



# Sustainable Evaluation of Factors Affecting Energy-Resource Conflict in the Western Region of Ghana Using Large Group-DEMATEL

Bismark Appiah Addae<sup>1</sup> · Weiming Wang<sup>1</sup> · Haiyan Xu<sup>1</sup> · Mohammad Reza Feylizadeh<sup>2</sup>

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## Abstract

As one of the latest in joining the African oil-producing countries, Ghana is facing energy resource associated conflict situations between the people and government, especially in the western region communities of the country, where the oil resources are in mass production. In avoiding open conflict, it is critical to identify and understand the key factors that induce and aggravate such situations. To serve this purpose, the present research first conducts a survey on relevant literature to obtain twenty-five factors for the situation of the Western Region of Ghana and then presents a novel large group-DEMATEL approach to rank these factors considering a large stakeholder engagement in strategic decision making. Applying the proposed approach, the interrelationship among factors are examined, and then the factor system is categorized into the cause-group and effect-group based on assessments of twenty stakeholders from various backgrounds. It is suggested that all the cause-group factors (i.e., key factors) should receive considerable attention, with the highest regarded one being the “increased unemployment” factor. Compared with the traditional DEMATEL, the novel large group-DEMATEL considers large group consensus of decision makers and thus promotes large group satisfaction among people. Therefore, the sustainable evaluation results of twenty-five factors are more reasonable and acceptable using the proposed approach.

**Keywords** Inclusive sustainable development · Large group decision-making · Ranking and selection · Strategic decision making

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✉ Haiyan Xu  
xuhaiyan@nuaa.edu.cn

Extended author information available on the last page of the article

## 1 Introduction

Led by the United Nations (UN), sustainable development has been taking a central position in global affairs. Countries are expected to work assiduously towards achieving the 17 sustainable development goals (SDGs) [1]. Amongst these SDGs, energy availability receives considerable attention since it is the foundation of other sustainable development goals [2, 3]. Yet more, from the social perspective, inclusive sustainable development including everyone's participation has been considered as one of the boosts to achieving these SDGs faster [4], in the sense that it involves the people on decisions that affect their living environment, economy, and society. However, on the contrary, there are challenges along this path stemming from the interdependencies in SDGs [5]. Among those challenges, the most common one is the presence of energy-resource conflict that may lead to unsustainable natural resource use [6] and induce increasing resource waste, poverty, unsustainable human development, environmental pollution, unsustainable economy, unsustainable consumption, unsustainable communities, and lack of peace. However, the literature from this aspect is rather limited. Moreover, although bringing everyone on board to the decision-making process can help, the resulting complication in the process may be extremely high, not to mention the complexity brought by seeking a desirable resolution of the energy-resource conflict itself caused by scarce resources from government or/and other policymakers.

As a developing country, Ghana, also known as the gateway to West Africa, is the latest to join the African oil producing countries. Recently, after the discovery and commercial production of oil, its Western Region community, where the oil resources are in mass production, is tested with conflict issues between the people and the government. Adopting an inclusive sustainable approach in the decision-making process can be effective given the broader engagement of the people in the affected communities. Nevertheless, as a technique that incorporates stakeholder engagement in the process of decision making on sustainable development [4], inclusive sustainable development still has many gaps to bridge. This research aims to answer the following questions. 1. What are the factors affecting energy-resource conflict in the Western Region communities of Ghana? 2. How can we identify the key factors from a large set of factors? 3. How can we account for the interrelationships existing between the factors to energy-resource conflicts? 4. How can we rank and select these factors to commit scarce resources? 5. How can we quantitatively address the inclusion of the people in these affected communities in the decision-making process?

Large group decision making (LGDM) in general has long been a decision-making technique in daily societal activities. Its formal representation has drawn much attention due to the advancement of society, social systems, and inclusive sustainable development. Besides, big data, the internet of things, and the 4th industrial revolution have brought further complexity in decision making [7, 8] and [9]. LGDM has been defined differently by different scholars; but what is common is the inclusion of a large group of decision-makers (DMs). Usually, the

definition is hinged on the number of DMs involved which determines how large it is, some above 11 [10] and others 20 and above [11]. Liu et al. [12] defined it as the selection of a set of feasible alternatives based on the preferences of large group DMs. Different from previous works, this research defines LGDM as the inclusion of at least 20 large-group DMs by which the best alternatives from a given set of feasible alternatives is selected based on the preferences of the large group DMs. Several methods of LGDM have been formulated and applied by different scholars in solving various research problems. For example, Tian et al. [13] developed a social network analysis (SNA) based on LGDM which focuses on the social relations of experts. Also, Liu et al. [14], Yu et al. [15], Liu et al. [16] and Song et al. [17] developed respectively a large group method considering the fairness of alternatives among stakeholders, an LGDM sustainable supplier approach using extended Technique for Order Preferences by Similarity to Ideal Solution (TOPSIS) under fuzzy environments, a large group-PROMETHEE II method in evaluating teacher appointment system reformation in a university, and an integrated LGDM based on probabilistic linguistic preference relation in an investment selection problem respectively. Though useful, the interdependence existing among the factors or sets of alternatives lacks recognition. Yet more, classifying these alternatives into cause and effect groups to commit scarce resources is also an unsolved issue of the above methods, while limited resources can be considered extremely important considering Ghana as a developing country.

Even though the application of LGDM in the prioritization of factors to the energy-resource conflict is rare, other decision-making approaches have been used in other areas of prioritizing and identifying key factors. For instance, Adams et al. [18] used econometric models to identify key factors affecting slow economic growth in developing countries rich in natural resources like Ghana. Ghimire and Kim [19] identified and ranked barriers to renewable energies in Nepal using the analytical hierarchical process (AHP). Also, Zaidi et al. [20] used the interpretive structural model (ISM) to investigate and rank the interrelationships among different factors of sustainable procurement implementation. Though the interactions between factors are considered somehow in these methodological approaches, the inclusion of a larger group decision-making body was not the focus. Additionally, Wu et al. [21] proposed the application of a hybrid fuzzy synthetic method and decision-making and trial evaluation laboratory (DEMATEL) to rank factors to sustainable resource management. Yet again, the large group of DMs was overlooked. In order to account for the interrelationships of the factors to energy-resource conflict when considering large group DMs, a large group-DEMATEL method is proposed here.

DEMATEL, originally proposed during the Geneva Research Center of the Battelle Memorial Institute around 1973, has a strong functionality embedded in its strong ability to prioritize criteria based on the type of relationship and severity of the influences existing between system elements [22]. Specifically, the factors having impacts on others are assumed to be more influential and therefore have higher priorities. These factors are categorized as the cause group. Those receiving most of the influences and thus having lower priorities are termed as the effect group. In addition, given the representation of causal relationships between two entities di-graphically and in matrices for easy visualization and

communication, DEMATEL can help us find key factors that affect the factor system. Recently, many methodology improvements in DEMATEL have been conducted to cater for diverse MCDA problems. Addae et al. [22] proposed a novel two-step fuzzy-DEMATEL to analyze barriers to smart energy city in Accra. With respect to the large group-DEMATEL, Jiang et al. [23] did a great job by extending the DEMATEL method to allow large group DMs via linguistic Z-numbers to determine key performance indicators for hospital management.

This study, to be particular, chooses a different approach in combining an LGDM method and the traditional DEMATEL method to form a hybrid large group-DEMATEL method. Compared with existing approaches, the proposed method has clear advantages in attaining the weights for both the DMs and the clusters, presenting the aggregation method, and considering a group consensus to make the result more reliable. This new approach is then applied to a case study in the Western Region of Ghana to find key factors from the entire factor system that affects energy-resource conflict in the area. The results yield insightful outcomes that can be used to facilitate the decision making process. The present study contributes to the existing literature in the following areas:

1. Aiming at analyzing the interrelationships existing between the factors to the energy-resource conflict in the Western Region of Ghana, this work assists in identifying the key factors in order to aid in strategic decision making to allocate scarce resources.
2. This paper addresses the decision-making challenges associated with employing an inclusive sustainable approach involving a large group of stakeholders to deal with energy-resource conflict.
3. A new approach to combining LGDM and DEMATEL is developed to form a hybrid large group-DEMATEL method. We first extend the traditional group-DEMATEL approach and propose a novel large group DEMATEL approach. Then a clustering technique is employed to compute the large group evaluation matrices. Based on the weights of the DMs and clusters, the large group evaluation matrices are aggregated by a consensus method.
4. This work forms a bridge between two research streams: the natural-resource conflict with energy-resource and the inclusive sustainable development.
5. To the best of our knowledge, this is the first study applying the proposed large group-DEMATEL method to quantitatively rank factors to the energy-resource conflict in the Western Region of Ghana.

