitality [14, 15], import-exporting activities [16, 17], supply chain management [18, 19], and finance and banking [20, 21], as well as being suitable approaches for dealing with recruitment and personnel selection [22]. Due to the ambiguity and complexity of decision problems, the difficulties of MCDM are constantly paired with uncertain and fuzzy topics. Therefore, fuzziness is a crucial component that must be considered in real-world decision-making. The grey system theory (GST) assumes that detailed information obtained by decision-makers or researchers may be partially unknown, uncertain, or inadequate. The GTS is appropriate for resolving problems involving complex interrelationships between various elements [23, 24]. Therefore, it is incorporated into diverse research areas, including personnel selection, where job applicants possess different skills and capabilities. Consequently, real-world decision-making problems are frequently ambiguous, known as grey MCDM problems. Although various investigations into analyzing effect factors based on the fuzzy and grey theories have been conducted, they rarely take into account the relative weights of different influencing elements and, in the lack of expertise, simply utilize the usual fuzzy number functions to evaluate the linguistic [23].

*1.2. Research Gaps and Motivations.* It is well noted that the personnel evaluation is a group decision-making issue. In the existing studies, the weights of criteria are often determined by AHP [25], entropy [26], and SWARA [22] techniques based on experts' experience, knowledge, and educational background. Accordingly, interpretive structural modeling (ISM) and DEMATEL are extensively used among the effective MCDM models. ISM and DEMATEL are often preferable to AHP when evaluating dependent components. In addition, DEMATEL is superior to ISM with a limited sample number of respondents since it offers the total degree of factor influence by decomposing features into cause-effect factors and identifying criteria weights [27]. In addition, combining GTS and DEMATEL can help decision-makers account for the ambiguous and incomplete information intrinsic to human judgments. Therefore, this study aims at filling this gap in the literature by not only proposing a causal relationship framework for enhancing HRM assessment capabilities but also identifying the relative weights of critical factors affecting applicants' performance by employing a DEMATEL-based GTS approach.

Genetic algorithm (GA) is a method for optimizing search tools for challenging tasks based on the genetic selection principle. It also serves the purposes of machine learning and research and development, in addition to optimization. It is analogous to biology for the formation of chromosomes, with variables such as selection, crossover, and mutation constituting genetic processes that may initially be applied to a random population [28–31]. GA aspires to produce solutions for future generations. Individual production success is directly proportional to the fitness of the solution it represents, assuring that the quality of subsequent generations will increase. The procedure concludes when a genetic algorithm is an optimal solution for optimizing the challenges linked to a computerized system. Personnel selection is regarded as a multicriteria human resource decision-making problem due to its complicated, time-consuming, and multifaceted structure with qualitative and quantitative factors to examine [32–35]. In this regard, the personnel selection problem calls for a framework encompassing functional and objective assessments rather than just subjective decisions.

Although there are many methods for selecting employees in the literature currently in existence, little study has been carried out on developing a "deep" and "wide" framework that combines subjective and objective data for analyzing the critical factors affecting staff selection. By providing a novel framework that elucidates the relationship between essential factors that influence personnel selection and identifies the top applicant for an open post in an agricultural organization, this study seeks to address this flaw and close the research gap.

To our best knowledge, this research first proposes a hybrid GA and grey-based DEMATEL (GA-GDEMATEL) approach for personnel selection to provide a broad and detailed list of potential criteria. In this study, the GDEMATEL method is proposed to prioritize the proposed criteria, and the interrelationships among the proposed criteria are illustrated in the cause-effect graphs. In the second stage, the GA model utilizes selection, crossover, and mutation with a new objective function of "Minimizing Distance to Ideal Solution" (MDIS) to find the optimal solution for robust recruitment.

The remainder of this analysis is structured as follows. Section 2 discusses the fundamentals of the GTS, the GDEMATEL model for causal relationships and weights, and GA for staff selection compromise optimization. Section 3 presents an observational case study in personnel assessment. This segment also contains the results and discussion. Finally, Section 4 contains the study's conclusions.

## 2. Literature Review

To explain the need for the literature review and justify our contribution in line with existing literature, previous reviews in the field are summarized in Table 1. It shows that few reviews considered the application of MCDM models for personnel selection. For instance, Dursun and Karsak [36] developed a fuzzy MCDM model using the principles of fusion of fuzzy information, a 2-tuple linguistic representation model, and technique for order preference by similarity to ideal solution (TOPSIS) for personnel selection. In a case study of an air-filter manufacturing company, Kilic et al. [32] integrated DEMATEL and Elimination and Choice Expressing the Reality (ELECTRE) methods under the intuitionistic fuzzy (IF) context to address the personnel selection problem. An extended version of the PIPRECIA-G method has recently been presented to help deal with the unpredictability and obscurity of optimal applicant recruitment. Based on the grey extended MCDM methods, the reliability and confidence of the selection process are improved [37, 38].

Krishankumar et al. proposed a novel extension of the VIKOR method. The suggested method combines the strengths of both interval-valued fuzzy sets and IFS with a simple formulation setup, which is more effective in dealing with vagueness in addressing personnel selection problems. Karabasevic et al. [22] approached the personnel recruitment process by applying the EDAS and SWARA methods. The model's superiority is the flexibility for decision-makers to add criteria and subcriteria depending on recruitment objectives. A key implication of this model is that growth in agricultural productivity is central to development. Low agricultural production might cause significant delays in industrialization. By delaying the onset of industrialization, poor agricultural technologies or policies result in a country's per capita income falling far behind that of the leader. Improvements in agricultural productivity can hasten the start of industrialization and, hence, have a significant impact on a country's relative income.

Dealing with incorrect information without agreement on variable judgment causes uncertainty. The term "uncertainty" has become very popular in decision-making where there are insufficient data, and decision-making participants should qualitatively compare several options. The evolution of qualitative and linguistic variables allows qualitative judgment of decision variables in an uncertain environment brought by fuzzy theories. GTS is a unique extraction of uncertain decision-making. The grey set theory is a practical approach to theoretically analyzing systems with imprecise and imperfect information [46]. The grey relational analysis (GRA) model was widely applied to integrate uncertainty and ambiguity into personnel evaluation [47]. Capaldo and Zollo [39] suggested three group factors, including managerial skills, personnel characteristics, and professional skills, for the reliability of rating scales in personnel assessment.

In his research and development (R & D) department, Dejiang [48] employed the grey theory and the TOPSIS method in an uncertain environment for the research and development (R&D) department. The author recognized the relative closeness of alternative ranking orders by calculating the grey relational grade with eight criteria: job performance, education, job training, work experience, title level, age, innovation capability, and loyalty.

Because of the vagueness and imprecision in the collected information, many researchers considered the personnel selection under a fuzzy environment [14, 21]. Consequently, MCDM methods based on a fuzzy environment and an intuitionistic fuzzy set have also been applied to these issues. The fuzzy set theory can be used to improve the evaluation and weighting of these factors in personnel selection problems. Liang and Wang [44] applied a fuzzy decision-making method to analyze both subjective assessments and objective tests. This study presented an empirical case study for hiring industrial engineers towards eight criteria: leadership, experience, comprehension, oral communication skills, personality, emotional steadiness, self-confidence, and general aptitude.

Zavadskas et al. [45] developed a novel method for dealing with the project manager selection dilemma called Complex Proportional Assessment of Alternatives with Grey Relations (COPRAS-G). They designed the managers' questionnaires using six parameters from a literature study on evaluating and selecting a building project manager. Professional qualities, entrepreneurial skills, analytical skills, project management skills, quality skills, and decision-making time were selected as requirements. Kabak et al. [41]

Table 1: Existing review paper in related fields.

| Authors | Year | Methods | Variables | Objectives |
|---|---|---|---|---|
| Capaldo and Zollo [39] | 2001 | Fuzzy logic | (i) Professional skills<br>(ii) Planning<br>(iii) Organization<br>(iv) Active orientation<br>(v) Emotional stability<br>(vi) Flexibility | To improve the effectiveness of personnel assessment within a large Italian corporation |
| Huang et al. [40] | 2004 | SAW<br>FAHP<br>FNN | (i) Capability trait<br>(ii) Motivational trait<br>(iii) Personality trait<br>(iv) Conceptual skill<br>(v) Interpersonal skill<br>(vi) Technical skill | To develop a decision support system in human resource selection |
| Kabak et al. [41] | 2012 | Fuzzy ANP, fuzzy, TOPSIS, fuzzy, ELECTRE | (i) Physical strength and stamina<br>(ii) Not being a substance abuser<br>(iii) Good health<br>(iv) Rapid decision-making and analytical thinking ability<br>(v) Being good at marksmanship<br>(vi) Ability to control body and concentrate<br>(vii) Emotional stability<br>(viii) Ability to work independently<br>(ix) Patience<br>(x) Calmness | To apply a fuzzy hybrid MCDM approach for professional selection |
| Kundakcı [42] | 2016 | Grey relational analysis | (i) Analytical thinking and problem solving<br>(ii) Results orientation<br>(iii) Initiative<br>(iv) Decision-making<br>(v) Ability to work independently<br>(vi) Influencing and persuading<br>(vii) Teamwork and collaboration<br>(viii) Conflict resolution<br>(ix) Change orientation<br>(x) Planning and organizing<br>(xi) Stress management<br>(xii) Openness to learning and development | To apply grey relational analysis for personnel selection problem of a technology firm |
| Ngo et al. [43] | 2020 | MDSB | | To apply the MDSB algorithm for the selection of students to participate in the international programming contest |
| Liang and Wang [44] | 1994 | Fuzzy set | (i) Emotional steadiness<br>(ii) Leadership<br>(iii) Self-confidence<br>(iv) Oral communication<br>(v) Personality<br>(vi) Past-experience | To propose an algorithm for personnel selection |
| Zavadskas et al. [45] | 2008 | COPRAS-G | (i) Personal skills<br>(ii) Project management skills<br>(iii) Business skills<br>(iv) Technical skills<br>(v) Quality skills<br>(vi) Time of decision-making | To apply grey criteria for the selection of construction project managers |
| Dursun and Karsak [36] | 2010 | OWA, TOPSIS, and BLTS | (i) Emotional steadiness<br>(ii) Leadership<br>(iii) Self-confidence<br>(iv) Oral communication skill<br>(v) Personality<br>(vi) Past- experience<br>(vii) General aptitude<br>(viii) Comprehension | To develop a decision-making model to a multiple information sources problem |

