

# Application of the Fuzzy Delphi Method to Identify and Prioritize the Social-Health Family Disintegration Indicators in Yemen

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**Abstract**—Constantly increasing political events and socially related changes have led governments worldwide to adopt strategies to reduce their negative effects on the cohesion of societies, which requires developing assessment frameworks that include realistic, measurable, and useful indicators for analyzing the family disintegration causes, taking into consideration the circumstances surrounding the countries and the development trends that they adopt. Therefore, this study aims to identify and prioritize indicators of a decision-making support framework for evaluation, ranking, and structural comparison of the family disintegration causes resulting from the child marriage phenomenon in Yemen. To achieve this, the Fuzzy Delphi Method was applied. Firstly, a set of related literature and theories were analyzed to extract the expected framework's suitable initial indicators. Then, with the participation of twenty-four local experts, the extracted factors were revised, and the most suitable factors were selected. As a result, one social factor out of nine social-health factors was excluded due to its inappropriateness, and a framework of eight indicators was built. Also, with a rating average of 0.727, it was consistently agreed that the indicator "Increasing divorce rates in marital cases that do not take place according to the common desire of the spouses" is the most important indicator. Also, with high consistent evaluation averages (0.652–0.658), all three health indicators were ranked in the second and third places, while the other four social indicators were ranked in the last three positions (fourth–sixth). Finally, the real applications of the proposed framework were recommended.

**Keywords**—Family disintegration; child marriage; early marriage; Fuzzy Delphi Method; multi-criteria decision making; Yemen

## I. INTRODUCTION

The family system is considered one of the oldest social systems throughout history, and it plays an essential role in the raising and upbringing of children and in determining their orientations, tendencies, and desires within the framework of customs and traditions that link the members of each system together. At the same time, individuals of the same society's family systems are linked by numerous cohesive linkages and relationships that contribute to the creation and growth of socially cohesive societies and generations capable of working, giving, and creating. And in return, the disintegration of family bonds in any society prompts the emergence and development of many types of manifestations that hinder human energies from fulfilling their intended roles and contribute to pushing members to embrace negative behaviors towards their society, which could negatively impact the process of society's development [1]. Therefore, the family is an important part of the social system, and its cohesion has a significant impact on society's progress.

On the other hand, the family is also affected by the society to which it belongs, and its structures, practices, and events fluctuate with changing economic, social, and political conditions and events in it. Such transformations in today's world have a particular impact on the central functions of the family and can sometimes amount to a breach of its social role, which in turn contributes to an increase in antisocial behavior among juveniles, and the intentional or unintentional violations of their civil rights [2]. The persistence of such manifestations in societies often has negative consequences

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and creates new barriers to achieving sustainable development in countries [3], particularly those with high rates of instability, economic hardships, conflicts, and wars, such as Yemen.

Within this context, during the last ten years, the Republic of Yemen has witnessed a lot of political events that eventually led to the deterioration of the sustainable development situation in Yemen, economically, socially, and environmentally [4]. Issues such as poverty, interruption of employee salaries in most government sectors, high and doubling prices of basic goods and services, the displacement of some families from areas experiencing conflicts and wars to relatively safe areas, and the loss of some families for their dependents, with women and children bearing the responsibilities and the brunt of the suffering, are but a few of the manifestations that Yemeni society is experiencing as a result of those events.

As a result of this tragic state of poverty, as well as other factors such as misunderstandings of religion, customs, and traditions, and a lack of awareness, the rate of early marriage for young girls has risen dramatically as one of the negative adaptive methods for survival, with the percentage of girls between the ages of ten and nineteen years marrying accounting for one-eighth of all girls' marriages. In any case, the early marriage phenomenon—as a negative phenomenon imposed on Yemeni society—has become a threat to the local family stability state. In this regard, studies [5] confirmed that it could negatively impact the compatibility between spouses, which constitutes the main element of family stability, not to mention that it is one of the main contributing factors to the high rates of conflict, negative conflict, violence, divorce, psychological cases, and the early death of underage wives [6], [7], [8], [9], which constitute the main causes of family disintegration at the local and international levels [4], [10], [11].

Research problem: Over the past decade, Yemen has been subjected to many political events, economic and cultural changes, causing an increase in the spread of the early marriage phenomenon, which has led to the emergence of risks and threats to the family stability of Yemeni society. This makes the local government responsible for taking objective and effective decisions that contribute to limiting the negative effects of this phenomenon on the life, welfare, and stability of Yemeni society by studying and analyzing the causes of family disintegration related to this phenomenon, prioritizing their treatments according to society's developmental circumstances and its development priorities, and conducting structural comparisons of these causes in different regions, in a manner that ensures optimum utilization and equitable distribution of available and limited resources and budgets. This cannot be practically realized without developing appropriate, realistic, and measurable local indicators through the active participation of a group of local experts.

Accordingly, this study aims to identify and arrange indicators of a local decision-making support framework evaluation, ranking, and structural comparison of the causes of

family disintegration resulting from the phenomenon of early marriage in the Republic of Yemen and through the participation of a group of Yemeni experts.

The remainder of this work is arranged in the following manner. The second section gives a quick summary of relevant sociological theories, their perspectives on family disintegration, and the causes and variables most directly linked to family breakup as a result of early marriage. The concepts and principles of Delphi techniques to enable multi-criteria group decision-making, as well as the proposed Fuzzy Delphi model for solving the problem, were discussed in the third section. In Section 4, the proposed assessment model, and the findings are presented, followed by a discussion, limitations of study, its applications, and future work, and conclusion in the last three parts.