The rest of the study is organized as follows. Sections 2 and 3 respectively present the background information and the literature review. The methodology is discussed in detail in Sect. 4. Section 5 performs the case study and analyze the results for insights. Section 6 gives further discussions of the case, and finally, Sect. 7 concludes this paper.

## 2 Problem Description

The Western Region of Ghana with Sekondi-Takoradi as the capital is made up of 13 districts (Ahanta West, Ellembelle, Jomoro, Mpohor, Nzema East, Prestea/Huni Valley, Sekondi/Takoradi Metropolis, Shama, Tarkwa Nsuaem, Wassa Amenfi Central, Wassa Amenfi East, Wassa Amenfi West and Wassa East). The region has a population of 2,165, 241 people according to the 2019 Ghana Statistical Service population update. It represents 10% of Ghana's total land area of about 23,921 square kilometers [24]. Most of the oil production in Ghana is found in this region and has generated both local and international recognitions in both business and research.

With natural resources such as oil deemed as having high potential to the development of a country,

much hope is anticipated by the people in the community to bring relief and prosperity to them and their community. However, these oil natural resource communities in Ghana are characterized by poor roads, bad infrastructure development, and high cost of living. A number of concerns are raised by the people of the Western-Region, such as the commercial mining of the oil inhibiting the major occupation (fish farming) in the community, claims of water pollution, unemployment, the oil serving the needs of foreigners rather than the indigens and also the government using the oil revenues to develop the capital city. This often than not generate conflicts between the local communities and the government. The case of energy-resource conflict in the Western Region is very sensitive learning from its devastating outcome in countries that have experienced it. There has been a number of clashes and internal conflicts cases reportage between the local communities in Western Region and the government due to the oil production that has had negative impact on the development of the local people and their environment. The loss of work especially farming due to restriction by the government, the unbalanced distribution of power in Ghana leading to challenges in structural transformation, socioeconomic equality as well as institution quality, the short-term political tenures characterized by high electoral turnovers leading to bureaucratic decisions, and the winner takes all syndrome in Ghana leading to individualism on public funds expenditure, are all drawbacks fueling this internal conflict in this region [25].

Only a handful of studies have been conducted on the energy-resource conflict in the Western Region of Ghana; many of those had predicted high possibility of future escalation of this internal conflict to an open one if measures are not implemented. It is therefore a pressing concern for the government and international policymakers to escape this possibility. Siakwah [26] applied the actor network theory (ANT) and assemblage to cross-examine the potential future manifestation of open conflict in this region. Ablo [27] studied the impact of local content policy (LCP) and corporated social responsibility (CSR) on enterprise development center (EDC) as a decisional strategy by the government in reducing the risk of oil-resource conflict in Ghana. In addition, Adjei and Overa [28] examined the discourses on the offshore coexistence between the petroleum industry and

small-scale fisheries in Ghana. Ackah et al. [29] performed the application of a desk review approach to examine development plans of three district assemblies (Jomoro, Ellembele, and Sekondi-Takoradi) around the petroleum-producing area respectively. Despite these efforts, the empirical quantitative representation on finding key factors leading to the energy-resource conflict in this region has not yet been undertaken.

### 3 Literature Review

#### 3.1 Energy-Resource Conflict

Conflict studies over natural resources can be seen as a series of events that start first as internal conflicts and later escalate into open conflicts with devastating outcomes. Mostly, conflict arises as a result of contradictory interests amongst different stakeholders over the use and exploitation of the resource. It was defined as the competition to control the resource by different parties while one of the parties seeks to control at the expense of others. This definition has also been broadened to include all parties recognizing the need for the resource but disagreeing on the distribution of the resource to meet their requirements [30]. Mostly, natural resource conflicts are studied from the social, ecological, and economic perspectives, even though some argue that these are not the only ones relevant, and others must include, such as social psychology, interdisciplinary methods, as well as the integration of cultural and biophysical environment [30]. Resource conflicts in Africa have undermined development efforts by destroying infrastructure, interrupting the production system, and putting to waste resource use. It has prevented the development of a good number of African countries by negatively affecting state structures, decreasing per capita income, and lowering the life expectancy of citizens [31].

Energy-resource conflict is considered a type of natural resource conflict in this study. Practical knowledge from other countries depicts that energy-resource conflicts arise between communities in extraction sites and extractive industries if early community engagements are not implemented, and the benefits from the resource extraction are not distributed fairly [32]. In respect of the so-called LCP and CSR interventions by the Ghanaian government, there are still somewhat limited capacity at the local level to influence decision-making. This asymmetry in power influences different stakeholder groups' public opinions and decision-making regarding the utilization of energy resources [28]. Available literature indicates that the acceptability of the outcome depends on the legitimacy of the planning and decision-making process [33]. Many decision science and conflict analysis methods have been dedicated to assisting policymakers in avoiding, resolving, and managing such a situation. Example of such methods includes game theory, metagame analysis, and conflict analysis. Also included is drama theory which adduces that conflict resolution requires actors to engage in a rational-emotional process of redefining both the game and their positions until a satisfactory resolution is reached [34]. Amongst various methodologies, the Graph Model to Conflict Resolutions (GMCR) demonstrates high flexibility in handling strategic conflicts due to its simplicity [35, 36].

### **3.2 Link Between Inclusive Sustainable Development and Energy-Resource Conflict**

Sustainable natural resources is important in order to support the needs of mankind. Amongst these resources, energy is central. Sustainable development has advanced from natural resource preservation to include the integration of humans and the satisfaction of their social, economic and environmental needs. Conflicts over energy-resources within a country and even across territorial borders is more likely to be intense as countries seek to its control and management to meet the demands of its citizens [37]. Hence, energy-resource conflict management has been becoming noticeable. The management of energy resources is complex and the process of decision making is therefore critical in diverse ways because it ascertains the path towards or away from sustainable development, according to [38].

To achieve SDGs, everyone's participation means a lot since they would be directly involved in the decisions affecting their living environment. Considering the social aspect of energy-resource conflict management the participation of the people in the affected communities is vital since its impacted by the people. Moreover, decision-making that receive inputs from wide-ranging stakeholders, concerns and disciplines since there is shared understanding and acceptance among parties of interest are more likely to be successful [39]. Inclusion is therefore of value, since it necessitates continuous enabling of society to actively engage in strategies, co-producing plans, processes, policies, and programs that can help address relevant issues. In this context, inclusive sustainable development which involves everyone as DMs is essential in energy-resource conflict decision making process because it has both socio-economic and environmental impacts.

More recently, inclusive development has shown much importance and has been considered at the heart of SDGs. The definition by the United Nations Development Program (UNDP) stated that development can be inclusive and reduce poverty only if all groups and people contribute and share the benefits of development and participate in decision-making [40]. Inclusive sustainability to natural resource studies is characterized by stakeholder participation in planning and decision making [41]. Towards this goal, we establish that inclusive sustainable development is an important approach to finding key factors to the energy-resource conflict in the Western Region of Ghana. Besides, not only in Ghana, but the proposed method can be also adopted by developing countries in their quest to deal with decision-making challenges to energy-resource conflicts.

## **4 Methodology for Identifying and Prioritizing Factors to Energy-Resource Conflict**

### **4.1 Identifying Factors to Energy-Resource Conflict in the Western-Region of Ghana**

In the identification of the factors to the energy-resource conflict in the Western Region of Ghana, this study used questionnaires to gather primary data and also

reviewed relevant literature to gather secondary data of relevance. In doing so, we first identify specific factors directly relevant to Ghana's case and other general ones for similar situations from the literature. These secondary data on the factors are then re-organized as shown in Table 1, based on which the structured matrix-questionnaires are prepared. Finally, a large group of stakeholders is requested to give their interrelation judgments among the re-organized factors.