Table 1: Continued.

| Authors | Year | Methods | Variables | Objectives |
|---|---|---|---|---|
| Kilic et al. [32] | 2020 | IF-DEMATEL<br>IF-ELECTRE | (i) Education<br>(ii) Experience<br>(iii) Technical skills<br>(iv) Personality and personal skills<br>(v) Foreign language | To address personnel selection problem at an air-filter manufacturing company |

proposed a sniper selection strategy that combined fuzzy ANP, fuzzy TOPSIS, and fuzzy ELECTRE strategies using qualitative and quantitative considerations. They classified sniper selection criteria into three categories: practical factors, physical factors, and personality factors.

Expert systems models (ESM) were the first induced by an American computer scientist, Edward Albert Feigenbaum, in the 1970s. As a result of the advantages of ESM, many researchers exploited expert systems to solve the personnel selection problem [49–51]. According to advances in information technology, data mining methodologies have been used to automate or semi-automate the exploration and study of vast amounts of data. Data mining is a broad term that encompasses a variety of methods, including analytics, genetic algorithms, neural networks, decision trees, and visualization. As a result, staff records are a priceless pool of information [52, 53]. The binary optimization programming approach has also been used in the literature to identify the ideal candidates for a cricket team. According to Edmondson and Harvey [54], the chosen team wanted to fulfill the bare minimum criteria for specific traditional skills. Ngo et al. [43] suggested a consensus strategy that ignored the decision-making process's criteria and only used algorithms like the CPLEX search algorithm to find the optimum team selection solution. Huang et al. [40] created a decision support method for the human resource selection system using a novel fuzzy neural network (FNN) model for evaluating managerial talent. Their suggested qualifications included aptitude, appearance, inspiration, intellectual capacity, organizational ability, and technological ability. Khorami and Ehsani [55] demonstrated the use of neuro-fuzzy approaches to analyze an organizational database of unemployed individuals and business profile results. The work opportunity is developed using six sectors. Six criteria were used to determine eligibility: age, education, prior employment, training, foreign language proficiency, and computer skills.

Various optimization approaches have been used to find the best human resource management solutions. However, some researchers used multiple objective functions, while others used a single objective junction when it came to the objective function. Heuristic algorithms have also been applied to a variety of problems, most notably staff selection. Numerous studies cited above have focused on linear programming models, which have been popular for various problem types. However, recent trends in human resource planning have resulted in a new development involving the use of various types of algorithms. Among these developments are an increase in the sophistication of decision-making problems and the use of interactive decision support systems. To the author's knowledge, a detailed and comprehensive review of the literature, as shown in Table 1, shows that the GA-GDEMATEL approach is first proposed to solve the personnel evaluation and selection problems. This study highlights some contributions as follows:

(i) This study provides a broad and detailed list of fifteen criteria considered in recruiting and staff selection.
(ii) The GDEMATEL method is proposed to visualize the interrelationships among personnel testing criteria and achieve the subjective weights of criteria.
(iii) The GA integrates subjective weights from the GDEMATEL approach with a new objective function of MDIS that is exploited to identify the best candidates among numerous applicants.

## 3. Methodology

In this section, some essential definitions of the GTS, GA, and proposed GA-GDEMATEL method are briefly presented in the following sections.

*3.1. Introduction to Grey Theory.* Julong [46] pioneered the concept of a grey system in 1989 in response to insufficient knowledge, unquantifiable information, and partial ignorance. The grey theory is often used to resolve issues in an unpredictable world. This study establishes a foundation of grey numbers, grey sets, and grey theory. Figure 1 illustrates the definition of a grey scheme. In the following, this research briefly reviews some essential definitions of the grey theory. The grey theory can be applied to any method that involves imprecise decision-making. Grey values can be quickly transformed to crisp numbers using the fuzzy value to crisp score conversion system.

*Definition 1.* A grey system is defined as a system containing uncertain information presented by a grey number and grey variables as given in Figure 1.

*Definition 2.* Let $X$ be the universal set. Then, a grey set $G$ of $X$ is defined by its two mappings $L_G(x)$ and $R_G(x)$:

$$\begin{cases} L_G(x)\colon x \longrightarrow [0,1], \\ R_G(x)\colon x \longrightarrow [0,1]. \end{cases} \tag{1}$$

$L_G(x) \geq R_G(x), x \in X, X = \mathbb{R}, L_G(x)$ and $R_G(x)$ are the upper and lower membership functions in $G$, respectively. When $L_G(x) = R_G(x)$, the grey set $G$ becomes a fuzzy set. It

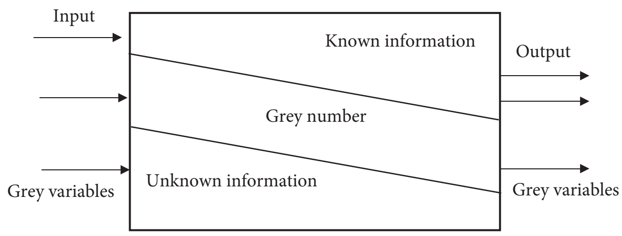


Figure 1: The concept of the grey system.

shows that the grey theory considers the condition of the fuzziness and can deal flexibly with the fuzziness situation.

*Definition 3.* The grey number can be defined as a number with uncertain information. For example, the linguistic variables describe the ratings of attributes; there will be a numerical interval expressing it. This numerical interval will contain uncertain information. Generally, the grey number is written as $\otimes G$, ($\otimes G = G|_R^L$).

*3.1.1. Grey Operations*

(1) Additive operation:

$$\otimes G_1 + \otimes G_2 = \left[G_1^L + G_2^L, G_1^R + G_2^R\right]. \quad (2)$$

(2) Subtraction operation:

$$\otimes G_1 - \otimes G_2 = \left[G_1^L - G_2^L, G_1^R - G_2^R\right]. \quad (3)$$

(3) Multiplication operation:

$$\otimes G_1 \times \otimes G_2 = \left[\min\left(G_1^L G_2^L, G_1^L G_2^R, G_1^R G_2^L, G_1^R G_2^R\right), \max\left(G_1^L G_2^L, G_1^L G_2^R, G_1^R G_2^L, G_1^R G_2^R\right)\right]. \quad (4)$$

(4) Reciprocal operation:

$$\otimes G^{-1} = \left[\frac{1}{G^R}, \frac{1}{G^L}\right]. \quad (5)$$

(5) Division operation:

$$\frac{\otimes G_1}{\otimes G_2} = \otimes G_1 \times \otimes G_2^{-1} = \left[G_1^L, G_1^R\right] \times \left[\frac{1}{G_2^R}, \frac{1}{G_2^L}\right] = \left[\min\left(\frac{G_1^L}{G_2^L}, \frac{G_1^L}{G_2^R}, \frac{G_1^R}{G_2^L}, \frac{G_1^R}{G_2^R}\right), \max\left(\frac{G_1^L}{G_2^L}, \frac{G_1^L}{G_2^R}, \frac{G_1^R}{G_2^L}, \frac{G_1^R}{G_2^R}\right)\right]. \quad (6)$$

(6) Scalar multiplication:

$$k.\otimes G = \left[k.G^L, k.G^R\right]. \quad (7)$$

(7) Scalar power:

$$\otimes G^k = \left[\left(G^L\right)^k, \left(G^R\right)^k\right]. \quad (8)$$

*3.2. Introduction to Genetic Algorithm.* GA was first proposed based on Darwin's evolutionary theory [56]. Subsequently, GA has been applied with a functional search method [57, 58]. GA is useful for problems that are impossible to find exact results by operators of evolution, such as selection, convergence, or mutations. Several steps are used in a GA, as shown in Figure 2 as follows:

Step 1: Randomly generating the initial population set and then defining each gene as an entity from the initial population set.

Step 2: Obtaining the fitness function and determining how much an individual fit by selecting the individual with the higher fitness scores for reproduction.

Step 3: Repeating selection and choosing the ideal individuals for next-generation from Steps 4 to 7 until convergence.

Step 4: Generating a new population at a random point in time using genes from any pair of parents through the crossover mechanism.

Step 5: Mutating a population of GA by inserting random genes from one generation.

Step 6: Achieving the optimal fitness for newly generated populations.

*3.3. Proposed GA-GDEMATEL Approach.* A novel two-phase GA-GDEMATEL approach is proposed for staff assessment and selection, as shown in Figure 2. In phase I, the DEMATEL approach, known as a structural modeling approach, is applied to analyze the cause and effect relationships in numerous studies [59, 60]. Despite its advantages, it lacks significant implications in uncertain, insufficient information contexts [61]. To overcome this drawback, the GDEMATEL approach is applied in this case. In phase II, GA utilizes the subjective weight results of the GDEMATEL technique and then optimizes and searches for an optimal solution to the recruiting and staff selection problem.