## II. RELATED WORK AND LITERATURE REVIEW

This section reviews the literature on the study's topic, including a basic background on the concept of early marriage, the concept and manifestations of family disintegration, key social theories about family disintegration, the factors of family disintegration most associated with the phenomenon of early marriage, and the MCDM tools chosen to solve the problem.

### A. The Concept and Causes of Early Marriage in Yemen

The phenomenon of early marriage is particularly prevalent in Yemeni society, especially in rural areas. The causes of this phenomenon have been many. In economic terms, early marriage is an important economic factor for rural families. Yemeni rural families tend to marry their male children at an early age in order to join their children's wives in assisting them by doing the animal and agricultural work they practice as their main source of income. Let them have children early, and also contribute in the future to the same tasks. From another economic perspective, some Yemeni families agree to marry girls at an early age because they are unable to support them for reasons such as poverty, low family income, the death of one or both parents, or other reasons reviewed in the introduction. From a social and cultural standpoint, customs and traditions also play a role in the spread of this negative phenomenon. Males and females are married early for various reasons, such as protecting them from falling into vice, being subjected to violence or harassment, or preventing the spread of extrajudicial sexual relations, which is not accepted by some local cultures. In any case, local studies such as [4], and [7] provide more details about this phenomenon and can be consulted for more information.

From a procedural standpoint, this study defines early marriage as a legitimate marital relationship that begins at a young age for both sexes, or for one of them, and qualifies each other for self-reliance in respect of their obligations to the other, as well as their qualification to have and raise legitimate children born as a result of this relationship, with the early age of that relationship being determined for children under nineteen years of age.

### B. The Concept of Family Disintegration and its Manifestations

The literature has reviewed a variety of definitions of family disintegration, which is defined as a situation that occurs as a result of the death of one or both parents [12], divorce [13], the abandonment of the family's head, polygamy, or the absence of the family's head for an extended period of time. Others refer to it as "family dispersion," which can occur as a result of polygamy, the death of one or both parents, or divorce [14]. It also includes residences that have been demolished as a result of a divorce, separation, or the death of one or both parents [15]. Family disintegration is a term used to describe the tension, rupture, or loss of control that occurs within a family system. The collapse of familial bonds and ties between family members, whether by divorce, abandonment, separation, or the loss of one or both parents, whether by death, jail, or otherwise due to particular socio-economic conditions [14], has the same meaning. The disruption of family functions, the collapse of family roles and structure as a result of early marriage, the resulting tension and ongoing family conflicts, or the weakness of family relations are the procedural definitions of family disintegration in this study.

### C. Social Theories and Family Disintegration

Based on current and previous studies, the theoretical trends serve as a point of reference for determining the nature of the direction in which the contemporary family has evolved as a result of the social changes that have occurred. Previous family disintegration studies used a variety of theories to investigate the causes and effects of family breakup. This section examines family disintegration studies in the literature and discusses the implications of a number of significant theories, including functional constructivism, conflict theory, and symbolic interaction theory.

1) *Functional constructive theory*: According to this idea, family stability is accomplished by completing the social functions of the family, which include proper socialization, meeting fundamental life requirements, providing economic security, and reducing individual conflict. The belief that society is a system made up of a series of social subsystems that must be balanced and complimentary is central to proponents of functional constructionism [16].

The belief that society is a collection of regulated social systems, as well as the balance and complementarity of their components, is central to proponents of functional constructivism. The most essential aspect of this theory is that it analyzes family responsibilities and functions and emphasizes the family's valuable functions [17]. This indicates that any component of the family system whose functional role is broken, obstructed, or disrupted may eventually lead to dysfunction and family collapse. Therefore, early marriage may be a cause of family break-up if either spouse breaks up, fails to perform his or her functional role, or evades responsibility. According to the study [18], if this requirement is met, it is likely to result in increased psychological pressure on the spouses, or at least one of them, as well as a role

conflict, which can lead to acceptable practices such as multiple employment, or unethical or illegal practices to adapt to the new situation requiring each other's role, or to meet the personal or family needs that have been lost as a result. According to the researchers, this could lead to various forms of family disintegration, such as diversion and relocation of family members, particularly if the new means of adjustment require the obligation of caring for the family to be separated from its members.

2) *Conflict theory*: Conflict theorists argue that conflict is a continuous phenomenon that only ends with the demise of society and that conflict and the process of social change are thus inextricably linked [19]. But, since disagreements are inevitable in married life, may they be a source of family disintegration? According to the study [20], positive family differences can be seen as a means of obtaining rights and as a good way of improving the marital relationship, whereas negative conflicts lead to mismatch and dilution of marital relations, weakening the level of compatibility and harmony between spouses and eventually developing into situations of family disintegration. From this perspective, early marriage can be viewed as a cause of family disintegration if it results in negative conflicts, especially because there are many differences and conflicts associated with early marriages, often due to the selfishness and self-love of one or both of the immature spouses, the dysfunctional role of one of the spouses vis-à-vis the other or the children, or the difference in marital life reality from one or both of the immature spouses' expectations about rigor. According to numerous studies, the persistence of such negative conflicts has a negative impact on marital harmony and harmony situations and may eventually lead to family disintegration.

3) *Symbolic interaction theory*: According to this theory, the family plays an important role in preparing individuals for their future roles. The family's role is to instill in children a set of symbols, values, and standards. As a result, children can evaluate their actions and shape their future roles [7]. These symbols and meanings differ from family to family, and the individual first attempts to absorb the role expected of him before attempting to adapt a course based on his experiences and knowledge. The individual's daily interactions in his life, the circumstances surrounding his upbringing, and the foundation of symbols he learns from his family are among the most important factors influencing the construction of his personality [21]. According to this viewpoint, early marriage can be regarded as one of the causes of family disintegration in two cases: (1) if one or both spouses are unable to build a sufficient knowledge base that allows each of them to cope with married life and develop a common language with each other; or (2) if one or both spouses are unable to succeed in instilling sound educational values in their children, develop their feelings of love and loyalty to society, and develop their skills and abilities to interact with the members of society in a manner that enhances their integration and cohesion.