Acknowledging previous studies, focusing on the same region, Siakwah [26] identified the "environmental pollution" ( $F_2$ ) as a factor that could lead to possible violent natural-resource conflicts. Even though agreed by the local fishermen following some negative environmental impact leading to health-related issues after the oil production, both the government of Ghana and the petroleum producing companies have played down on this, saying, there is not substantial scientific proof. Also, in their study, the government institutional quality ("poor institutional quality",  $F_{23}$ ) was questioned. The reason was that an independent investigative body was not required to investigate this health-related issue due to the extraction activities and

**Table 1** Re-organised factors affecting the energy-resource conflict in the Western Region of Ghana

Indicators	Factors	References
$F_1$	Increased unemployment	[25, 26, 42–43]
$F_2$	Environmental pollution	[25, 26, 45–45]
$F_3$	High cost of living	[25, 26, 46]
$F_4$	Corruption	[18, 25–27, 49–49]
$F_5$	Lack of job creation	[25, 50]
$F_6$	Health hazards	[25]
$F_7$	Income reduction/Poverty	[25, 26, 42, 51, 52, 45, 50, 53]
$F_8$	Lack of technical skills	[25, 51]
$F_9$	Restricted Fishing Activity	[25, 26, 42]
$F_{10}$	Weak governance	[18, 27, 52, 54, 55]
$F_{11}$	Political deceit	[25]
$F_{12}$	Increased price commodities	[25, 46]
$F_{13}$	Bureaucracy	[25, 48]
$F_{14}$	High cost of electricity	[25]
$F_{15}$	High cost of house rent	[25]
$F_{16}$	Lack of local infrastructure development	[27, 42]
$F_{17}$	Dutch Disease	[25, 26, 55, 55]
$F_{18}$	Rent-seeking	[26, 44, 56, 55]
$F_{19}$	Forced-relocation of local citizens	[25]
$F_{20}$	High rate of urbanization	[25, 42, 45, 50]
$F_{21}$	Increased crime rates	[26, 45, 50]
$F_{22}$	Lack of transparency and accountability	[18, 52, 54, 49]
$F_{23}$	Poor institutional quality	[18, 27, 51, 52, 45, 54, 55, 49]
$F_{24}$	Decrease in electricity access	[29]
$F_{25}$	Weak legal framework	[26, 48, 49]



this investigation was left solely to the technical capacities of the petroleum producing companies. Also, the factor “increased crime rates” ( $F_{21}$ ) was as well identified in that same study.

Yet more, Nyarko et al. [25] and Ablo [27] identified “increased unemployment” ( $F_1$ ), “lack of job creation” ( $F_5$ ), “income reduction/poverty” ( $F_7$ ), “corruption” ( $F_4$ ), “forced re-location of local citizens” ( $F_{19}$ ), “restricted fishing activity” ( $F_9$ ), “high cost of living” ( $F_3$ ), “decrease in electricity access” ( $F_{24}$ ), “high cost of electricity” ( $F_{14}$ ), “health hazards” ( $F_6$ ), “lack of technical skills” ( $F_8$ ), “political deceit” ( $F_{11}$ ), “lack of local infrastructure development” ( $F_{16}$ ), “weak governance” ( $F_{10}$ ), “high cost of house rent” ( $F_{15}$ ), “increased price commodities” ( $F_{12}$ ), “increased crime rates” ( $F_{21}$ ), and “high rate of urbanization” ( $F_{20}$ ) as specific factors in their studies. We also recognize overlaps between determinants of resource literature and that of resource-conflict as in many cases they result in each other, so the findings of [19] were considered as well Table 1. In addition, according to [44, 48, 56, 55, 49] and [52], factors “Dutch disease” ( $F_{17}$ ), “lack of transparency and accountability” ( $F_{22}$ ), “rent-seeking” ( $F_{18}$ ), “weak legal framework” ( $F_{25}$ ), and “bureaucracy” ( $F_{13}$ ) were included.

## 4.2 Proposed Method: A Novel Large Group-DEMATEL

In this section, we present a novel large group-DEMATEL approach for analyzing the interdependence of factors affecting the energy-resource conflict in the Western Region of Ghana. However, to understand in better form of the proposed approach, the traditional group-DEMATEL approach is first introduced.

### 4.2.1 Traditional Group DEMATEL Approach

In principle, the traditional group DEMATEL approach follows a two-stage process: (1) Aggregating group evaluation matrices; (2) Identifying factors to affect complex system.

Suppose that  $F = F_1, F_2, \dots, F_n$  is a set of factors for affecting a complex system to be analyzed by a group of DMs  $D = D^1, D^2, \dots, D^m$ . Let  $X^j = (x_{kl}^j)_{n \times n}$  be the direct influencing matrix of DM  $D^j$ , where  $x_{kl}^j$  is the evaluation information provided by DM  $D^j$  on the direct influence between factors  $F_k$  and  $F_l$  based on the evaluation scale  $S = \{0, 1, 2, 3, 4\}$  (where 0, 1, 2, 3 and 4 represent ‘no effect’, ‘very low’, ‘low’, ‘high’, and ‘very high’ effects, respectively).

**Stage 1** Aggregating group evaluation matrices.

**Step 1** Obtain the weights of DMs.

The weight of DM  $D^j, u_j$ , can be obtained by.

$$u_j = \frac{1}{m} \quad (1)$$

where  $m$  is the number of DMs.

*Example 1:* Assume a group of DMs  $D = D^1, D^2, D^3, D^4$ , then we have  $m = 4$  and  $u_1 = u_2 = u_3 = u_4 = 0.25$ .

**Step 2** Compute the direct influencing matrix of group decision makers.

The direct influencing matrix of decision makers,  $Y = (y_{kl})_{n \times n}$ , can be computed by.

$$Y = \sum_{j=1}^m u_j X^j \tag{2}$$

where  $u_j$  is the weight of DM  $D^j$ .

Follow Step 1, and assume that DMs  $D^1, D^2, D^3$  and  $D^4$  give evaluation matrices  $X^1, X^2, X^3$  and  $X^4$ , respectively, as follows:

$$X^1 = \begin{bmatrix} 0 & 1 & 2 \\ 0 & 0 & 3 \\ 2 & 4 & 0 \end{bmatrix}, X^2 = \begin{bmatrix} 0 & 3 & 2 \\ 0 & 0 & 3 \\ 1 & 3 & 0 \end{bmatrix}, X^3 = \begin{bmatrix} 0 & 2 & 4 \\ 1 & 0 & 4 \\ 3 & 2 & 0 \end{bmatrix}, X^4 = \begin{bmatrix} 0 & 2 & 2 \\ 0 & 0 & 4 \\ 1 & 3 & 0 \end{bmatrix}.$$

Then we can compute

$$Y = \begin{bmatrix} 0.00 & 2.00 & 2.50 \\ 0.25 & 0.00 & 3.50 \\ 1.75 & 3.00 & 0.00 \end{bmatrix}.$$

**Stage 2** Identifying factors to affect complex system.

**Step 3** Compute the normalized direct influencing matrix of decision makers.

The normalized direct influencing matrix of decision makers,  $P = (p_{kl})_{n \times n}$ , can be computed by

$$p_{kl} = y_{kl} / \max_{1 \leq k \leq n} \sum_{l=1}^n y_{kl}. \tag{3}$$

Following the result in Step 2, we have

$$P = \begin{bmatrix} 0.000 & 0.154 & 0.192 \\ 0.019 & 0.000 & 0.269 \\ 0.135 & 0.231 & 0.000 \end{bmatrix}.$$

**Step 4** Compute the total direct influencing matrix of decision makers.

The total direct influencing matrix of decision makers,  $T = (t_{kl})_{n \times n}$ , can be computed by.

$$T = \lim_{h \rightarrow \infty} (P^1 + P^2 + \dots + P^h) = P(I - P)^{-1} \tag{4}$$

Following Step 3, we can get

$$T = \begin{bmatrix} 0.039 & 0.220 & 0.259 \\ 0.061 & 0.079 & 0.302 \\ 0.154 & 0.279 & 0.105 \end{bmatrix}.$$

**Step 5** Calculate the Influences given and received for each factor.

The influences given and received for each factor,  $R_j$  and  $C_j$ , can be calculated by

$$R_i = \sum_{j=1}^n t_{ij}, C_i = \sum_{j=1}^n t_{ji}. \quad (5)$$

From the result in Step 4, then  $R_1 = 0.518, R_2 = 0.443, R_3 = 0.537$  and  $C_1 = 0.252, C_2 = 0.577, C_3 = 0.666$ .

**Step 6** Calculate the center degree and cause degree for each factor.

The center degree for each factor is  $R_i + C_i$  and the cause degree for each factor is  $R_i - C_i$ .

Following the result from Step 5, we have  $R_1 + C_1 = 0.770, R_2 + C_2 = 1.020, R_3 + C_3 = 1.203$  and  $R_1 - C_1 = 0.266, R_2 - C_2 = -0.134, R_3 - C_3 = -0.129$ .

**Step 7** Construct the influential relation diagram and analyze the structure of factors.

In spite of the advantages for the above-mentioned method, that is, this method can make full use of the knowledge and experiences of DMs so as to analyze the interdependence of factors. It is noted that the traditional group DEMATEL is often assigned weights for the small group based on subjective judgment and fails in considering the large group consensus and is difficult to realize the maximization of large group satisfaction. In this regard, the proposed novel large group DEMATEL expands the traditional group DEMATEL including to develop a new clustering approach and design a method to calculate weights for DMs and subgroups.