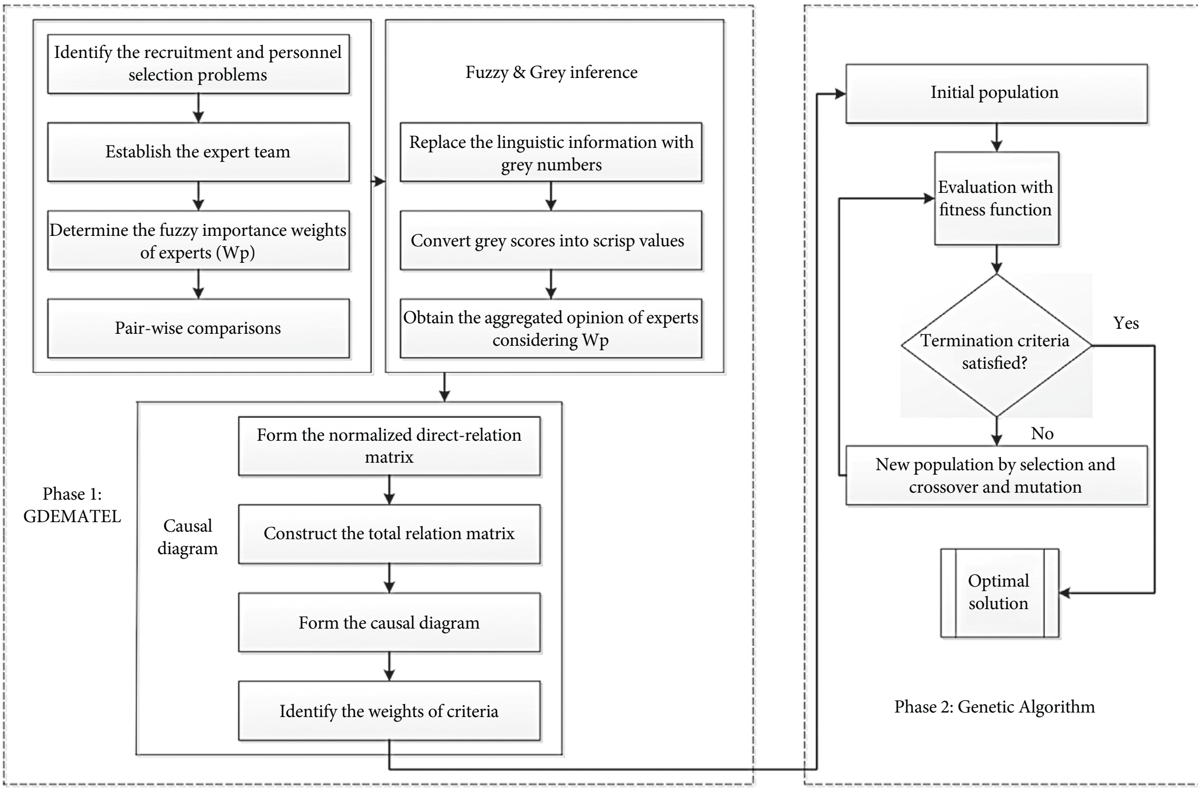


FIGURE 2: Proposed research framework.

Phase I: The process of the GDEMATEL approach is presented as follows:

Step 1: Considering and defining the relationships between criteria of the staff selection process based on experts' opinions. A matrix of direct relationships is constructed in

$$\otimes A = \begin{bmatrix} \otimes G_{11} & \cdots & \otimes G_{1n} \\ \vdots & \ddots & \vdots \\ \otimes G_{m1} & \cdots & \otimes G_{mn} \end{bmatrix} = \begin{bmatrix} \left[G_{11}^{L}, G_{11}^{R}\right] & \cdots & \left[G_{1n}^{L}, G_{1n}^{R}\right] \\ \vdots & \ddots & \vdots \\ \left[G_{m1}^{L}, G_{m1}^{R}\right] & \cdots & \left[G_{mn}^{L}, G_{mn}^{R}\right] \end{bmatrix}. \quad (9)$$

Step 2: The determining criteria for staff selection were constructed using the grey set theory. We are forming a systemic grey direction relationship. $K$ experts use a grey linguistic scale to evaluate criteria $C_i$ (as shown in Table 2).

Step 3: Normalizing the lower and upper bounds using the grey values as given in the following equations:

$$\Delta_{\min}^{\max} = \max G_{ij}^{R} - \min G_{ij}^{L}, \quad (10)$$

$$X_{G_{ij}^{L}}^{*} = \frac{G_{ij}^{L} - \min G_{ij}^{L}}{\Delta_{\min}^{\max}}, \quad (11)$$

$$X_{G_{ij}^{R}}^{*} = \frac{G_{ij}^{R} - \min G_{ij}^{R}}{\Delta_{\min}^{\max}}. \quad (12)$$

Step 4: Computing the total normalized crisp value using the following equations:

$$Y_{G_{ij}}^{\text{Crisp}} = \frac{\left(X_{G_{ij}^{L}}^{*} x \left(1 - X_{G_{ij}^{L}}^{*} x\right) + \left(X_{G_{ij}^{R}}^{*} x X_{G_{ij}^{R}}^{*}\right)\right)}{1 - X_{G_{ij}^{L}}^{*} x + X_{G_{ij}^{R}}^{*}}, \quad (13)$$

$$Z_{G_{ij}}^{*} = \min X_{G_{ij}^{L}}^{*} + Y_{G_{ij}}^{\text{Crisp}} x \Delta_{\min}^{\max}. \quad (14)$$

Step 5: Hence, $k$ direct-relation grey matrices ($Z^1$, $Z^2$, ..., $Z^k$) of $k$ expert are obtained. Then, the average grey direct-relation matrix is taken by

$$Z = \frac{\sum_{i=1}^{k} Z_{G_{ij}}^{*}}{k}. \quad (15)$$

Table 2: Linguistic grey assessment.

| Values | Linguistic assessment | Grey values $(G^L_{(x)}, G^R_{(x)})$ |
|---|---|---|
| 0 | No influence | (0.0, 0.1) |
| 1 | Very low influence | (0.1, 0.3) |
| 2 | Low influence | (0.2, 0.5) |
| 3 | Medium influence | (0.4, 0.7) |
| 4 | High influence | (0.6, 0.9) |
| 5 | Very high influence | (0.9, 1.0) |

Step 6: Normalizing the initial direct-relation matrix. $D$ is denoted as a normalized initial direct-relation matrix, and $S$ is denoted as the auxiliary parameter for normalizing the initial direct-relation matrix as given in the following equations:

$$S = \max\left[\max_{1<i<n} \sum_{1<j<n}^{n} Z_{ij}; \max_{1<j<n} \sum_{1<i<n}^{n} Z_{ij}\right], \quad (16)$$

$$D = \frac{Z}{S}. \quad (17)$$

Step 7: Calculating the total relation matrix $T$. The powers of $D$ represent the indirect effects between any two factors. $T$ is denoted as the total relation matrix and $I$ is denoted as the identity matrix. Then, the total relation matrix $T$ can be calculated by the following equation:

$$T = \left[T_{G_{ij}}\right]_{nxn} = \left[T^L_{G_{ij}}; T^R_{G_{ij}}\right]_{nxn} = D + D^2 + D^3 + .. + D^{\infty}, \quad (18)$$

$$T^L_G = \left[T^L_{G_{ij}}\right]_{nxn} = D^L x\left(I - D^L\right)^{-1}, \quad (19)$$

$$T^R_G = \left[T^R_{G_{ij}}\right]_{nxn} = D^R x\left(I - D^R\right)^{-1}, \quad (20)$$

$$D^L = \left[d^L_{G_{ij}}\right]_{nxn}, \quad (21)$$

$$D^R = \left[d^R_{G_{ij}}\right]_{nxn}. \quad (22)$$

Step 8: Determining the prior sequence of the factors from most to least important, and identifying the cause-effect relations. The total effect that is directly and indirectly exerted by the i$^{\text{th}}$ factor is denoted by $R_i$. The total effect including direct and indirect effects received by the j$^{\text{th}}$ factor is denoted by $D_j$. The value of $(R_i + D_j)$, $(R_i - D_j)$ is established using the following equation:

$$R_i = \sum_{j=1}^{n} T_{G_{ij}}, \quad (23)$$

$$D_j = \sum_{i=1}^{n} T_{G_{ij}}. \quad (24)$$

The sum $(R_i + D_j)$ represents the total effects given and received by the $i^{\text{th}}$ factor. In other words, $(R_i + D_j)$ is a measure of the degree of the importance of the $i^{\text{th}}$ factor in the system. The prior sequence of the $n$ factors could be determined based on the value of $(R_i + D_j)$. The bigger the value of $(R_i + D_j)$, the more important the factor is. The difference $(R_i - D_j)$ is called relation. It shows the net effect that is contributed by the $i^{\text{th}}$ factor to the system. When $(R_i - D_j) > 0$, the $i^{\text{th}}$ factor is a net cause, which means the factor belongs to the "cause group." On the contrary, when $(R_i - D_j) < 0$, the $i^{\text{th}}$ factor is a net receiver/result, which means the factor belongs to the "effect group." The fuzzy numbers were converted to crisp values by taking the average. The results were validated through feedbacks from industrial and academic experts. The causal relationship diagram will then be used to illustrate the influencing aspects.