#### D. The Social Factors of Family Disintegration Related to Early Marriage

According to those points of view and based on studies on early marriage and previously analyzed theories, marriage requires a degree of love, desire, a sense of security, and the ability to properly raise and raise children, which can only be achieved in the case of so-called [19] cognitive readiness, which many boys and girls who marry early do not achieve. As a result, ignorance of marital life and adjustment requirements endangers marital peace and harmony (F1) and leads to family breakdown [20]. Furthermore, selfishness, selfishness, and the inability of some child couples to meet the requirements and duties of marriage and upbringing have caused family conflicts [22], which have sometimes escalated to the use of physical or verbal violence (F2), which is considered unacceptable in Yemeni society and is a major cause of divorce [8]. Authors in [9] goes on to say that the proper child rearing necessitates adequate knowledge of the foundations of sound socialization, health and psychology, and basic rules of care, and that one minor spouse's lack of such knowledge causes a dysfunctional role for the other or for the children [11] (F3), which can lead to family disintegration and disruption. On the other hand, that study [11] also, emphasized that the family was responsible for meeting the emotional needs of their sons and daughters, such as kindness, compassion, love, and justice, as well as releasing them from fear, anxiety, and anything else that might jeopardize their social and psychological well-being. According to the study, underage wives were found to be ineffective in this capacity [22]. Failure of minor spouses to fulfill their functional role in satisfying children's demand for family attachment (F4) is counterproductive, according to [19], resulting in emotions of alienation rather than feelings of family and community in children.

Locally, the study [23] indicates the existence of an expulsion relationship between early marriage and divorce, in which some minor spouses are subject to their guardians' desire to marry and choose the other partner, which causes a situation of incompatibility between the spouses, sometimes leading to separation (F5). Also, there have been a few instances when young children have been paired with adult females for various social reasons. Regardless of the reasons or motives, the age gap between them plays a crucial role in the incompatibility and harmony between the couples. In some of these circumstances, however, repeated marriages while keeping the first wife is a socially acceptable approach. Multiple marriages with the abandonment of the first wife (F6), on the other hand, is a bad outcome.

#### E. Health Factors of Family Disintegration and their Relationship to Early Marriage

Pregnancy and childbirth, in terms of health, are a substantial risk to the lives of teenage mothers [11] and can result in death, which is considered a cause of family breakdown. Some early marriages result in "early pregnancy," which leads to an increase in the number of underage mothers dying during childbirth (F7), has a negative impact on the mother's health, and even causes a variety of disorders (F8). In this context, the survey found [23] that two-thirds of Yemeni

moms had their babies aborted during their first trimester in 2008. According to the same survey, underage wives accounted for 19% of all moms who died during childbirth.

Psychologically, one of the minor spouses' incapacity to fulfill his functional role toward the other or to meet the needs of the children, as well as the consequent negative confrontations, leads to the escalation of psychological problems (F9) [20], [24].

### III. METHODOLOGY

#### A. The Fuzzy Delphi Method

At the beginning of the sixties of the last century, the Delphi method was developed by two world scientists, "Olaf Helmer and Norman Dalkey" [25]. It is considered not only one of the most widely used and reliable surveying and expert judgment collection methods [26], [27], but one of the most widespread methods for solving numerous group decision-making problems by selecting and/or ranking factors, criteria, questionnaire elements, or measuring index elements [28]. Among the most prominent features of this method are that responses collected during its implementation remain uncharted and unknown, rely on a conditional phased statistical processing operation, and on countable, limited, and repeated processes that are managed and controlled by a phased outcome-based feedback operation. Besides, its outputs constitute consistent, revised, and collective statistical scores. Moreover, it is also characterized by the ability to address qualitative nature-based problems by relying on multiple survey rounds, which helps researchers in formulating additional quantitative survey rounds and promoting consensus opinions and effective decisions. So, it has been widely used to obtain a sequential series of consistent and revised responses and answers through multiple-round expert-opinion-based surveys in a lot of multidisciplinary studies [26], [27], [28].

TABLE I. THE PRIMARY FAMILY DISINTEGRATION FACTORS MOST ASSOCIATED WITH THE EARLY MARRIAGE PHENOMENON

Type	Factor	Description
Social factors (SF)	F1	Weakness in marital harmony and compatibility.
	F2	Increasing the domestic violence rates
	F3	The imbalance of the spouses' roles towards each other and towards their children.
	F4	Parents' failure in the proper family upbringing of their children.
	F5	Increasing divorce rates in marital cases that do not take place according to the common desire of the spouses.
	F6	Increasing of abandonment cases as a result of the heterogeneity arising from the presence of large age differences between spouses.
Health Factors (HF)	F7	Increasing the death rate among underage mothers during childbirth.
	F8	Negatively impacts on the health status of mothers
	F9	Increasing the rates of psychological cases among underage wives

While the efficiency of this technique and the widespread use of it over time have been proven, the inappropriateness of its application for many group decision-making situations has also been proven [29], [30]. For instance, some of these scenarios are: (1) limited time and financial resources of researchers due to the multiplicity of rounds imposed by the phased outcomes of surveys, especially when the assessment processes are conducted in fuzzy environments by a large number of heterogeneous experts, which requires more survey rounds to reach an acceptable convergence level in experts' prediction values, causing an increase in effort and costs. (2) cases that necessitate the use of uncommon and time-sensitive experts. In such multi-round survey situations, a shortage in the number of experts in the advanced survey rounds or a loss of the phased assessment data of some of them could occur, which also negatively affects the quality of the results. Furthermore, (3) evaluation cases that occur in ambiguous environments where conducting the evaluation process quantitatively is practically impossible due to a clear and unified understanding of measuring level. Rather, experts are forced to express their opinions through qualitative measures, which often have different meanings, connotations, and interpretations. Because this strategy is unable to deal with such uncertainty, it may produce erroneous results, lowering the quality of final decisions.