#### 4.2.2 A novel large group DEMATEL approach

Similar to the traditional group DEMATEL approach, the proposed large group DEMATEL approach also consists of two stages: (1) Aggregating large group evaluation matrices; (2) Identifying factors to affect energy-resource conflict in the Western Region of Ghana with a traditional DEMATEL method.

Suppose that  $F = F_1, F_2, \dots, F_n$  is a set of energy-resource conflict factors to be analyzed by a large group of DMs  $D = D^1, D^2, \dots, D^m$  ( $m \geq 20$ ). Note that a group decision making problem can be called LGDM problem when the number of DMs is or exceeds 20. The LGDM problem is different from the traditional decision making problem which considers a small number of DMs of about 3–5 [7–10]. Let  $X^j = (x_{kl}^j)_{n \times n}$  be the direct influencing matrix of the DM  $D^j$ , where  $x_{kl}^j$  is the evaluation information provided by DM  $D^j$  on the direct influence between factors  $F_k$  and  $F_l$  based on the evaluation information  $S = \{0, 1, 2, 3, 4\}$  (where 0, 1, 2, 3 and 4 represent ‘no effect’, ‘very low’, ‘low’, ‘high’, and ‘very high’ effects respectively). Next, the procedure of the proposed large group-DEMATEL approach for identifying factors to affect the energy-resource conflict in the Western Region of Ghana is detailed.

**Stage 1** Aggregating large group evaluation matrices.

**Step 1** Compute the difference degrees between DMs’ evaluation matrices.

The difference degrees between matrices  $X^{j_1}$  and  $X^{j_2}$ ,  $d_{j_1 j_2}$ , can be computed by Eq. (6):

$$d_{j_1j_2} = d(X^{j_1}, X^{j_2}) = \frac{1}{n(n-1)} \sum_{k=1}^n \sum_{l=1, l \neq k}^n d(x_{kl}^{j_1}, x_{kl}^{j_2}) \tag{6}$$

where  $d(x_{kl}^{j_1}, x_{kl}^{j_2}) = |x_{kl}^{j_1} - x_{kl}^{j_2}|/4$  is the difference degrees between  $x_{kl}^{j_1}$  and  $x_{kl}^{j_2}$ , and satisfying  $d_{j_1j_2} = d_{j_2j_1}$ .

*Example 2:* Assume that DMs  $D^1, D^2, D^3$  and  $D^4$  give evaluation matrices  $X^1, X^2, X^3$  and  $X^4$ , respectively, as follows:

$$X^1 = \begin{bmatrix} 0 & 1 & 2 \\ 0 & 0 & 3 \\ 2 & 4 & 0 \end{bmatrix}, X^2 = \begin{bmatrix} 0 & 3 & 2 \\ 0 & 0 & 3 \\ 1 & 3 & 0 \end{bmatrix}, X^3 = \begin{bmatrix} 0 & 2 & 4 \\ 1 & 0 & 4 \\ 3 & 2 & 0 \end{bmatrix}, X^4 = \begin{bmatrix} 0 & 2 & 2 \\ 0 & 0 & 4 \\ 1 & 3 & 0 \end{bmatrix}.$$

According to Eq. (6), we will have  $d_{11} = d_{22} = d_{33} = d_{44} = 0, d_{12} = d_{21} = 0.167, d_{13} = d_{31} = 0.333, d_{14} = d_{41} = 0.167, d_{23} = d_{32} = 0.333, d_{24} = d_{42} = 0.083$  and  $d_{34} = d_{43} = 0.250$ .

**Step 2** Cluster for DMs into subgroups according to the clustering threshold.

To cluster the DMs into subgroups, a clustering threshold,  $\lambda$ , can be determined by

$$\lambda = \frac{1}{4} \max_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2} + \frac{3}{4} \min_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2} \tag{7}$$

If  $d_{j_1j_2} \leq \lambda$ , we place  $D^{j_1}$  and  $D^{j_2}$  into the same subgroup. In this way, we can divide the  $m$  DMs into  $q$  subgroups, that is,  $\mathbf{D} = \{D^{(1)}, D^{(2)}, \dots, D^{(q)}\}$ . Assume that the  $r$ th subgroup  $D^{(r)} = \{D_1^{(r)}, D_2^{(r)}, \dots, D_{m_r}^{(r)}\}$  and the number of the members of the  $r$ th subgroup is  $m_r$ , satisfying  $\sum_{r=1}^q m_r = m$ .

Note that if  $\lambda = \max_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2}$ , then the  $m$  DMs into a subgroup; if  $\lambda = \min_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2}$ , then the  $m$  DMs into  $m$  subgroup. Obviously, the clustering

threshold is within  $\left[ \min_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2}, \max_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2} \right]$ . Given that the similarity

degrees among large group evaluation matrices are often great in group DEMATEL problems due to the reason that all the DMs have the similar knowledge and experiences, thus, the values of  $d_{j_1j_2}$  are often small. Therefore, the clustering threshold should be close to  $\min_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2}$  rather than  $\max_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2}$ . Moreover, a

sensitivity analysis based on linear operation was made for determining an appropriate clustering threshold, and then we found that the clustering threshold  $\lambda = \frac{1}{4} \max_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2} + \frac{3}{4} \min_{j_1, j_2=1, 2, \dots, m, j_1 \neq j_2} d_{j_1j_2}$  can make the numbers of the members of each subgroup are evenly distributed, which is reasonable for the result of clustering DMs.

Following the result from Step 1 in Example 2, we can get  $\lambda = 0.146$ , then the clustering results are  $\mathbf{D} = \{D^1, D^2, D^3, D^4\} = \left\{ D^{(1)} = \{D_1^{(1)} = D^1\}, D^{(2)} = \{D_1^{(2)} = D^2, D_2^{(2)} = D^4\}, D^{(3)} = \{D_1^{(3)} = D^3\} \right\}$ .

**Step 3** Obtain the weights of DMs.

$u_{j_1}$ , the weight of DM  $D^{j_1}$ , can be obtained by

$$u_{j_1} = \frac{\sum_{j_2=1, j_2 \neq j_1}^m (1 - d_{j_1 j_2})}{\sum_{j_1=1}^m \sum_{j_2=1, j_2 \neq j_1}^m (1 - d_{j_1 j_2})} \tag{8}$$

where  $u_{j_1}$  represents the relative importance degree of DM  $D^{j_1}$  among all the DMs. It is noted that, in the group DEMATEL problems, if a DM has the greater close degree with other DMs, it means the DM is closer to the group opinion, it is more likely that his/her preference is more reasonable and reliable, hence more weight should be assigned for him/her. In this context,  $\sum_{j_2=1, j_2 \neq j_1}^m (1 - d_{j_1 j_2})$  can denote the close degree between DM  $D^{j_1}$  and other DMs. Therefore, the greater value of  $\sum_{j_2=1, j_2 \neq j_1}^m (1 - d_{j_1 j_2})$ , the larger weight of DM  $D^{j_1}$ . That is to say, the formula to obtain the weight  $u_{j_1}$  is rational. In fact,  $\sum_{j_2=1, j_2 \neq j_1}^m (1 - d_{j_1 j_2})$  can also reflect the group consensus of DM  $D^{j_1}$ , and then  $\sum_{j_1=1}^m \sum_{j_2=1, j_2 \neq j_1}^m (1 - d_{j_1 j_2})$  can further reflect the sum of the group consensus of all the DMs, thus  $u_{j_1}$  can consider group consensus and finally improve group's satisfaction.

From the example in step 2, then we conclude  $u_1 = 0.250, u_2 = 0.259, u_3 = 0.223, u_4 = 0.268$ .

**Step 4** Obtain the weights of subgroups.

$\xi_r$ , the weight of subgroup  $D^{(r)}$ , can be obtain by

$$\xi_r = (m_r)^2 / \sum_{r=1}^q (m_r)^2 \tag{9}$$

where  $\xi_r$  represents the relative importance degree of subgroup  $D^{(r)}$  among all the subgroups. It is noted that,  $m_r$  is the number of the members of subgroup  $D^{(r)}$ , and  $(m_r)^2$  can reflect the consensus of subgroup  $D^{(r)}$ , then  $\sum_{r=1}^q (m_r)^2$  can further reflect the sum of the consensus of all the subgroups, thus  $\xi_r$  can also consider group consensus and finally improve group's satisfaction.

Following the result of Step 3 in Example 2, we can get  $\xi_1 = 0.167, \xi_2 = 0.666$  and  $\xi_3 = 0.167$ .