Step 9: The GDEMATEL method establishes hierarchical relationships between the evaluated items, which is a prerequisite for using GDEMATEL for requirement weighting. In this analysis, we assess criteria weights using the findings of GDEMATEL with the following equations:

$$W_{C_i} = \sqrt{(Ri + Dj)^2 + (Ri - Dj)^2}, \quad (25)$$

$$W^{\text{nor}}_{C_i} = \frac{W_{C_i}}{\sum_{i=1}^{n} W_{C_i}}. \quad (26)$$

Phase II: GA utilizes selection, crossover, and mutation with a new objective function of MDIS based on the Euclidean distance technique (EDBA) as a fitness function to find the optimal solution for robust recruitment and personnel selection. It is suggested that MDIS be applied to minimize the distance between groups of 10 candidates and the ideal combination of the best candidates. The MDIS is proposed as follows:

$X_i = (0, 1)$ with $i = 1, 2, \ldots, k$; where $X_i = 1$ if candidate $i^{\text{th}}$ is selected; otherwise, $X_i = 0$;
$W_j$ with $j = 1, 2, \ldots, n$; where $W_j$ is the weight of $j^{\text{th}}$ testing criteria;
$R_{ij}$ with $i = 1, 2, \ldots, k$; $j = 1, 2, \ldots, n$, then $R_{ij}$ is the score of $i^{\text{th}}$ candidates for $j^{\text{th}}$ testing criteria;
$B_j$ is sum scores of top 10 candidates, which has the highest scores for $j^{\text{th}}$ testing criteria;
$\sum_{i=1}^{k} X_i = m$; with $m$ is the number of members in a selected team when $X_i = 1$;
$Z_j$ is the minimum value of $B_j$ that a selected team must obtain;
$C$ is the maximum salary budget for a selected team, and $C_i$ is the expected salary of $i^{\text{th}}$ candidate as given in (27):
Objective function:

$$Min\left[d(B,P)=\sqrt{\sum_{j=1}^{n}\left(B_j-\sum_{i=1}^{k}\left(R_{ij}*W_j*X_i\right)\right)^2}\right]$$

$$= \text{Subject to: } \begin{array}{l}\sum_{i=1}^{k}\left(R_{ij}*X_i\right)\geq Z_j;\\ \sum_{i=1}^{k}\left(X_i*C_i\right)\leq C;\end{array}. \quad (27)$$

Step 7: Defining $p_{i,j}^{(g)}$ as the candidate $j^{th}$ in the group $p_i^{(g)}$; $p_i^{(g)}=\left\{p_{i,1}^{(g)},p_{i,2}^{(g)},\ldots,p_{i,m}^{(g)}\right\}$ with $i=1,\ 2,\ \ldots,\ k$ and $k$ is the number of individuals in $g^{\text{th}}$ generation.

(1) Fitness function denoted the same objective function $=\sqrt{\sum_{j=1}^{n}(B_j-\sum_{i=1}^{k}R_{i,j}*W_j*X_i)^2}$.
(2) Denoting a set of candidates as $T$. Number of generations as $G$, which have the same fitness values.
(3) The process of GA with MDIS is given as follows:

Step 8: Building the set of the initial population of $k$ candidates from $T$ randomly.
Step 9: Selection: $r$ is the elitism rate among $k$ candidates with the higher fitness scores for the reproduction of next-generation, best fitness scores of the $g^{th}$ generation as $b^g$.
Step 10: Crossover: L is the crossover rate of the candidates with higher fitness scores as $S$.
Step 11: Selecting $p_{\text{parents}}^{(g)}$ from S randomly. Repeatedly selecting the ideal individuals for next-generation until convergence.

(i) Defining $P$ as the probability of dominant (dom) individual the position $j^{th}$ in the $p_i^{(g+1)}$ as shown in the following equation:

$$P\left(\text{dominant}=\operatorname{argmax}_{z\in\left\{p_{\text{parent},j}^{(g)}\right\}}\left(\sum_{s=1}^{n}R_{z,s}\right)\right). \quad (28)$$

(ii) Define rec as the probability of recessive individual the position $j^{th}$ in $p_i^{(g+1)}$ in the following equation:

$$P\left(\text{recessive}=\left\{p_{\text{parent},j}^{(g)}\right\}-\{\text{dominant}\}\right). \quad (29)$$

(iii) Defining mut as the mutation rate for the position $j^{th}$ in the $p_i^{(g+1)}$, and $P$ is the probability that a randomly considered candidate in a set of candidates of $T$ as above mentioned (30):

$$\text{Mut}=P(T). \quad (30)$$

(iv) Selecting $(a,\ b,\ c)$ is the function based on $j^{\text{th}}$ individuals in the following equation (31):

$$\begin{aligned}\rho_{i,j}^{(g+1)}&=\text{select}(\text{dom},\text{rec},\text{mut})\,\forall i\\&=1\ldots(Q-(Q*L))\,j\\&=1.m;\ \text{where dom}+\text{rec}+\text{mut}=1.\end{aligned} \quad (31)$$

Step 12: Validating constraints: if any candidate $\rho_i$ does not meet the requirement of one of MDIS constraints, it is deleted.
Step 13: Creating replication two times, three times, and four times until convergence and getting the optimal group of 10 ideal candidates for personnel selection problem and then ranking 10 alternatives for planned positions.

## 4. Case Study

*4.1. Proposed Data.* The proposed framework in this study was practically tested in the Leading Agriculture Manufacturing and Services Corporation in Vietnam. For confidentiality reasons, the case study corporation is denoted as the abbreviation "ABC" for recruitment and personnel selection. This company has both local and overseas activities in Vietnam and Asia. ABC recently faced some issues related to businesses and operational management due to problems with stakeholders under the COVID-19 impacts. ABC planned to make some significant modifications in their personnel evaluation and selection strategies, after that. Thus, staff screening and recruiting procedures are critical in assisting managers in considering and assigning applicants to corporation-related duties. A panel of expert was conducted to identify the critical criteria affecting the staff recruitment and selection. Additionally, five experts have indulged in the research and teaching on the agricultural industry for more than ten years. After having a comprehensive review from various previous studies in the existing literature, the panel of experts considers a sets of 15 critical criteria, which affects the staff recruitment and selection as shown in Table 3.

The application of the proposed approach to the case study is elaborated as follows:

Step 1: A committee of four decision-makers (DMs) was created to consider and review staff hiring criteria in light of ABC's particular requirements. The DMs chosen were specialists with a minimum of ten years of experience. They have chosen to take into consideration the 15 criteria based on previous literature and the ABCs' recruiting requirements in Table 4. They precisely assessed the direct impact of criteria on linguistic evaluations ranging from "no influence" to "very high influence." Based on the numerical scale scores, four initial relation matrices were formed.

Step 2: Based on the influence scores obtained four preliminary grey relationship matrices were suggested.

Step 3: Equal weightings were applied to all experts, and the grey relation matrix is averagely calculated by normalizing the lower and upper bounds using Equation (10)-(12). The average grey value matrix is shown in Table 4.

Step 4: Convert the average grey relational matrix into a crisp relation matrix using Equation (13)-(14), as shown in Table 5.

Table 3: Proposed criteria.

| Code | Criteria | Explanation | References |
|---|---|---|---|
| C1 | Professional experience | Professional experience is experience gained via full-time employment in an educationally related field or a field in which the applicant aspires to become licenced. | [62] |
| C2 | Degrees | A degree is a credential granted to students who have successfully completed a course of study in higher education, typically in a college or university. | [63] |
| C3 | Teamwork skills | A process that is more concerned with how team members interact than with the team's ultimate success or the quality of its final result. | [64] |
| C4 | Analytic thinking | Analytic thinking relates to having less traditional moral values, making less emotional or disgust-based moral judgments, and being less cooperative and more rationally self-interested in social dilemmas. | [65] |
| C5 | Salary | An employee's annual compensation, or one of the payments they receive monthly, for doing their duties. | [66] |
| C6 | Technology usage | Refers to technological readiness, preparedness. | [67] |
| C7 | Leadership | Leadership is defined as the process of inspiring people to work together collaboratively to achieve great things. | [68] |
| C8 | Productivity | Refers to the amount of output acquired from a set of inputs. | [69] |
| C9 | Emotional steadiness | The act of controlling one's impulses by the use of one's "self" or "ego." | [70] |
| C10 | Deadline management | Relates to the effective control of time towards the final goals. | [71] |
| C11 | Oral communication | The verbal conversation between two or more people is referred to as oral communication. | [72] |
| C12 | Self-confidence | Implies that one knows his/her weaknesses and strengths well, and the abilities to succeed. | [73] |
| C13 | Lifelong learning | The continuous process of learning, growing, developing, and acquiring knowledge throughout the whole life. | [73] |
| C14 | Foreign languages | Foreign language is a language that is not generally spoken in the native speaker's country. However, a clear distinction must be made between the foreign language and the second language. It is also a language that is not spoken in the person's own country. | [73] |
| C15 | Training fee | Training costs include the actual materials created or utilized for training and time spent in each training module or conference. | [74] |

Table 4: Average grey value matrix.