In any case, the current study is characterized by the above three cases, which means that this technique in its traditional version is not suitable for use. In this regard, the fuzzy version of this method has been developed by [31], and its calculation procedures rely on fuzzy numbers and allow experts to express their opinions through them. It is also able to deal with the uncertainty problem on the one hand. On the other hand, it relies on a limited number of survey rounds, which contributes to reducing the costs, effort, and time of researchers and experts at the same time. It also enhances an expert's interest and desire for continuity, which contributes to raising the recovery rates of their questionnaires. It helps to enhance the completeness and consistency of opinions as it provides a mechanism to deal with non-consensus cases and obtain consensus in the opinions without subjecting the original opinions of experts to change, which also leads to more realistic and objective decisions.

**B. FDM Implementation Procedures**

Given that decision-making processes require a good study and analysis of decision requirements [32], [33], [34],[35] and the selection and application of the appropriate systematic tools to solve them [36], [37], [38],[39] and based on the recommendations of previous studies that have demonstrated the effectiveness of Fuzzy based techniques in general [40],[41] compared to traditional evaluation techniques [42],[43] and taking into account the efficiency of the Fuzzy version of the Delphi method, this study relied on this method to solve the study's problem and on the following implementation steps [30] [44] [45]:

Step 1: Determining the main areas of the factors to be evaluated according to the nature of the study.

Step 2: Reviewing pertinent theories and literature and suggesting significant factors for each main area.

Step 3: Developing the data collection tool, selecting the panel of experts, and gathering judgments of the decision group on each factor: Determine the assessment score of each factor's importance as presented by each of them through the application of a five-point Likert variable and convert the collected scores to their equivalent fuzzy numbers.

**Step 4: Data Processing and Analysis:**

Step 4-1: Calculating the average fuzzy rating scores of group decisions for each alternative factor.

As noted above, the evaluation process of the causes of family disintegration is usually accompanied by a case of ambiguity, which requires a conversion of the assessment data obtained using Likert's five-point evaluation scale into equivalent fuzzy numbers within a specific fuzzy logic set. In this regard, the literature provides many forms of those numbers, such as triangular and trapezoidal numbers. The fuzzy set in the subset of real numbers (X) is defined by a two-part combination, the first representing the "x" component, while the second reflects the degree to which that element belongs to the fuzzy set. A numerical membership function (MF) is used to determine whether an element belongs or does not belong to that fuzzy set, and its values are limited to the range [0,1]. The closer this value is to zero, the less the fact that the element belongs to the set, and the opposite is true, as the validity of that statement increases the closer the value of the function is to one.

Given that the personal opinions of experts about the appropriateness of a particular factor to be an indicator of a general domestic framework for measuring, ranking, and structured comparing of family disintegration causes associated with early marriage in the Republic of Yemen are relative and probabilistic and cannot be determined accurately and objectively, the use of MF functions constitutes an appropriate and acceptable solution to deal with this case of ambiguity. As shown in Table II, fuzzy numbers with relative values limited to the range [0,1] were used in this study to represent cases of ambiguity among respondents.

However, the analysis process requires calculating the average fuzzy rating scores of group decisions for each alternative factor. Assuming the assessment value of the appropriateness of No. "z" factor given by an expert No. "r" of a total number "n" experts is  $\tilde{w}_{rz} = (a_{rz}, b_{rz}, c_{rz})$ ,  $r = (1.2 \dots n)$ ,  $z = (1.2 \dots m)$ .

Then the average fuzzy number  $\tilde{w}_z$  of No. "z" factor is defined as [44], [45]:

$$\tilde{w}_z = (a_z, b_z, c_z) = \left( \frac{1}{n} \sum_{r=1}^n a_{rz}, \frac{1}{n} \sum_{r=1}^n b_{rz}, \frac{1}{n} \sum_{r=1}^n c_{rz} \right) \quad (1)$$

TABLE II. LIKERT AND FUZZY SCORING SCALES

Likert scale scoring	Linguistic variable	Fuzzy Scale scoring
1	Highly Not Agree	(0,0,0,0,2)
2	Not Agree	(0,0,0,2,0,4)
3	Moderately / Not sure	(0,2,0,4,0,6)
4	Agree	(0,4,0,6,0,8)
5	Highly Agree	(0,6,0,8,1,0)

Step 4-2: Defuzzification: convert the calculated average fuzzy rating score  $\widetilde{w}_z$  of each factor "z" to its equivalent crisp numbers.

In this study, the simple center of gravity approach was applied to defuzzify the aggregated fuzzy rating scores ( $D_z$ ) of factors as follows.

$$D_z = \frac{(a_z \cdot b_z \cdot c_z)}{n} \quad (2)$$

Step 5: Examine the acceptability of the evaluation domain.