**Step 5** Compute the direct influencing matrix of group decision making.

The direct influencing matrix of group decision making,  $Y = (y_{kl})_{n \times n}$ , can be computed by

$$Y = \sum_{r=1}^q \xi_r \sum_{i=1}^{m_r} u_i^{(r)} X_i^{(r)} \tag{10}$$

where  $\xi_r$  is the weight of subgroup  $D^{(r)}$ ,  $X_i^{(r)}$  is the evaluation matrix provided by  $i$ th DM  $D_i^{(r)}$  in subgroup  $D^{(r)}$ .  $u_i^{(r)}$  is the normalized weight of DM  $D_i^{(r)}$  in subgroup  $D^{(r)}$ , that is,  $u_i^{(r)} = u_{r(i)} / \sum_{r(i)=1}^{m_r} u_{r(i)}$ . Note that if there exists a subjective weight ( $u_{r(i)}^{\odot}$ ) of DM

$D_i^{(r)}$ , then  $u_{r(i)} = u_{r(i)}^\circledast u_{r(i)}^\otimes / \sum_{r(i)=1}^{m_r} u_{r(i)}^\circledast u_{r(i)}^\otimes$  is the comprehensive weight of DM  $D_i^{(r)}$ , where  $u_{r(i)}^\otimes$  is the objective weight of DM  $D_i^{(r)}$  obtained using Eq. (8).

From the results of Steps 1,2,3 and 4 in Example 2, and assuming the subjective weight of each DM is equal, we can then calculate  $u_1^{(1)} = 1, u_1^{(2)} = 0.491, u_2^{(2)} = 0.507, u_1^{(3)} = 1$ , then

$$Y = \begin{bmatrix} 0.000 & 2.160 & 2.334 \\ 0.167 & 0.000 & 3.506 \\ 1.501 & 3.000 & 0.000 \end{bmatrix}.$$

**Stage 2** Ranking factors to energy-resource conflict.

**Step 6** Compute the normalized direct influencing matrix of group decision making.

The normalized direct influencing matrix of group decision making,  $P = (p_{kl})_{n \times n}$ , can be computed by

$$p_{kl} = \frac{y_{kl}}{\max_{1 \leq k \leq n} \sum_{l=1}^n y_{kl}}, \tag{11}$$

where  $y_{kl}$  is the collective evaluation information of group decision making on the direct influence between factors  $F_k$  and  $F_l$ .

Following the result of Step 5 in Example 2, we have

$$P = \begin{bmatrix} 0.000 & 0.171 & 0.184 \\ 0.013 & 0.000 & 0.277 \\ 0.118 & 0.237 & 0.000 \end{bmatrix}.$$

**Step 7** Compute the total direct influencing matrix of group decision making.

The total direct influencing matrix of group decision making,  $T = (t_{kl})_{n \times n}$ , can be computed by

$$T = \lim_{h \rightarrow \infty} (P^1 + P^2 + \dots + P^h) = P(I - P)^{-1}, \tag{12}$$

where  $I$  is the identity matrix, i.e.,

$$I = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

From the result of Step 6 in Example 2, we can get

$$T = \begin{bmatrix} 0.033 & 0.237 & 0.256 \\ 0.051 & 0.082 & 0.309 \\ 0.134 & 0.284 & 0.103 \end{bmatrix}.$$

**Step 8** Calculate the Influences given and received for each factor.

The influences given and received for the factors,  $R_i$  and  $C_i$ , can be calculated by

$$R_i = \sum_{j=1}^n t_{ij}, C_i = \sum_{j=1}^n t_{ji}. \quad (13)$$

Following the results of Step 7 in Example 2, then  $R_1 = 0.526, R_2 = 0.441, R_3 = 0.522$  and  $C_1 = 0.219, C_2 = 0.603, C_3 = 0.668$ .

**Step 9** Calculate the center degree and cause degree for each factor.

The center degree for each factor is  $R_i + C_i$  and the cause degree for each factor is  $R_i - C_i$ .

From the example in step 8, we can establish that  $R_1 + C_1 = 0.745, R_2 + C_2 = 1.044, R_3 + C_3 = 1.190$  and  $R_1 - C_1 = 0.307, R_2 - C_2 = -0.161, R_3 - C_3 = -0.146$ .

**Step 10** Construct the influential relation diagram and analyze the structure of factors affecting energy-resource conflict in the Western Region of Ghana.

Compared with the traditional DEMATEL approach, some advantages with regard to the proposed large group DEMATEL approach are as follows. First, a new clustering technique is employed to compute the large group evaluation matrices so as to get a more reasonable clustering result for DMs, where we put forward a formula to determine the clustering threshold and describe the process of clustering large group DMs. Then, we present a weighting determining method for DMs and subgroups, which can take large group consensus into account so as to improve the large group satisfaction. Finally, a consensus method based on the weights of DMs and subgroups is provided, which can improve the reliability and accuracy for the result of decision making.

The flowchart of the proposed large group-DEMATEL approach is shown in Fig. 1.

## 5 Application and Results Analysis

### 5.1 Application to Case Study

As previously indicated in the conflict background (Sect. 2), the proposed method is then applied to an energy conflict study in the Western Region of Ghana between the local people and government. The purpose of this novel method is to involve all stakeholders in large group decision-making in prioritizing identified factors contributing to this conflict with an overall goal of contributing to conflict resolution. In effect, this also promotes inclusive sustainable development in Ghana. In this study, we invited a total of twenty stakeholders made of ten experts and ten “people” selected randomly from the Western Region of Ghana. Ten experts consisted of four university researchers in the field of energy, economy, environment, and social science, three government workers with energy background, two workers in the private energy companies, and one social worker with an NGO. The “people” group contained three fishing folks, four unemployed youths, two petty traders, and one enterprise owner. Based on the

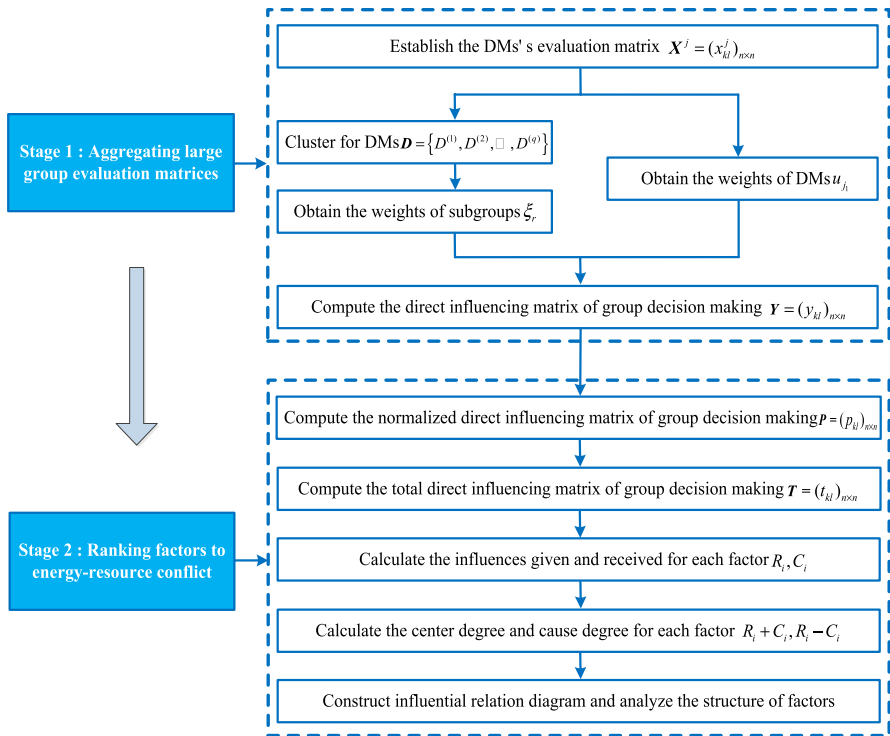


Fig. 1 Flowchart of the proposed large group DEMATEL approach

rational assumption, we assigned different subjective weights, 0.75 and 0.25, to the experts and “people”, respectively.

The constructed matrix-questionnaire was administered to these stakeholders to fill, as such the data on the interrelations of these factors were collected. All responses were valid, and hence, no statistical error was recorded. We then conducted all calculations following the methodology steps given in Fig. 1.

**Step 1** By Eq. (6), the difference degrees between DMS’ evaluation matrices,  $d_{j_1 j_2}$  ( $j_1, j_2 = 1, 2, \dots, 20$ ), were computed, the matrix of difference degrees,  $D = (d_{j_1 j_2})_{20 \times 20}$ , is as Table 2.