| Criteria | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 0, 0.1 | 0.1 | 0.4 | 0.2 | 0.6 | 0.1 | 0.1 | 0 | 0.025 | 0.1 | 0.4 | 0.225 | 0.1 | 0.2 | 0.45 |
| | 0.1 | 0.3 | 0.7 | 0.5 | 0.9 | 0.3 | 0.3 | 0.1 | 0.15 | 0.3 | 0.7 | 0.5 | 0.3 | 0.5 | 0.75 |
| C2 | 0.4 | 0.025 | 0.6 | 0.4 | 0.2 | 0.6 | 0.1 | 0.1 | 0 | 0.1 | 0.4 | 0.25 | 0.1 | 0.4 | 0.2 |
| | 0.7 | 0.15 | 0.9 | 0.7 | 0.5 | 0.9 | 0.3 | 0.3 | 0.1 | 0.3 | 0.7 | 0.55 | 0.3 | 0.7 | 0.5 |
| C3 | 0.2 | 0.6 | 0 | 0.9 | 0.6 | 0.4 | 0.25 | 0.175 | 0.125 | 0.2 | 0.6 | 0.35 | 0.25 | 0.6 | 0.4 |
| | 0.5 | 0.9 | 0.1 | 1 | 0.9 | 0.7 | 0.55 | 0.45 | 0.35 | 0.5 | 0.9 | 0.65 | 0.55 | 0.9 | 0.7 |
| C4 | 0.225 | 0.2 | 0.9 | 0 | 0.6 | 0.6 | 0.4 | 0.9 | 0.2 | 0.075 | 0.2 | 0.2 | 0.4 | 0.4 | 0.6 |
| | 0.45 | 0.5 | 1 | 0.1 | 0.9 | 0.9 | 0.7 | 1 | 0.5 | 0.25 | 0.5 | 0.5 | 0.7 | 0.7 | 0.9 |
| C5 | 0.1 | 0.2 | 0.2 | 0.2 | 0 | 0.1 | 0.1 | 0.2 | 0.1 | 0.2 | 0.35 | 0.175 | 0.1 | 0.6 | 0.4 |
| | 0.3 | 0.5 | 0.5 | 0.5 | 0.1 | 0.3 | 0.3 | 0.5 | 0.3 | 0.5 | 0.65 | 0.45 | 0.3 | 0.9 | 0.7 |
| C6 | 0.2 | 0.25 | 0.4 | 0.45 | 0.4 | 0 | 0.6 | 0.4 | 0.4 | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.4 |
| | 0.5 | 0.55 | 0.7 | 0.75 | 0.7 | 0.1 | 0.9 | 0.7 | 0.7 | 0.5 | 0.5 | 0.5 | 0.7 | 0.7 | 0.7 |
| C7 | 0.2 | 0.175 | 0.4 | 0.6 | 0.6 | 0.4 | 0.05 | 0.6 | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.6 | 0.6 |
| | 0.5 | 0.45 | 0.7 | 0.9 | 0.9 | 0.7 | 0.2 | 0.9 | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | 0.9 | 0.9 |
| C8 | 0.2 | 0.2 | 0.2 | 0.6 | 0.6 | 0.2 | 0.2 | 0 | 0.2 | 0.4 | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 |
| | 0.5 | 0.5 | 0.5 | 0.9 | 0.9 | 0.5 | 0.5 | 0.1 | 0.5 | 0.7 | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 |
| C9 | 0.1 | 0.1 | 0.2 | 0.2 | 0.2 | 0.075 | 0.175 | 0.2 | 0.025 | 0.2 | 0.2 | 0.2 | 0.1 | 0.2 | 0.6 |
| | 0.3 | 0.3 | 0.5 | 0.5 | 0.5 | 0.25 | 0.4 | 0.5 | 0.15 | 0.5 | 0.5 | 0.5 | 0.3 | 0.5 | 0.9 |
| C10 | 0.1 | 0.075 | 0.125 | 0.2 | 0.4 | 0.2 | 0.1 | 0.2 | 0.125 | 0 | 0.2 | 0.2 | 0.4 | 0.4 | 0.5 |
| | 0.3 | 0.25 | 0.35 | 0.5 | 0.7 | 0.5 | 0.3 | 0.5 | 0.35 | 0.1 | 0.5 | 0.5 | 0.7 | 0.7 | 0.8 |
| C11 | 0.1 | 0.1 | 0.2 | 0.2 | 0.4 | 0.15 | 0.2 | 0.2 | 0.2 | 0.25 | 0 | 0.4 | 0.9 | 0.6 | 0.4 |
| | 0.3 | 0.3 | 0.5 | 0.5 | 0.7 | 0.4 | 0.5 | 0.5 | 0.5 | 0.55 | 0.1 | 0.7 | 1 | 0.9 | 0.7 |
| C12 | 0.075 | 0.1 | 0.2 | 0.2 | 0.4 | 0.4 | 0.4 | 0.2 | 0.2 | 0.6 | 0.4 | 0 | 0.6 | 0.55 | 0.45 |
| | 0.25 | 0.3 | 0.5 | 0.5 | 0.7 | 0.7 | 0.7 | 0.5 | 0.5 | 0.9 | 0.7 | 0.1 | 0.9 | 0.85 | 0.75 |
| C13 | 0.1 | 0.1 | 0.45 | 0.25 | 0.2 | 0.2 | 0.2 | 0.45 | 0.2 | 0.2 | 0.6 | 0.2 | 0.025 | 0.6 | 0.4 |
| | 0.3 | 0.3 | 0.75 | 0.55 | 0.5 | 0.5 | 0.5 | 0.75 | 0.5 | 0.5 | 0.9 | 0.5 | 0.15 | 0.9 | 0.7 |
| C14 | 0.075 | 0.125 | 0.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.4 | 0.4 | 0.6 | 0 | 0.4 |
| | 0.25 | 0.35 | 0.7 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.7 | 0.7 | 0.9 | 0.1 | 0.7 |
| C15 | 0.45 | 0.5 | 0.45 | 0.6 | 0.6 | 0.4 | 0.45 | 0.55 | 0.6 | 0.6 | 0.4 | 0.4 | 0.55 | 0.6 | 0 |
| | 0.75 | 0.8 | 0.75 | 0.9 | 0.9 | 0.7 | 0.75 | 0.85 | 0.9 | 0.9 | 0.7 | 0.7 | 0.85 | 0.9 | 0.1 |

Table 5: Initial crisp relation matrix.

| Criteria | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 0 | 0.112 | 0.5 | 0.267 | 0.746 | 0.12 | 0.106 | 0 | 0.027 | 0.12 | 0.509 | 0.29 | 0.111 | 0.273 | 0.568 |
| C2 | 0.527 | 0.025 | 0.733 | 0.5 | 0.273 | 0.746 | 0.106 | 0.118 | 0 | 0.12 | 0.509 | 0.332 | 0.111 | 0.509 | 0.273 |
| C3 | 0.284 | 0.725 | 0 | 0.9 | 0.746 | 0.509 | 0.302 | 0.227 | 0.156 | 0.273 | 0.746 | 0.45 | 0.311 | 0.746 | 0.509 |
| C4 | 0.275 | 0.259 | 0.9 | 0 | 0.746 | 0.746 | 0.475 | 0.9 | 0.273 | 0.086 | 0.273 | 0.273 | 0.484 | 0.509 | 0.746 |
| C5 | 0.124 | 0.259 | 0.267 | 0.267 | 0 | 0.12 | 0.106 | 0.267 | 0.12 | 0.273 | 0.45 | 0.231 | 0.111 | 0.746 | 0.509 |
| C6 | 0.284 | 0.316 | 0.5 | 0.558 | 0.509 | 0 | 0.705 | 0.5 | 0.509 | 0.273 | 0.273 | 0.273 | 0.484 | 0.509 | 0.509 |
| C7 | 0.284 | 0.218 | 0.5 | 0.733 | 0.746 | 0.509 | 0.05 | 0.733 | 0.509 | 0.509 | 0.509 | 0.509 | 0.484 | 0.746 | 0.746 |
| C8 | 0.284 | 0.259 | 0.267 | 0.733 | 0.746 | 0.273 | 0.245 | 0 | 0.273 | 0.509 | 0.746 | 0.746 | 0.714 | 0.746 | 0.746 |
| C9 | 0.124 | 0.112 | 0.267 | 0.267 | 0.273 | 0.086 | 0.191 | 0.267 | 0.027 | 0.273 | 0.273 | 0.273 | 0.111 | 0.273 | 0.746 |
| C10 | 0.124 | 0.08 | 0.153 | 0.267 | 0.509 | 0.273 | 0.106 | 0.267 | 0.156 | 0 | 0.273 | 0.273 | 0.484 | 0.509 | 0.627 |
| C11 | 0.124 | 0.112 | 0.267 | 0.267 | 0.509 | 0.193 | 0.245 | 0.267 | 0.273 | 0.332 | 0 | 0.509 | 0.878 | 0.746 | 0.509 |
| C12 | 0.089 | 0.112 | 0.267 | 0.267 | 0.509 | 0.509 | 0.475 | 0.267 | 0.273 | 0.746 | 0.509 | 0 | 0.714 | 0.686 | 0.568 |
| C13 | 0.124 | 0.112 | 0.558 | 0.325 | 0.273 | 0.273 | 0.245 | 0.558 | 0.273 | 0.273 | 0.746 | 0.273 | 0.025 | 0.746 | 0.509 |
| C14 | 0.089 | 0.146 | 0.5 | 0.267 | 0.273 | 0.273 | 0.245 | 0.267 | 0.273 | 0.273 | 0.509 | 0.509 | 0.714 | 0 | 0.509 |
| C15 | 0.587 | 0.609 | 0.558 | 0.733 | 0.746 | 0.509 | 0.533 | 0.675 | 0.746 | 0.746 | 0.509 | 0.509 | 0.657 | 0.746 | 0 |

Table 6: Normalized initial direct-relation matrix.