Step 5-1: For each factor "z", calculate the difference value ( $D_{rz}$ ) between the average fuzzy number ( $\widetilde{w}_z$ ), and each expert's fuzzy evaluation value ( $\widetilde{w}_{rz}$ ) using equation 3.

$$D_{rz} = \sqrt{\frac{(a_z - a_{rz})^2 + (b_z - b_{rz})^2 + (c_z - c_{rz})^2}{3}} \quad (3)$$

Step 5-2: Determining the threshold value ( $Th_z$ ) of each factor "z" by using equation 4.

$$Th_z = \frac{1}{n} \sum_{r=1}^n D_{rz} \quad (4)$$

Step 5-3: Testing the threshold value ( $Th_{domain}$ ) of each evaluation domain by using equation 5.

$$Th_{domain} = \frac{1}{n} \sum_{z=1}^m Th_z \quad (5)$$

Based on the " $Th_{domain}$ " value, the acceptability of the evaluation domain should be determined. In this study, an evaluation domain is accepted if  $Th_{domain} \leq 0.02$ .

Step 6: Testing the Expert Group Consensus:

Using equation 6, calculate the expert agreement on each evaluated factor.

$$EA_z = \frac{E_z}{n} \% \quad (6)$$

Where the " $E_z$ " is the total number of experts, who's the distance between their fuzzy evaluation values ( $\widetilde{w}_{rz}$ ) on a particular factor "z" and the average fuzzy number of all experts on that factor ( $\widetilde{w}_z$ ) is  $\leq 2$ . Based on an expert's agreement value " $EA_z$ ", the expert group consensus for each factor should be determined. In this study, an expert's agreement with a " $(EA_z) \geq 75\%$ " is used to screen out the expert group consensus for each factor. Factors with an expert consensus of less than 75% are ignored.

Step 6: Testing the final acceptability decision of each evaluation factor.

Once the evaluation domain is accepted and the list of factors with an acceptable expert consensus level is defined. The selected accepted factors should be analyzed based on the overall group evaluation crisp scores ( $D_z$ ). These factors should be ranked, and the low-rated (low-ranked) factors should be discarding. In this study, the value of "0.4" was applied to describe the low-ranked factors.

### C. Assessment Model of Study

Based on the previously described implantation stages of the Fuzzy Delphi Method, the assessment model for

developing the general framework's indicators to evaluate, analyze, and compare the family disintegration causes associated with the early marriage phenomenon in the Republic of Yemen was designed and applied. Fig. 1 describes it.

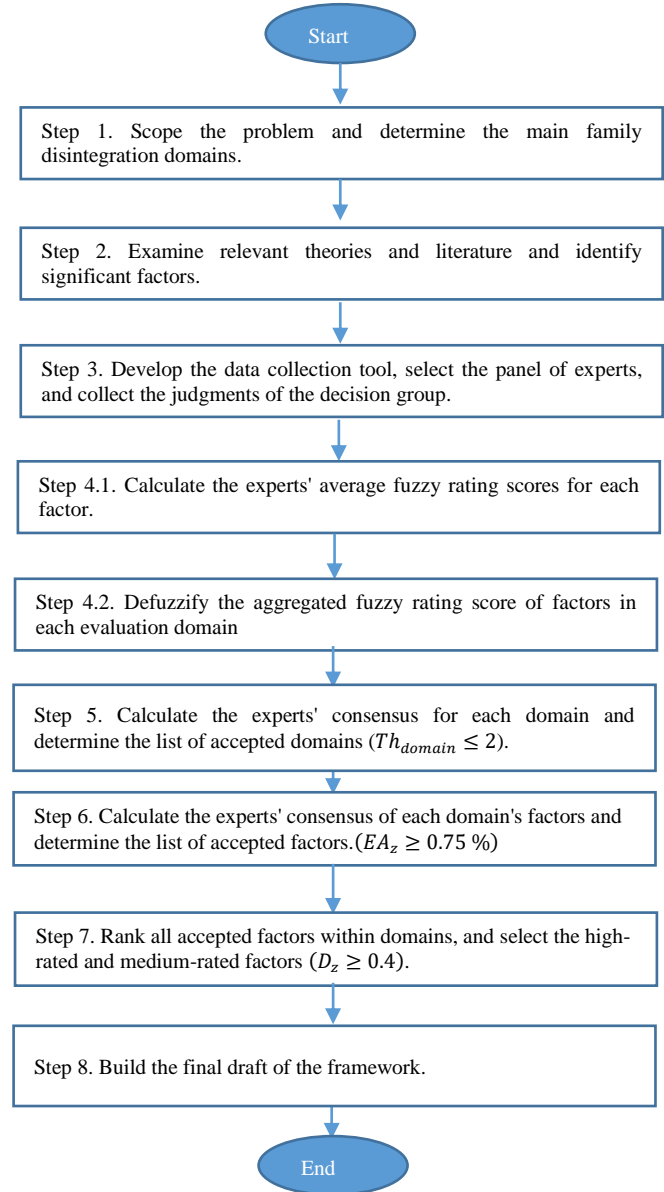


Fig. 1. The Assessment Model of Study.

## IV. ASSESSMENT MODEL APPLICATION AND RESULTS

### A. Scoping the Problem

The social and health domains of the family disintegration factors that are related to the phenomenon of family disintegration were chosen as the two main areas of factors to be identified and prioritized (refer to Section 1).

### B. Reviewing Pertinent Theories and Literature and Suggest the Significant Factors

Nine major factors of family disintegration that are highly related to early marriage have been proposed, six of which are

social factors, and three others are health. These factors were proposed based on reviewing more than thirty relevant studies (refer to Section 2), accordingly, the primary family disintegration factors most associated with the early marriage phenomenon were crystallized, as shown in Table I.