**Step 2** Using Eq. (7), the clustering threshold was determined as  $\lambda = 0.022$ . Then, according to the introduced clustering method, the clustering results were  $D = \{D^1, D^2, \dots, D^{20}\} = \left\{ \left\{ D_1^{(1)} = D^1, D_2^{(1)} = D^4, D_3^{(1)} = D^5, D_4^{(1)} = D^6, D_5^{(1)} = D^{12}, D_6^{(1)} = D^{18} \right\}, \left\{ D_1^{(2)} = D^2, D_2^{(2)} = D^7, D_3^{(2)} = D^{17}, D_4^{(2)} = D^{19}, D_5^{(2)} = D^{20} \right\} \right\}$ ,



**Table 2** The matrix of difference degrees  $D = (d_{j,i})_{20 \times 20}$

$D^1$	$D^2$	$D^3$	$D^4$	$D^5$	$D^6$	$D^7$	$D^8$	$D^9$	$D^{10}$	$D^{11}$	$D^{12}$	$D^{13}$	$D^{14}$	$D^{15}$	$D^{16}$	$D^{17}$	$D^{18}$	$D^{19}$	$D^{20}$	
$D^1$	0.000	0.030	0.046	0.004	0.002	0.005	0.033	0.051	0.040	0.043	0.050	0.004	0.050	0.059	0.060	0.050	0.028	0.002	0.032	0.034
$D^2$	0.030	0.000	0.061	0.032	0.029	0.033	0.007	0.063	0.043	0.045	0.064	0.033	0.054	0.068	0.069	0.064	0.002	0.032	0.007	0.008
$D^3$	0.046	0.061	0.000	0.050	0.047	0.050	0.064	0.008	0.060	0.063	0.004	0.048	0.069	0.079	0.080	0.003	0.059	0.048	0.063	0.065
$D^4$	0.004	0.032	0.050	0.000	0.006	0.009	0.035	0.052	0.043	0.047	0.055	0.008	0.053	0.062	0.063	0.054	0.030	0.005	0.035	0.036
$D^5$	0.002	0.029	0.047	0.006	0.000	0.007	0.032	0.052	0.038	0.041	0.051	0.006	0.048	0.058	0.060	0.050	0.028	0.004	0.032	0.033
$D^6$	0.005	0.033	0.050	0.009	0.007	0.000	0.036	0.055	0.043	0.047	0.055	0.009	0.052	0.062	0.063	0.054	0.031	0.007	0.035	0.037
$D^7$	0.033	0.007	0.064	0.035	0.032	0.036	0.000	0.066	0.048	0.051	0.067	0.036	0.058	0.070	0.072	0.066	0.005	0.035	0.010	0.010
$D^8$	0.051	0.063	0.008	0.052	0.052	0.055	0.066	0.000	0.063	0.066	0.013	0.053	0.072	0.082	0.083	0.012	0.062	0.053	0.064	0.068
$D^9$	0.040	0.043	0.060	0.043	0.038	0.043	0.048	0.063	0.000	0.004	0.064	0.043	0.013	0.065	0.066	0.063	0.042	0.041	0.046	0.048
$D^{10}$	0.043	0.045	0.063	0.047	0.041	0.047	0.051	0.066	0.004	0.000	0.067	0.046	0.016	0.068	0.069	0.065	0.045	0.045	0.049	0.051
$D^{11}$	0.050	0.064	0.004	0.055	0.051	0.055	0.067	0.013	0.064	0.067	0.000	0.053	0.073	0.083	0.085	0.008	0.063	0.053	0.066	0.068
$D^{12}$	0.004	0.033	0.048	0.008	0.006	0.009	0.036	0.053	0.043	0.046	0.053	0.000	0.053	0.062	0.063	0.052	0.032	0.006	0.036	0.038
$D^{13}$	0.050	0.054	0.069	0.053	0.048	0.052	0.058	0.072	0.013	0.016	0.073	0.053	0.000	0.072	0.073	0.070	0.053	0.051	0.056	0.059
$D^{14}$	0.059	0.068	0.079	0.062	0.058	0.062	0.070	0.082	0.065	0.068	0.083	0.062	0.072	0.000	0.005	0.083	0.066	0.060	0.068	0.069
$D^{15}$	0.060	0.069	0.080	0.063	0.060	0.063	0.072	0.083	0.066	0.069	0.085	0.063	0.073	0.005	0.000	0.084	0.067	0.061	0.069	0.070
$D^{16}$	0.050	0.064	0.003	0.054	0.050	0.054	0.066	0.012	0.063	0.065	0.008	0.052	0.070	0.083	0.084	0.000	0.063	0.052	0.065	0.068
$D^{17}$	0.028	0.002	0.059	0.030	0.028	0.031	0.005	0.062	0.042	0.045	0.063	0.032	0.053	0.066	0.067	0.063	0.000	0.030	0.005	0.007
$D^{18}$	0.002	0.032	0.048	0.005	0.004	0.007	0.035	0.053	0.041	0.045	0.053	0.006	0.051	0.060	0.061	0.052	0.030	0.000	0.034	0.036
$D^{19}$	0.032	0.007	0.063	0.035	0.032	0.035	0.010	0.064	0.046	0.049	0.066	0.036	0.056	0.068	0.069	0.065	0.005	0.034	0.000	0.012
$D^{20}$	0.034	0.008	0.065	0.036	0.033	0.037	0.010	0.068	0.048	0.051	0.068	0.038	0.059	0.069	0.070	0.068	0.007	0.036	0.012	0.000

$$D^{(3)} = \left\{ D_1^{(3)} = D^3, D_2^{(3)} = D^8, D_3^{(3)} = D^{11}, D_4^{(3)} = D^{16} \right\},$$

$$D^{(4)} = \left\{ D_1^{(4)} = D^9, D_2^{(4)} = D^{10}, D_3^{(4)} = D^{13} \right\}, D^{(5)} = \left\{ D_1^{(4)} = D^{14}, D_2^{(4)} = D^{15} \right\}.$$

**Step 3** Applying Eq. (8)), the weights of DMs were obtained as  $u_1 = 0.0507, u_2 = 0.0503, u_3 = 0.0497, u_4 = 0.0505, u_5 = 0.0507, u_6 = 0.0505, u_7 = 0.0502, u_8 = 0.0495, u_9 = 0.0500, u_{10} = 0.0498, u_{11} = 0.0495, u_{12} = 0.0505, u_{13} = 0.0495, u_{14} = 0.0490, u_{15} = 0.0489, u_{16} = 0.0496, u_{17} = 0.0504, u_{18} = 0.0506, u_{19} = 0.0502, u_{20} = 0.0501.$

**Step 4** By Eq. (9), the weights of subgroups were obtained as  $\xi_1 = 0.4000, \xi_2 = 0.2778, \xi_3 = 0.1778, \xi_4 = 0.1000, \xi_5 = 0.0444.$

**Step 5** Using Eq. (10), the direct influencing matrix of group decision making  $Y = (y_{kl})_{25 \times 25}$  was computed as shown in Table 3.

**Step 6** The normalized direct influencing matrix of group decision making  $P = (p_{kl})_{25 \times 25}$  was computed using Eq. (11) as presented in Table 4.

**Step 7** The total direct influencing matrix of group decision making  $T = (t_{kl})_{25 \times 25}$  was calculated using Eq. (12) and listed in Table 5.

**Step 8** The influences given and received for each factor,  $R_i$  and  $C_i$ , were calculated using Eq. (13) and shown in Table 6.

**Step 9** The center degree and the cause degree for each factor,  $R_i + C_i$  and  $R_i - C_i$ , were calculated using Eq. (14), The results are displayed in Table 6.

**Step 10** Based on the data of the center degree  $R_i + C_i$  and the cause degree  $R_i - C_i$ , the influential relation diagram of 25 factors was drawn as shown in Fig. 2, and the structure of factors affecting energy-resource conflict in the Western Region of Ghana was analyzed.

It can be inferred, from the results of Table 6, that “increased unemployment” ( $F_1$ ) (4.5017), ( $F_4$ ) “corruption” (3.7742), ( $F_3$ ) “high cost of living” (3.6265), ( $F_5$ ) “lack of job creation” (3.5577) and ( $F_{18}$ ) “rent-seeking” (3.4578) recorded the highest top five center degree index (importance) score in the whole factor system. However, since the traditional DEMATEL thrives on the principle of cause vs effect, those factors found in the cause-group are deemed critical they have high tendencies of giving rise to those factors categorized under the effect group [22]. Based on this ideology, even though factors ( $F_4$ ) “corruption” (3.7742) and ( $F_3$ ) “high cost of living” (3.6265) have high center degree score, they can be ignored on the assumption of cause vs effect since they can be found in the effect group category, as shown in Fig. 2.