| I-P | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 0.000 | 0.013 | 0.056 | 0.030 | 0.084 | 0.014 | 0.012 | 0.000 | 0.003 | 0.014 | 0.057 | 0.033 | 0.013 | 0.031 | 0.064 |
| C2 | 0.059 | 0.003 | 0.083 | 0.056 | 0.031 | 0.084 | 0.012 | 0.013 | 0.000 | 0.014 | 0.057 | 0.037 | 0.013 | 0.057 | 0.031 |
| C3 | 0.032 | 0.082 | 0.000 | 0.102 | 0.084 | 0.057 | 0.034 | 0.026 | 0.018 | 0.031 | 0.084 | 0.051 | 0.035 | 0.084 | 0.057 |
| C4 | 0.031 | 0.029 | 0.102 | 0.000 | 0.084 | 0.084 | 0.054 | 0.102 | 0.031 | 0.010 | 0.031 | 0.031 | 0.055 | 0.057 | 0.084 |
| C5 | 0.014 | 0.029 | 0.030 | 0.030 | 0.000 | 0.014 | 0.012 | 0.030 | 0.014 | 0.031 | 0.051 | 0.026 | 0.013 | 0.084 | 0.057 |
| C6 | 0.032 | 0.036 | 0.056 | 0.063 | 0.057 | 0.000 | 0.080 | 0.056 | 0.057 | 0.031 | 0.031 | 0.031 | 0.055 | 0.057 | 0.057 |
| C7 | 0.032 | 0.025 | 0.056 | 0.083 | 0.084 | 0.057 | 0.006 | 0.083 | 0.057 | 0.057 | 0.057 | 0.057 | 0.055 | 0.084 | 0.084 |
| C8 | 0.032 | 0.029 | 0.030 | 0.083 | 0.084 | 0.031 | 0.028 | 0.000 | 0.031 | 0.057 | 0.084 | 0.084 | 0.081 | 0.084 | 0.084 |
| C9 | 0.014 | 0.013 | 0.030 | 0.030 | 0.031 | 0.010 | 0.022 | 0.030 | 0.003 | 0.031 | 0.031 | 0.031 | 0.013 | 0.031 | 0.084 |
| C10 | 0.014 | 0.009 | 0.017 | 0.030 | 0.057 | 0.031 | 0.012 | 0.030 | 0.018 | 0.000 | 0.031 | 0.031 | 0.055 | 0.057 | 0.071 |
| C11 | 0.014 | 0.013 | 0.030 | 0.030 | 0.057 | 0.022 | 0.028 | 0.030 | 0.031 | 0.037 | 0.000 | 0.057 | 0.099 | 0.084 | 0.057 |
| C12 | 0.010 | 0.013 | 0.030 | 0.030 | 0.057 | 0.057 | 0.054 | 0.030 | 0.031 | 0.084 | 0.057 | 0.000 | 0.081 | 0.077 | 0.064 |
| C13 | 0.014 | 0.013 | 0.063 | 0.037 | 0.031 | 0.031 | 0.028 | 0.063 | 0.031 | 0.031 | 0.084 | 0.031 | 0.003 | 0.084 | 0.057 |
| C14 | 0.010 | 0.016 | 0.056 | 0.030 | 0.031 | 0.031 | 0.028 | 0.030 | 0.031 | 0.031 | 0.057 | 0.057 | 0.081 | 0.000 | 0.057 |
| C15 | 0.066 | 0.069 | 0.063 | 0.083 | 0.084 | 0.057 | 0.060 | 0.076 | 0.084 | 0.084 | 0.057 | 0.057 | 0.074 | 0.084 | 0.000 |

Step 5: Table 6 presents the initial direct-relation matrix, which was normalized using Equation (16)-(17)

Step 6: The total relation matrix $T$ can be calculated by Equation (18)-(22), as shown in Table 7.

Step 7: Let $R_i$ and $D_i$ be defined as $15 \times 1$ and $1 \times 15$ vectors, respectively, representing the number of row elements and sum of column elements for the complete relation matrix $T$. Using (13) and (14), $R_i$ represents the net effects of criterion $i$ on others, and $D_j$ summarizes the direct and indirect effects obtained by factor $j$ from other indicators. From the total relation matrix, the casual and impact criteria $(P_i = R_i + D_j)$ and $(E_i = R_i - D_j)$ were computed for value $i = j$. If $E_i$ is greater than one, then criterion is a net cause. If $E_i$ is less than zero, the criterion is a net result. Table 8 contains more details. The drawn digraph for lower and upper values demonstrates a causal relationship among parameters, as shown in Figure 3.

Step 8: Determine criteria weights using the results of GDEMATEL with (15) and (16) in this study (Table 9).

Step 9: Employ GA with a new fitness function to optimize and achieve the best group of 10 candidates from data of 2258 applicants with the search algorithm, written in the Python coding language to find the optimal solution (Table 10). The execution time and fitness values are identified as follows: The rate of remained candidates with the higher fitness scores for reproduction and next-generation $r$ is from 0.1 to 0.3 and then makes GA have a good convergence with ethical fitness values. $Q$ is denoted as the candidate $j^{th}$ in group $p_i^{(g)}$ with $p_i^{(g)} = \left\{p_{i,1}^{(g)}, p_{i,2}^{(g)}, \ldots, p_{i,m}^{(g)}\right\}$. And then, GA generates stable fitness with $Q = 0.7$ to 0.9 in a short time. The crossover rate is considered from 0.2 to 0.5, which provides relatively stable fitness values. The probability of dominant, recessive, and mutation steps during the crossover is proposed (0.6, 0.3, and 0.1), respectively.

*4.2. Results and Discussions.* In this study, the GDEMATEL method was employed to find out the cause-effect relationships among criteria of personnel selection seen in the

Table 7: Total relational matrix $T$.

| Criteria | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 0.032 | 0.050 | 0.112 | 0.089 | 0.152 | 0.062 | 0.053 | 0.053 | 0.043 | 0.062 | 0.120 | 0.084 | 0.077 | 0.114 | 0.134 |
| C2 | 0.099 | 0.051 | 0.157 | 0.133 | 0.124 | 0.145 | 0.068 | 0.081 | 0.051 | 0.072 | 0.139 | 0.104 | 0.096 | 0.160 | 0.126 |
| C3 | 0.089 | 0.140 | 0.110 | 0.201 | 0.205 | 0.145 | 0.107 | 0.121 | 0.087 | 0.112 | 0.195 | 0.142 | 0.149 | 0.225 | 0.187 |
| C4 | 0.092 | 0.099 | 0.207 | 0.120 | 0.216 | 0.172 | 0.131 | 0.196 | 0.106 | 0.101 | 0.156 | 0.132 | 0.173 | 0.211 | 0.220 |
| C5 | 0.047 | 0.065 | 0.090 | 0.091 | 0.073 | 0.064 | 0.054 | 0.083 | 0.055 | 0.080 | 0.116 | 0.082 | 0.082 | 0.164 | 0.131 |
| C6 | 0.084 | 0.093 | 0.153 | 0.161 | 0.173 | 0.082 | 0.143 | 0.144 | 0.121 | 0.109 | 0.139 | 0.118 | 0.157 | 0.190 | 0.180 |
| C7 | 0.095 | 0.096 | 0.174 | 0.201 | 0.225 | 0.154 | 0.090 | 0.188 | 0.137 | 0.153 | 0.188 | 0.164 | 0.185 | 0.247 | 0.234 |
| C8 | 0.089 | 0.093 | 0.141 | 0.188 | 0.212 | 0.122 | 0.105 | 0.101 | 0.105 | 0.146 | 0.202 | 0.179 | 0.201 | 0.235 | 0.221 |
| C9 | 0.047 | 0.049 | 0.087 | 0.090 | 0.102 | 0.059 | 0.062 | 0.083 | 0.044 | 0.080 | 0.094 | 0.083 | 0.078 | 0.112 | 0.154 |
| C10 | 0.049 | 0.048 | 0.082 | 0.094 | 0.132 | 0.082 | 0.058 | 0.089 | 0.062 | 0.054 | 0.102 | 0.088 | 0.124 | 0.146 | 0.149 |
| C11 | 0.055 | 0.059 | 0.110 | 0.109 | 0.149 | 0.087 | 0.083 | 0.103 | 0.085 | 0.103 | 0.091 | 0.127 | 0.183 | 0.193 | 0.157 |
| C12 | 0.058 | 0.066 | 0.120 | 0.122 | 0.164 | 0.129 | 0.116 | 0.114 | 0.094 | 0.155 | 0.156 | 0.083 | 0.179 | 0.202 | 0.178 |
| C13 | 0.058 | 0.063 | 0.143 | 0.122 | 0.131 | 0.099 | 0.086 | 0.135 | 0.087 | 0.099 | 0.174 | 0.108 | 0.099 | 0.197 | 0.162 |
| C14 | 0.051 | 0.062 | 0.130 | 0.108 | 0.122 | 0.094 | 0.081 | 0.099 | 0.083 | 0.094 | 0.142 | 0.124 | 0.162 | 0.109 | 0.152 |
| C15 | 0.133 | 0.141 | 0.192 | 0.211 | 0.237 | 0.163 | 0.147 | 0.188 | 0.165 | 0.183 | 0.200 | 0.172 | 0.211 | 0.260 | 0.169 |

Table 8: Cause/effect relationship of criteria.