C. Developing the Data Collection Tool, Selecting the Panel of Experts and Collecting Judgments of the Decision Group

This study followed the recommendations of previous studies on the application of FDM, whereby at least 10 experts must be selected in a purposeful manner that meets the requirements of homogeneity in order to participate in the evaluation [30], [44], [45]. To achieve the requirements of homogeneity, this study followed the recommendations of the study [30], and a total of twenty-four experts have been selected, all of whom are currently engaged in thematic work close to the topic of this study and have accumulated knowledge and experience for more than 10 years in a related domain. Depending on the specialization, they are equally split up into three directions: demography science, sociology, and health and psychological sciences. This study used an assessment tool (questionnaire) to collect data from experts. A number of 24 closed questionnaires were sent by e-mail to all experts, each questionnaire containing nine factors, and they were asked to indicate their level of agreement on the

appropriateness of these factors as indicators of a general domestic framework for measuring, ranking, and structured comparing of family disintegration associated with early marriage in the Republic of Yemen, using the five-point Likert scale (strongly disagree = (1), strongly agree = (5)). Subsequently, all questionnaires were also received by e-mail. After that, all ratings were converted to their equivalent fuzzy number scores using the conversion table proposed by [44] (see Table II). Table III illustrates the fuzzy ratings of all experts.

D. Data Processing and Analysis

For this purpose, a simulation program has been developed using the Excel 2013 application. Using that tool, the average fuzzy rating score of all experts ( $\widetilde{w}_{rz}$ ) on each factor (z) was calculated ( $\widetilde{w}_z$ ) and defuzzified ( $D_z$ ) using equations (1) and (2), respectively.

These two rating score vectors are illustrated in Table IV. Subsequently, the experts' consensus of the two evaluation domains of study ( $Th_{domain}$ ) was examined using equations (3), (4), and (5). Both domains were accepted ( $Th_{domain} \leq 0.02$ ). After that, the experts' consensus on each evaluation factor was tested using equation (6). This step adopts factors with a threshold ( $EA_z$ ) above or equal to 75%

TABLE III. EXPERTS' FUZZY RATING SCORES

Expert	F1	F2	F3	F4	F5	F6	F7	F8	F9
1	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.0,2,0.4)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.4,0.6,0.8)
2	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
3	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.0,0.2,0.4)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
4	(0.4,0.6,0.8)	(0.0,0.2,0.4)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.0,0.2,0.4)	(0.4,0.6,0.8)	(0.6,0.8,1)	(0.6,0.8,1.0)
5	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.0,0.2,0.4)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
6	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
7	(0.4,0.6,0.8)	(0.0,6,0.8,1)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.2,0.4,0.6)	(0.6,0.8,1.0)	(0.6,0.8,1)	(0.4,0.6,0.8)
8	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.0,0.2,0.4)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
9	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
10	(0.4,0.6,0.8)	(0.6, 0.0,8,1)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
11	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.0,0.2,0.4)	(0.6,0.8,1.0)	(0.6,0.8,1.0)	(0.6,0.8,1.0)
12	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.6,0.8,1.0)	(0.6,0.8,1.0)	(0.4,0.6,0.8)
13	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.6,0.8,1.0)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
14	(0.0,0.2,0.4)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.0,0.2,0.4)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
15	(0.4,0.6,0.8)	(0.0,0.2,0.4)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.2,0.4,0.6)	(0.6,0.8,1.0)	(0.6,0.8,1.0)	(0.4,0.6,0.8)
16	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
17	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.6,0.8,1.0)	(0.6,0.8,1.0)	(0.6,0.8,1.0)
18	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.2,0.4,0.6)	(0.6,0.8,1)	(0.6,0.8,1.0)	(0.2,0.4,0.6)	(0.6,0.8,1.0)	(0.4,0.6,0.8)	(0.4,0.6,0.8)
19	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.0,0.2,0.4)	(0.6,0.8,1.0)	(0.6,0.8,1.0)	(0.6,0.8,1.0)
20	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.0,0.0,0.2)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.2,0.4,0.6)	(0.2,0.4,0.6)	(0.2,0.4,0.6)	(0.4,0.6,0.8)
21	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.0,0.2,0.4)	(0.6,0.8,1.0)	(0.4,0.6,0.8)	(0.6,0.8,1.0)
22	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.6,0.8,1.0)	(0.2,0.4,0.6)	(0.6,0.8,1.0)	(0.6,0.8,1.0)	(0.4,0.6,0.8)
23	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.6,0.8,1.0)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.2,0.4,0.6)	(0.6,0.8,1.0)
24	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.2,0.4,0.6)	(0.6,0.8,1.0)	(0.0,0.2,0.4)	(0.4,0.6,0.8)	(0.4,0.6,0.8)	(0.4,0.6,0.8)

TABLE IV. THE FUZZY AVERAGE EVALUATION SCORES ( $\bar{w}_z$ ), AND THEIR EQUIVALENT DEFUZZIFIED ( $D_z$ ) VALUES

Type	F	$\bar{w}_z$	$D_z$
SF	F1	(0.383,0.583,0.783)	0.58
	F2	(0.375,0.575,0.775)	0.57
	F3	(0.367,0.558,0.758)	0.56
	F4	(0.375,0.575,0.775)	0.57
	F5	(0.525,0.725,0.925)	0.72
	F6	(0.125,0.325,0.525)	0.32
HF	F7	(0.458,0.658,0.858)	0.58
	F8	(0.458,0.658,0.858)	0.57
	F9	(0.450,0.650,0.850)	0.56

As a result, all factors have been accepted at this stage. Then, factors were ranked in accordance with the defuzzified assessment values ( $D_z$ ), and only the high-rated and medium-rated factors were selected.

The ranking step uses factors with a defuzzified value of 0.4 or above, and those factors with a defuzzified value of less than 0.4 are ignored. However, with an average group assessment rate of more than 0.4 and an average group evaluation consistency rate of more than 75%, eight out of all nine evaluated factors were agreed to be general local framework's indicators for measuring, ranking, and structured comparing of family disintegration associated with an early marriage phenomenon in the Republic of Yemen, while, with the an acceptable consistency rate ( $EA_z=96\%$ ) and an average group assessment rate of ( $D_z=0.325<=0.4$ ), the last social factor (the sixth factor) was agreed to be inappropriate for that.