However, ( $F_1$ ) “increased unemployment” (4.5017), ( $F_5$ ) “lack of job creation” (3.5577), and ( $F_{18}$ ) “rent-seeking” (3.4578) can be judged as highly critical since they dispatch both high centre (importance) and cause degree index influence of 0.5463, 0.1321, and 0.1185 respectively on the entire factor system (Table 6 and Fig. 2). Similar logic can be used to explain the situations of other factors. Those with positive cause-group index were grouped together as cause-group factors, for example, ( $F_8$ ) “lack of technical skills” (0.3167), whilst those with negative cause-group index were grouped as effect-group factors, for example ( $F_{12}$ ) “increased price commodities” (-0.6770).

**Table 3** The direct influencing matrix of group decision making  $Y = (y_{ij})_{25 \times 25}$

$F_1$	$F_2$	$F_3$	$F_4$	$F_5$	$F_6$	$F_7$	$F_8$	$F_9$	$F_{10}$	$F_{11}$	$F_{12}$	$F_{13}$	$F_{14}$	$F_{15}$	$F_{16}$	$F_{17}$	$F_{18}$	$F_{19}$	$F_{20}$	$F_{21}$	$F_{22}$	$F_{23}$	$F_{24}$	$F_{25}$
$F_1$	0.0	3.6	3.1	3.5	3.0	3.2	3.1	3.2	3.6	3.8	3.2	3.2	2.4	3.2	3.2	3.2	3.8	3.2	4.0	2.4	4.0	2.4	3.2	2.2
$F_2$	2.1	0.0	1.9	2.6	2.1	4.0	2.0	2.0	1.8	2.3	3.0	2.0	2.0	2.3	2.0	1.8	1.9	2.6	2.0	2.0	3.0	3.0	3.0	3.0
$F_3$	2.1	3.6	0.0	2.0	3.9	2.0	2.0	2.0	3.0	3.0	1.0	2.0	2.1	2.3	1.2	2.0	3.0	2.0	2.1	2.3	2.0	2.0	2.0	2.0
$F_4$	2.0	1.0	2.1	0.0	3.0	1.0	3.0	2.0	3.0	4.0	2.0	3.0	1.0	1.0	3.0	3.0	3.0	1.0	2.0	1.0	4.0	3.0	1.1	2.0
$F_5$	3.4	2.5	2.9	3.7	0.0	1.7	1.0	2.2	3.1	2.4	2.6	1.1	2.4	4.0	1.9	1.1	2.0	2.2	3.0	3.9	1.0	2.5	1.0	1.2
$F_6$	2.3	2.0	1.0	2.0	1.6	0.0	2.0	1.6	2.0	1.0	0.0	0.0	0.0	0.0	0.2	0.2	1.7	3.0	1.1	1.1	1.1	1.0	0.2	0.1
$F_7$	3.7	0.0	3.0	3.0	1.0	2.0	0.0	2.0	1.0	2.1	3.0	2.0	1.0	3.0	1.0	2.0	1.0	2.0	3.0	3.0	2.0	2.0	2.0	2.0
$F_8$	3.7	1.8	3.3	2.2	3.4	1.4	3.0	0.0	4.0	1.0	2.0	1.0	2.0	1.0	2.6	4.0	3.1	2.4	2.0	4.0	1.0	0.4	0.6	0.0
$F_9$	3.6	1.1	3.5	3.5	3.4	2.0	3.0	1.0	0.0	2.2	2.0	4.0	2.0	2.0	2.1	2.2	4.0	1.0	1.0	3.0	2.0	2.0	1.0	1.0
$F_{10}$	2.9	3.0	2.0	2.1	2.0	2.0	2.0	2.0	0.0	2.0	2.0	2.0	2.3	2.0	3.0	3.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
$F_{11}$	2.1	2.0	3.0	1.9	2.0	2.1	2.0	1.0	2.0	0.0	2.1	2.0	1.0	2.0	2.0	1.0	2.0	1.0	1.0	2.0	2.0	1.2	2.0	2.0
$F_{12}$	1.0	1.0	0.0	1.0	1.0	2.0	1.1	1.0	1.0	2.0	0.0	1.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	0.0
$F_{13}$	2.1	2.0	2.1	2.1	2.1	1.9	1.9	1.9	2.3	2.0	2.0	2.0	2.0	2.0	2.3	3.0	3.1	2.0	2.1	2.0	2.0	2.0	2.0	2.0
$F_{14}$	2.0	1.1	2.0	2.0	2.0	1.0	2.0	1.0	1.0	1.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
$F_{15}$	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0	2.0	1.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0	0.0
$F_{16}$	3.1	1.9	2.9	2.3	2.9	1.0	2.9	2.9	3.0	1.0	2.9	2.0	2.1	2.0	0.0	1.0	2.0	2.3	1.0	2.1	1.0	2.0	3.3	1.0
$F_{17}$	3.0	1.2	3.8	3.0	2.9	1.0	3.0	3.0	2.0	1.0	2.0	1.0	2.0	1.0	3.0	0.0	3.0	1.0	2.0	3.0	1.0	2.1	1.0	3.0
$F_{18}$	3.7	0.4	2.5	3.2	2.0	4.0	2.3	1.0	3.0	1.0	4.0	1.0	2.0	1.0	1.9	2.1	3.0	0.0	1.6	3.0	1.0	2.0	2.0	3.0
$F_{19}$	2.3	1.3	1.6	2.0	1.1	1.1	2.2	1.0	2.9	1.1	1.0	1.1	1.0	0.1	1.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0
$F_{20}$	2.8	2.0	2.7	2.1	2.8	2.3	2.0	1.1	1.2	1.2	2.0	3.0	1.2	2.0	2.8	2.0	1.0	2.0	0.0	3.0	2.0	2.0	3.0	2.0
$F_{21}$	2.4	2.0	1.9	2.1	1.1	2.0	3.1	2.0	2.0	2.1	2.0	2.1	2.0	1.0	2.0	1.0	2.0	1.0	2.1	0.0	2.0	2.0	2.0	2.0
$F_{22}$	2.3	2.0	1.0	2.7	2.0	1.0	2.0	2.0	1.2	2.3	1.0	2.0	2.0	2.0	1.2	2.2	2.0	2.0	2.0	1.0	0.0	1.0	1.0	2.0
$F_{23}$	3.5	2.6	2.0	3.2	1.5	2.3	1.8	2.2	2.0	1.6	2.2	2.4	2.3	1.8	2.2	2.1	2.5	1.8	2.2	2.2	3.0	0.0	2.3	3.2
$F_{24}$	1.1	2.0	3.0	1.0	2.0	2.0	4.0	1.1	0.0	1.0	2.0	1.0	0.0	3.1	2.0	0.0	0.1	2.0	1.2	2.8	1.2	1.2	0.0	0.0
$F_{25}$	1.3	2.0	1.0	3.9	1.0	2.0	2.3	2.0	1.0	2.3	2.0	2.0	1.0	2.0	2.0	3.2	3.0	2.0	2.0	2.0	2.0	2.0	0.1	0.0

Analysing from the cause-group results, ( $F_{23}$ ) “poor institutional quality” (0.4267), emerged as the second important factor with a high tendency of resulting in other factors. This was followed by ( $F_2$ ) “environmental pollution” (0.3968) and ( $F_{10}$ ) “weak governance” (0.3967) shown in Table 6. Again, ( $F_{11}$ ) “political deceit” (-0.2758), ( $F_{19}$ ) “forced re-location of local citizens” (-0.4910), and ( $F_{15}$ ) “high cost of house rent” (-0.7944) all emerged as effect-group factors and can be ignored as seen in Table 6.

## 5.2 Comparison Analysis

In this section, a comparative analysis is presented to demonstrate the effectiveness of our proposed large group DEMATEL approach. The traditional DEMATEL approach is also applied to solve the above case study with a different ranking result. The ranking results of center degree and cause degree for each factor about the two methods are shown in Table 7, Figs. 3, and 4. As we can see, the rankings of center degree by two methods for  $F_1, F_3, F_4, F_5, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}, F_{15}, F_{16}, B_{18}, B_{19}, B_{20}, B_{21}, B_{22}$ , and  $B_{25}$  are exactly the same, and the rankings of cause degree by two methods for  $F_2, F_3, F_6, F_7, F_9, F_{10}, F_{11}, F_{12}, F_{13}, F_{14}, F_{15}, F_{16}, F_{19}, F_{20}, F_{21}, F_{24}$ , and  $F_{25}$  are exactly the same. Therefore, the consistency of the proposed large group DEMATEL approach can be proved. However, the rankings of center degree by two methods for  $F_2, F_6, F_7, F_8, F_9, F_{17}, F_{23}$ , and  $F_{24}$  are different, and the rankings of cause degree by two methods for  $F_1, F_4, F_5, F_8, F_{17}, F_{18}, F_{22}$ , and  $F_{23}$  are different. These differences are clearly caused by 1) clustering the large group evaluation matrices, 2) obtaining the weights of both the DMs and clusters, and 3) using a consensus model to aggregate large group evaluation matrices.