| Criteria | $R_i$ | $D_j$ | $R_i+D_j$ | $R_i-D_j$ |
|---|---|---|---|---|
| C1 | 1.236 | 1.078 | 2.314 | 0.158 |
| C2 | 1.605 | 1.176 | 2.781 | 0.429 |
| C3 | 2.217 | 2.008 | 4.224 | 0.209 |
| C4 | 2.332 | 2.040 | 4.372 | 0.292 |
| C5 | 1.276 | 2.416 | 3.692 | −1.140 |
| C6 | 2.047 | 1.659 | 3.706 | 0.388 |
| C7 | 2.530 | 1.383 | 3.914 | 1.147 |
| C8 | 2.341 | 1.777 | 4.118 | 0.564 |
| C9 | 1.223 | 1.324 | 2.548 | −0.101 |
| C10 | 1.358 | 1.602 | 2.961 | −0.244 |
| C11 | 1.693 | 2.215 | 3.908 | −0.522 |
| C12 | 1.936 | 1.791 | 3.728 | 0.145 |
| C13 | 1.763 | 2.157 | 3.920 | −0.393 |
| C14 | 1.613 | 2.764 | 4.377 | −1.151 |
| C15 | 2.772 | 2.553 | 5.325 | 0.219 |

case of ABC company. According to Table 8, the value $R_i - D_j$ means the higher the value, the stronger the influence on personnel evaluation and selection. Furthermore, factors with positive values are called causal factors. They are the most affecting factors that lead to select ideal candidates directly. The prominence sorts causal factors for the influence of the recruitment process as C7 > C8 > C2 > C6 > C4 > C15 > C3 > C1 > C12. They can be used to develop sustainable criteria. Factors with negative values are called effect factors. They are sorted as C9 > C10 > C13 > C11 > C5 > C14. Effect factors are influenced by causal factors, which lead to choosing suitable candidates as shown in Figure 3.

Among the causal factors of concern, "Leadership" (C7) is on the top of the cause group, which indicates that C7 is the primary causal factor for making decision in the recruitment process, followed by "Productivity" (C8), "Degrees" (C2), "Analytic thinking" (C4), "Teamwork skills" (C3), "Training fee" (C15), and so on. Regarding supporting results, Liang and Wang [44] also found that leadership ability becomes more conducive to technological innovation, and the collective impact of perceived company capacity and high actual capacity affect personnel selection, especially for sustainable development. Reference [75] identified the importance of "Productivity" in the workplace, and being productive can help the firm increase and utilize the capacity of the human resources it has. In previous research studies of [47, 75], "Analytic thinking" (C4) and "Teamwork skills" (C3) were considered the most critical factors in 22 subcriteria to find the best personnel using the integrated Consistent Fuzzy Preference Relations (CFPRs) and fuzzy AHP methodology. "Training fee" (C15) and "Self-confidence" (C12) are determined as a casual criterion because it is fruitful to both employers and employees of an organization and an ideal employee will become more efficient and productive if he or she is trained well. Therefore, the experts confirmed that nine of casual factors are the fundamental measures to prioritize the personnel alternatives [75].

In the effect factors, "Emotional steadiness" (C9) is the most obvious factor, followed by "Deadline management" (C10). "Deadline management" (C10) and "Time of decision-making" are investigated in the related literature and interviews of management personnel involved in the project manager's selection, and they selected the most important criteria for a project manager in the construction firm. As stated in the literature, due to the unique characteristics of the agricultural sector, like being "Lifelong learning" (C13), "Oral communication" (C11), "Salary" (C5), and "Foreign languages" (C14) become critical [55, 63, 76]. It is desirable to determine the oral communication skill and language ability to work overseas and co-operate with business partners and stakeholders for a sustainable working environment. Many failures have generated adverse impacts on the employees, which affect business decisions and do not mention a longer-term effect if they fail to learn from the failures. Improper response strategies of contrary word-of-mouth will lead to a direct influence on business failure.

The values $R_i + D_i$ in Table 8 represent the center of factors. The higher the value of a criterion is (i.e., "Training fee" (C15), in Figure 3), the stronger the contribution of that factor to select suitable candidates. The center of factors can be arranged as follows: C15 > C14 > C4 > C3 > C8 > C13 > C7 > C11 > C12 > C6 > C5 > C10 > C2 > C9 > C1. Key

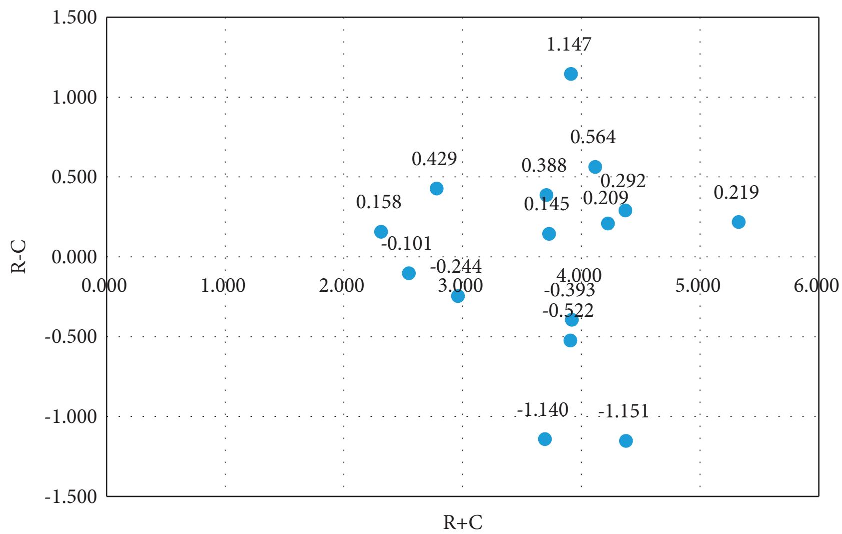


Figure 3: Causal relationship diagram.

Table 9: Weights of criteria.

| Criteria | $R_i + D_j$ | $R_i - D_j$ | $W_{C_i}$ | $W_{C_i}^{nor}$ | Rank |
|---|---|---|---|---|---|
| C1 | 2.314 | 0.158 | 2.319 | 0.041 | 15 |
| C2 | 2.781 | 0.429 | 2.814 | 0.050 | 13 |
| C3 | 4.224 | 0.209 | 4.229 | 0.075 | 4 |
| C4 | 4.372 | 0.292 | 4.382 | 0.077 | 3 |
| C5 | 3.692 | −1.140 | 3.864 | 0.068 | 9 |
| C6 | 3.706 | 0.388 | 3.726 | 0.066 | 11 |
| C7 | 3.914 | 1.147 | 4.078 | 0.072 | 6 |
| C8 | 4.118 | 0.564 | 4.156 | 0.073 | 5 |
| C9 | 2.548 | −0.101 | 2.550 | 0.045 | 14 |
| C10 | 2.961 | −0.244 | 2.971 | 0.053 | 12 |
| C11 | 3.908 | −0.522 | 3.942 | 0.070 | 7 |
| C12 | 3.728 | 0.145 | 3.730 | 0.066 | 10 |
| C13 | 3.920 | −0.393 | 3.940 | 0.070 | 8 |
| C14 | 4.377 | −1.151 | 4.526 | 0.080 | 2 |
| C15 | 5.325 | 0.219 | 5.329 | 0.094 | 1 |

Table 10: Criteria weights in respect to 2258 applicants.

| $W_{C_i}^{nor}$ | 0.041 | 0.050 | 0.075 | 0.077 | 0.068 | 0.066 | 0.072 | 0.073 | 0.045 | 0.053 | 0.070 | 0.066 | 0.070 | 0.080 | 0.094 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ALT | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 | C15 |
| ALT1 | 60 | 98 | 42 | 15 | 90 | 17 | 95 | 61 | 65 | 87 | 74 | 21 | 96 | 67 | 51 |
| ALT2 | 2 | 45 | 51 | 84 | 56 | 73 | 19 | 51 | 12 | 51 | 39 | 20 | 71 | 66 | 36 |
| ALT3 | 62 | 70 | 34 | 22 | 32 | 82 | 80 | 34 | 24 | 61 | 75 | 67 | 41 | 22 | 49 |
| ALT4 | 44 | 17 | 30 | 58 | 77 | 16 | 28 | 16 | 36 | 1 | 66 | 3 | 63 | 11 | 91 |
| ALT5 | 78 | 73 | 4 | 45 | 34 | 0 | 67 | 98 | 1 | 0 | 57 | 84 | 90 | 78 | 28 |
| ALT6 | 21 | 45 | 4 | 54 | 21 | 71 | 79 | 95 | 48 | 48 | 55 | 49 | 93 | 86 | 89 |
| ALT7 | 59 | 92 | 9 | 9 | 81 | 63 | 77 | 80 | 10 | 46 | 91 | 64 | 5 | 79 | 25 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... | ... |
| ALT2254 | 27 | 78 | 30 | 43 | 10 | 45 | 87 | 25 | 80 | 96 | 28 | 13 | 6 | 24 | 17 |
| ALT2255 | 52 | 98 | 86 | 64 | 58 | 43 | 13 | 71 | 93 | 85 | 10 | 99 | 34 | 64 | 69 |
| ALT2256 | 3 | 43 | 92 | 7 | 25 | 2 | 99 | 93 | 19 | 73 | 94 | 31 | 30 | 37 | 83 |
| ALT2257 | 94 | 16 | 26 | 36 | 7 | 29 | 21 | 53 | 28 | 53 | 64 | 34 | 41 | 91 | 41 |
| ALT2258 | 3 | 70 | 2 | 72 | 4 | 38 | 62 | 10 | 83 | 79 | 97 | 38 | 99 | 23 | 21 |

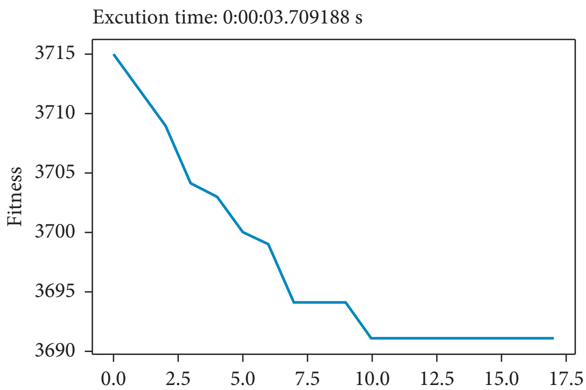


Figure 4: The fitness values over generations in execution time.

testing criteria should be developed based on that. The factor with the strongest contribution is the "Training fee" (C15). It is affected by "Foreign languages" (C14), "Analytic thinking" (C4), "Teamwork skills" (C3), and so on. Some prior studies [43, 75] have shown that companies can effectively avoid recruiting failures if companies concern about training fees for both "on the job training" and "off the job training." "Degrees" (C2) and "Salary" (C5) may result in conflicts of interest between the company and other subjects. Ideal candidates' leadership capacities affect the productivity of corporations directly or indirectly. In contrast, "Professional experience" (C1) is the least correlated with other factors.