Table V shows the obtained consistency ratios of the evaluation domains ( $Th_{domain}$ ) and factors ( $EA_z$ ), the defuzzified evaluation scores ( $D_z$ ) and levels (EL) of each factor, the accepted and deleted factors (Status), and the ranking order of accepted factors (R).

TABLE V. EVALUATION RESULTS

Type	$Th_{domain}$	F	$D_z$	EL	$EA_z$	Status	R
SF	0.081	F1	0.58	Moderate	96%	ACCEPTED	4
		F2	0.57	Moderate	75%	ACCEPTED	5
		F3	0.56	Moderate	96%	ACCEPTED	6
		F4	0.57	Moderate	92%	ACCEPTED	5
		F5	0.72	high	96%	ACCEPTED	1
		F6	0.32	Low	96%	REJECTED	
HF	0.096	F7	0.66	high	92%	ACCEPTED	2
		F8	0.66	high	92%	ACCEPTED	2
		F9	0.65	high	100%	ACCEPTED	3

## V. DISCUSSION OF RESULTS

As mentioned earlier, Yemen's political conditions and the associated social, health, and economic changes have caused

domestic instability in Yemen. However, putting in place the necessary measures, solutions, and treatments, and distributing resources and services that contribute to limiting their effects, requires carrying out many relevant studies and analyses. Some examples of these requirements are: evaluation processes for the causes of disintegration; classification, clustering, and ranking of causes in each sector according to the probability and impact of each of the causes; classification and clustering of geographical sectors according to the factor's influence level on them and according to their need for relevant solutions and treatments; and determining the percentage of what each sector needs compared to others. Weaknesses in one or several areas related to the factors of disintegration.

In any case, these processes, which we briefly refer to in this study as assessment, arrangement, classification, and regular comparison, can only bear fruit by building the correct assessment framework, which includes comprehensive and accurate measurement indicators. So, this study aimed to build a general local framework that can later be used as a main tool for the implementation of these processes in order to solve this problem.

However, this paper fulfilled the purpose of the study. And the general local framework's indicators for measuring, ranking, and structured comparing of family disintegration associated with the early marriage phenomenon in Yemen was built by getting the consensus of a group of local experts on the relevance of the theoretically predefined factors using the Fuzzy Delphi Method.

The findings disclosed in the current paper indicate the consistency of experts' opinions on all indicators. The consistency rates across those indicators are acceptable (greater than 75%). A small degree of discrepancy (not exceeding 3%) between the experts' consistency ratio averages on the health (95%) and social (92%) fields' indicators was observed. This confirms the accuracy and integrity of the theoretical procedures followed for theoretically extracting the initial indicators of study. It also confirms the accuracy of the methodological procedures used in selecting a homogeneous sample of experts [41], and the accuracy and objectivity of experts during the evaluation process.

However, the expert opinions' consistency on indicators does not mean that all of them are appropriate. For example, with an average evaluation rate of 0.33 and a very high consistency rate of 96%, experts unanimously agreed on the poor suitability of the sixth indicator, "Incrementing of abandonment cases as a result of heterogeneity arising from the presence of large age differences between spouses," which represents 11% of all initial indicators, to represent a measurement indicator of family disintegration resulting from the phenomenon of early marriage. And this can be explained by the fact that this indicator is more related to the phenomenon of polygamy than to the phenomenon of early marriage. According to [46], this case is related to wives who marry boys younger than them and with large age differences, where large age differences over time cause cases of polygamy, especially in light of the unequal relationship between them.



In addition, for various reasons, which may be economic or social, some of these cases may result in the husband preferring to live with the second wife and abandoning the first wife, which may sometimes lead to divorce [47]; So, the sixth social factor may be considered a cause of family disintegration, but it is not mainly related to early marriage but rather to the phenomenon of multiple marriage.

Regarding the accepted indicators, with the exception of the sixth social indicator, all preliminary social and health indicators were accepted.

With an evaluation average of 0.72, the fifth indicator, "Increasing divorce rates in marital cases that do not take place according to the common desire of the spouses," came in first place. And this may be due to the local prevalence rate of these marriage cases [18], on the one hand, and their negative social effects on the compatibility and homogeneity between spouses [48], and their causing dire social consequences that reduce the cohesion of local families [49], on the other hand.

On the health side, with an average group evaluation score of 0.66, the seventh and eighth indicators, "increase in the number of deaths of underage mothers during childbirth" and "impact on maternal health" came in second place, and with a very small difference (-0.008), the ninth indicator, "Increasing the rates of psychological cases among underage wives," came in third place, which indicates the importance of the health factors of early marriage and the extent to which they cause family disintegration. And this may be due to the negative health effects of child marriage [6] and the resulting dire social consequences that hinder the wife from playing her integrative role in society [23].

These findings also emphasize the magnitude of health problems associated with early marriage, such as mental illness, personality disorders, disorders in sexual relations, depression and anxiety, increasing rates of induced abortions, and increasing rates of childbirth [4]. According to the International Women's Health Coalition (IWHC), women married before the age of 15 are "five times more likely to die in childbirth than women in their 20s and face a higher risk of pregnancy-related injuries [4]. Also, these findings highlight the need to consider health factors during the relevant monitoring, evaluation, and planning processes.

Socially, the average evaluation degree of the accepted social indicators (0.603) was slightly and almost insignificantly lower than its equivalent for health indicators (0.656), which also highlights the importance of indicators of a social nature within the proposed framework. In addition, with relatively different evaluation averages swinging between 0.58 and 0.57, the first four social indicators were ranked in the fourth, fifth, sixth, and fifth positions, respectively. And this confirms that there are no significant differences in their importance among experts.