Subjective weights achieved from the GDEMATEL technique were exploited with 15 testing criteria for 2258 applicants in Table 10. GA combining with GDEMATEL weights is utilized the developed objective function of MDIS to select and rank the best group of ten candidates for some high positions in the ABC company. The GA defined an optimal solution using the Python code. The author performs the proposed scheme of the genetic algorithm repeatedly with various initial solutions. The objective values and execution durations of several executions are depicted in Figure 4. It demonstrates that the set of chosen parameters balanced the two predicted factors of execution time and optimal solution. The results of GA to find an ideal group of 10 best candidates are displayed in Figure 4 and Table 11. GA created mutations of interest in a short time of approximately 3 seconds within nine generations by creating a huge population of 2258 applicants. The results reveal that the objective values of selected candidates are ALT934, ALT986, ALT309, ALT491, ALT1714, ALT1403, ALT2054, ALT1304, ALT1332, and "ALT1399." Furthermore, the ranking of the 10 ideal candidates is obtained as ALT491 > ALT934 > ALT986 > ALT1714 > ALT1304 > ALT1403 > ALT1399 > ALT2054 > ALT1332 > ALT309. Thus, the orders of objective candidates were applied to the specific positions and the planned salaries.

In some circumstances, GAs are not committed to finding a universal optimal solution. However, it allows modelers and stakeholders to easily customize each case's designs. The GA creates mutations in a large population. The crossover step helps to deliver best fitness genes quickly. Finally, an optimal solution is given. It is simple but practical. Both algorithms have proved valuable tools for solving the personnel selection problem. In the HRM problem, two factors that increase the search space size are the number of candidates and the size of the selected team of the most potential applicants ($S$). Figure 4 shows the execution times and objective values for different values of ($S$). It is easy to see that the GA has always found better solutions, even though processing time has increased linearly according to the search space size.

Table 11: The results of generations and ideal alternatives.

| Population in the beginning: 1807 | | |
|---|---|---|
| Generation: 1 | Fitness: 3714.9965593713546 | Population: 1687 |
| Generation: 2 | Fitness: 3711.900130677009 | Population: 1748 |
| Generation: 3 | Fitness: 3709.244929713324 | Population: 1753 |
| Generation: 4 | Fitness: 3704.3722621549523 | Population: 1780 |
| Generation: 5 | Fitness: 3703.144328915766 | Population: 1773 |
| Generation: 6 | Fitness: 3699.6034495249623 | Population: 1786 |
| Generation: 7 | Fitness: 3699.465662027829 | Population: 1793 |
| Generation: 8 | Fitness: 3694.187815025516 | Population: 1790 |
| Generation: 9 | Fitness: 3694.187815025516 | Population: 1803 |
| Generation: 10 | Fitness: 3694.187815025516 | Population: 1796 |
| Generation: 11 | Fitness: 3691.1379079286644 | Population: 1796 |
| Generation: 12 | Fitness: 3691.1379079286644 | Population: 1798 |
| Generation: 13 | Fitness: 3690.596192194968 | Population: 1798 |
| Generation: 14 | Fitness: 3690.596192194968 | Population: 1792 |
| Generation: 15 | Fitness: 3690.596192194968 | Population: 1800 |
| Generation: 16 | Fitness: 3690.596192194968 | Population: 1798 |
| Generation: 17 | Fitness: 3690.596192194968 | Population: 1796 |
| Generation: 18 | Fitness: 3690.596192194968 | Population: 1796 |
| ["ALT934," 68.0, 56.0, 96.0, 98.0, 83.0, 81.0, 91.0, 84.0, 30.0, 54.0, 77.0, 39.0, 70.0, 89.0, 43.0] | | |
| ["ALT986," 55.0, 74.0, 67.0, 98.0, 96.0, 44.0, 12.0, 83.0, 80.0, 100.0, 80.0, 82.0, 80.0, 89.0, 45.0] | | |
| ["ALT309," 43.0, 69.0, 16.0, 93.0, 56.0, 59.0, 88.0, 92.0, 2.0, 50.0, 60.0, 75.0, 88.0, 87.0, 96.0] | | |
| ["ALT491," 87.0, 79.0, 90.0, 43.0, 80.0, 81.0, 87.0, 78.0, 56.0, 89.0, 69.0, 54.0, 72.0, 84.0, 75.0] | | |
| ["ALT1714," 12.0, 69.0, 90.0, 99.0, 79.0, 67.0, 85.0, 98.0, 78.0, 89.0, 24.0, 53.0, 38.0, 67.0, 94.0] | | |
| ["ALT1403," 85.0, 56.0, 6.0, 98.0, 100.0, 96.0, 100.0, 20.0, 94.0, 99.0, 68.0, 68.0, 48.0, 74.0, 63.0] | | |
| ["ALT2054," 90.0, 40.0, 67.0, 82.0, 36.0, 48.0, 17.0, 90.0, 71.0, 69.0, 93.0, 84.0, 94.0, 72.0, 75.0] | | |
| ["ALT1304," 96.0, 12.0, 98.0, 90.0, 74.0, 43.0, 56.0, 98.0, 95.0, 61.0, 53.0, 76.0, 87.0, 63.0, 67.0] | | |
| ["ALT1332," 88.0, 43.0, 30.0, 28.0, 5.0, 99.0, 65.0, 82.0, 83.0, 87.0, 92.0, 80.0, 74.0, 90.0, 90.0] | | |
| ["ALT1399," 87.0, 95.0, 66.0, 36.0, 91.0, 82.0, 34.0, 81.0, 54.0, 11.0, 98.0, 67.0, 60.0, 91.0, 86.0] | | |

## 5. Conclusions

Human resource managers should carefully select the most suitable candidates to perform managing tasks, which is a complicated and time-consuming MCDM problem. Improper selection may lead to a loss in productivity and product quality, which may significantly adversely impact the corporation's overall performance. Differentiating the prior studies, this research investigates a "deep" and "wide" range of influencing factors in HRM evaluation and selection through a comprehensive literature review and in-depth expert interviews. First, the grey DEMATEL method was developed to identify the critical criteria in terms of their relative importance and examine their cause-effect relationships. According to the research results obtained from the GDEMATEL analysis, practical advice was provided to decision-makers or stakeholders to evaluate and recruit staff in the case of ABC agricultural company. According to the priority order and the cause-effect relationships of the 15 criteria, the following aspects should be taken into deeper consideration: "Training fee" (C15), "Foreign languages" (C14), "Analytic thinking" (C4), and "Teamwork skills" (C3). Second, a genetic algorithm with a new objective function of MDIS based on the Euclidean distance technique as a fitness function was used to find the optimal solution for robust recruitment and personnel selection.

Different views on the prior research on HRM, the relative weights, and cause-effect relationships among the critical criteria can help managers and stakeholders put forward more effective measures for recruiting and personnel selection problems. Moreover, the proposed method provides a reasonable approach by combining subjective and objective weights to evaluate alternatives regarding interdependent and conflicting criteria in the actual case. In future work, a friendly human-computer interface based on artificial intelligence should be developed to make the MCDM model more intelligent and practical and extend into other fields.

Although the new integrating grey MCDM and genetic algorithm approach obtained some findings when considering the set of criteria of personnel selection problems, the study still contains some limitations. First, this research data investigates only 15 evaluation criteria to find the best team of 10 candidates from 2258 applicants; the further studies should exploit more criteria for the recruitment and personnel selection problems, such as "Business discipline," "Inefficient activity," and "Auxiliary activity," making the evaluation method more comprehensive and practical. Second, the other MCDM methods such as criteria importance through intercriteria correlation (CRITIC) and entropy incorporating with various extensions of fuzzy sets should be applied to choose ideal alternatives in future study. Third, the case study focuses on personnel selection in the agriculture industry. The evaluation results may be different in other fields, such as construction, transportation, and real estate, which need further research.

## Data Availability

The data presented in this study are available on request from the corresponding author.

## Conflicts of Interest

The author declares that there are no conflicts of interest.

## Authors' Contributions

PHN conceptualized the study, developed the methodology, helped with software, validated the study, carried out formal analysis, investigated the study, curated the data, wrote and prepared the original draft, and reviewed, edited, and supervised the study.

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