Based on the foregoing, with the exception of the sixth factor, the experts' assessments confirmed that all factors that were theoretically derived could be considered as appropriate indicators to measure the family disintegration associated with the child marriage phenomenon in Yemen, and that they could be practically used to measure the causes of disintegration in

different regions of Yemen. Also, previous local and global studies such as [40, 50,51] on the development of planning and resource allocation decision support systems have confirmed that evaluation frameworks are a key component of the evaluation, ranking, comparison, classification, and clustering models of the national planning and resource allocation decision support systems, which are used to determine the actual needs of the geographical sectors; arrange and classify sectors according to their needs; and arrange and classify the causes according to the level of their spread and impact and the percentage of needs needed for each sector in comparison with other sectors.

These studies also indicate that these systems effectively contribute to the optimal utilization of resources, the promotion of sustainability practices, and the requirements of justice and the equal allocation of resources to address them. Taking into account all these assumptions, the researchers in this study recommend that decision makers adopt the proposed framework as part of the national decision support system for family and social stability planning and resource allocation management.

## VI. LIMITATIONS, APPLICATIONS AND FUTURE WORK

The study addressed the development of indicators within the general framework that could be applied in practice for other research purposes and examined only social and health indicators of family disintegration linked specifically to the phenomenon of early marriage in Yemen and ignored other types of indicators or factors, such as social and health indicators associated with polygamy or economic factors associated with family disintegration in general. Also, the indicators' ranking process has been carried out from the perspective of their suitability to measure the extent to which early marriage in Yemen generally causes family disintegration. In other words, priorities were not studied from the perspective of their impact level on the family disintegration state, nor from their relative importance as influential criteria according to certain developmental considerations.

Nevertheless, the proposed framework is fundamental and central to resolving many of the resolution's issues that this study has not been able to address. For example, to prioritize the proposed framework's domains and indicators as benchmarks from different experts' specialized perspectives and according to specific developmental considerations through the use of appropriate techniques such as AHP, F-AHP, BWM, or F-BWM; Conduct an analysis of the causal analysis between indicators, and to understand the different levels of impact results and the logical relationship that links them to each other, with the possibility of studying them from a general perspective, or from multiple specialized perspectives for decision experts through the application of appropriate techniques such as ANP, F-ANP, DEMATEL, or F-DEMATEL.

On the other hand, it could be used to assess and rank the causes of family disintegration in different Yemeni regions from the perspective of members of the community in those areas using a suitable hybrid technique that combines a subjective weighting method or/and objective weighting method with another ranking method such as TOPSIS or F-

TOPSIS; or to carry out structural comparative studies between those indicators in the different Yemeni governorates or areas to propose more effective solutions and treatments. This will help to promote the equity and investment of government resources and budgets on the one hand, and to attract institutions with different directions to implement their social responsibility practices in line with their directions on the other. Based on the foregoing, these applications will constitute the most prominent set of future research directions for researchers in this study.

## VII. CONCLUSION

The problem of family disintegration associated with the phenomenon of early marriage is one of the most prominent local issues negatively affecting the stability, prosperity, and development of society. The planning and building of sustainable sound strategies to reduce the negative effects of this problem requires the building of integrated decision support systems, capable of assisting in the implementation of assessments, arrangement, classification, comparison, and other relevant planning functions commensurate with local conditions, environment, and priorities. Also, the effectiveness, quality, and functionality of such systems depend on the validity and efficiency of the evaluation tools used to collect the inputs of such systems, which in turn must include real indicators that have been identified in accordance with the relevant theoretical foundations and principles and through the real participation of experts and specialists, taking into account the requirements and variables imposed by the local environment.

To achieve that goal, the problem was first examined and described as a decision problem. This step was followed by the selection and analysis of a set of relevant literature and theories. At this stage, a total of six social and three health indicators were defined to form the initial social and health indicators of the study. Then, twenty-four local experts were surveyed through a questionnaire tool designed for this purpose. After that, the FDM methodology was applied to study and analyze experts' opinions on the appropriateness of developed indicators. Based on that, eight key final indicators of family disintegration were drawn to represent the main structure of the proposed framework.

By analyzing the study's findings, the following conclusions were reached: (1) Experts focused on the subject of divorce. They believe that divorce arising from cases where the spouses or one of them is forced to marry another without the full conviction or desire to associate with them, to satisfy the family or to fulfill their wishes, is the main indicator for measuring family disintegration in early marriages. (2) Experts focused heavily on the health criterion, with an average assessment of the indicators of this criterion of 0.656, possibly because their concerns were focused on the importance of women's safety and health, which is a key pillar of family stability. (3) Although the average evaluation of health domain indicators was higher than social, the difference was small and did not exceed 0.05, which also underscores the importance of this domain. (4) Experts pay almost equal attention to health indicators, and relatively different to social indicators. The value of the average standard deviation of the

health indicators assessment averages was (0.0028), and that value increased by almost twenty-one times for the social standard indicators (0.059). Despite that, the discrepancy in the importance of social indicators for the group of experts remains relative and ineffective.

In any case, this study reached one final output called the general framework for the evaluation of the family disintegration causes associated with the child marriage phenomenon in Yemen. This framework is characterized by specialization, systematic, and appropriateness, as it was built according to multiple social and health theories, with the participation of local experts who live, influence, and are affected by the surrounding environmental conditions and using a reliable and globally approved decision support technique in order to contribute to solving a specific problem, according to the Yemeni context. Also, it has many real applications, and it can be used as a major component of the assessment, ranking, comparison, classification, and clustering models of the national and social related planning and resource allocation decision support systems.

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