## 6 Policy Discussions

Employing the inclusive sustainable approach for the energy-resource conflict allows people to actively participate in decisions-makings that affect their living environment, economy, and society. In this study, the main aim is to quantitatively prioritize factors to energy-resource conflict which account for the participation of the affected community in the decision-making process. By employing a large group-DEMATEL method, the results, therefore, reflect the decisions of people in the affected communities in the Western Region of Ghana. The policy implications of the results are discussed next, first on the most important degree factor(s), secondly the cause-group factor rank, and finally, the effect-group factor rank.

From the results, the overall rank of factors is given by  $F_1 > F_4 > F_3 > F_5 > F_9 > F_7 > F_2 > F_{21} > F_{23} > F_8 > F_{17} > F_{16} > F_{11} > F_{13} > F_{10} > F_{20} > F_{22} > F_{25} > F_{19} > F_6 > F_{24} > F_{12} > F_{15} > F_{14}$ . From the rank, “increased unemployment” ( $F_1$ ) is the most important factor in the entire factor system that affects the energy resource-conflict in the Western Region of Ghana. “Increased unemployment” ( $F_1$ ) had a centre degree score of 4.5017 and cause degree score of 0.5463. This implies that, in terms of the general ranking of the factors based on importance (with a centre degree score of

**Table 4** The normalized direct influencing matrix of group decision making  $P = (p_{ik})_{25 \times 25}$

$F_1$	$F_2$	$F_3$	$F_4$	$F_5$	$F_6$	$F_7$	$F_8$	$F_9$	$F_{10}$	...	$F_{21}$	$F_{22}$	$F_{23}$	$F_{24}$	$F_{25}$
$F_1$	0.0000	0.0463	0.0469	0.0405	0.0450	0.0386	0.0411	0.0398	0.0414	0.0466	...	0.0307	0.0521	0.0307	0.0283
$F_2$	0.0279	0.0000	0.0243	0.0344	0.0273	0.0521	0.0260	0.0260	0.0260	0.0237	...	0.0260	0.0391	0.0391	0.0391
$F_3$	0.0268	0.0472	0.0000	0.0260	0.0508	0.0260	0.0260	0.0260	0.0260	0.0391	...	0.0297	0.0257	0.0260	0.0257
$F_4$	0.0260	0.0130	0.0273	0.0000	0.0391	0.0130	0.0391	0.0391	0.0260	0.0391	...	0.0130	0.0521	0.0391	0.0261
$F_5$	0.0444	0.0324	0.0381	0.0485	0.0000	0.0227	0.0130	0.0286	0.0401	0.0307	...	0.0508	0.0136	0.0324	0.0155
$F_6$	0.0293	0.0260	0.0130	0.0260	0.0202	0.0000	0.0260	0.0202	0.0260	0.0130	...	0.0148	0.0148	0.0130	0.0009
$F_7$	0.0477	0.0000	0.0391	0.0391	0.0130	0.0260	0.0000	0.0260	0.0130	0.0273	...	0.0391	0.0260	0.0260	0.0260
$F_8$	0.0485	0.0240	0.0435	0.0283	0.0448	0.0182	0.0391	0.0000	0.0521	0.0130	...	0.0521	0.0136	0.0052	0.0000
$F_9$	0.0466	0.0145	0.0459	0.0443	0.0443	0.0260	0.0391	0.0135	0.0000	0.0283	...	0.0391	0.0260	0.0260	0.0134
$F_{10}$	0.0382	0.0385	0.0260	0.0270	0.0260	0.0260	0.0260	0.0260	0.0260	0.0000	...	0.0260	0.0260	0.0260	0.0257
$F_{11}$	0.0273	0.0260	0.0391	0.0253	0.0260	0.0273	0.0260	0.0130	0.0260	0.0260	...	0.0260	0.0260	0.0156	0.0260
$F_{12}$	0.0130	0.0136	0.0006	0.0130	0.0130	0.0255	0.0137	0.0136	0.0130	0.0136	...	0.0137	0.0137	0.0137	0.0000
$F_{13}$	0.0274	0.0258	0.0268	0.0275	0.0276	0.0247	0.0247	0.0253	0.0297	0.0260	...	0.0260	0.0260	0.0260	0.0260
$F_{14}$	0.0260	0.0144	0.0260	0.0260	0.0260	0.0130	0.0257	0.0136	0.0136	0.0136	...	0.0130	0.0130	0.0130	0.0130
$F_{15}$	0.0130	0.0135	0.0260	0.0143	0.0130	0.0133	0.0130	0.0130	0.0130	0.0000	...	0.0130	0.0130	0.0130	0.0000
$F_{16}$	0.0402	0.0249	0.0376	0.0304	0.0382	0.0130	0.0379	0.0382	0.0391	0.0130	...	0.0273	0.0130	0.0266	0.0130
$F_{17}$	0.0385	0.0155	0.0493	0.0391	0.0379	0.0130	0.0391	0.0391	0.0263	0.0130	...	0.0391	0.0130	0.0279	0.0391
$F_{18}$	0.0485	0.0052	0.0320	0.0414	0.0260	0.0515	0.0302	0.0130	0.0391	0.0135	...	0.0391	0.0130	0.0260	0.0391
$F_{19}$	0.0297	0.0165	0.0202	0.0266	0.0145	0.0140	0.0292	0.0136	0.0373	0.0149	...	0.0130	0.0130	0.0130	0.0130
$F_{20}$	0.0367	0.0260	0.0356	0.0269	0.0367	0.0297	0.0266	0.0142	0.0158	0.0153	...	0.0391	0.0260	0.0260	0.0260
$F_{21}$	0.0315	0.0260	0.0249	0.0273	0.0143	0.0260	0.0399	0.0265	0.0260	0.0269	...	0.0000	0.0260	0.0260	0.0260
$F_{22}$	0.0297	0.0260	0.0130	0.0357	0.0260	0.0135	0.0260	0.0260	0.0153	0.0297	...	0.0130	0.0000	0.0130	0.0260
$F_{23}$	0.0462	0.0338	0.0259	0.0422	0.0194	0.0297	0.0233	0.0283	0.0266	0.0210	...	0.0282	0.0391	0.0000	0.0419
$F_{24}$	0.0148	0.0260	0.0391	0.0136	0.0260	0.0260	0.0521	0.0141	0.0006	0.0130	...	0.0367	0.0153	0.0000	0.0006
$F_{25}$	0.0172	0.0260	0.0130	0.0514	0.0130	0.0260	0.0297	0.0260	0.0260	0.0135	...	0.0260	0.0260	0.0012	0.0000

4.5017), “increased unemployment” ( $F_1$ ) emerged the most important. With regard to the rank based on the tendencies of a factor giving rise to other barriers (cause group factors) in the whole factor system, “increased unemployment” ( $F_1$ ) was ranked first. Critical attention must be paid to  $F_1$  by policymakers by strategically committing scarce resources to offset this factor. Policies that ensure equal distribution of the energy resource to create jobs for the people in this region must be adhered. The government of Ghana gave an excuse that “lack of technical skills” ( $F_8$ ) by the people was a barrier to their employment in the oil production in their community. This reason by the government and the oil extraction companies is no longer accepted by the people and will go a long way to result in an open conflict if care is not taken. There are diverse ways to solve such unemployment. For example revenues can be invested to equip the people enhance their respective individual skill capacities either than that needed by the extraction companies. Also, the vocational and technical institutes in the region can be allocated by the government to run resource extraction-related programs in attempt to expiate the shortfall in technical skills. Again, government can move to support small and medium-scale (SME) enterprises’ growth in these communities; or better still, provide financial support for “petty trading” to grow which indirectly help solve the “lack of job creation” ( $F_5$ ) problem.

The large group-DEMATEL cause-group factor rank is given as follows in descending order: “increased unemployment” ( $F_1$ ) > “poor institutional quality” ( $F_{23}$ ) > “environmental pollution” ( $F_2$ ) > “weak governance” ( $F_{10}$ ) > “lack of technical skills” ( $F_8$ ) > “Dutch disease” ( $F_{17}$ ) > “weak legal framework” ( $F_{25}$ ) > “bureaucracy” ( $F_{13}$ ) > “restricted fishing activity” ( $F_9$ ) > “lack of local infrastructure development” ( $F_{16}$ ) > “high rate of urbanization” ( $F_{20}$ ) > “rent-seeking” ( $F_{18}$ ) > “lack of job creation” ( $F_5$ ), as shown in Fig. 2. This indicates that, in the whole factor system, these 13 factors (cause-group) have the overall tendencies of giving rise to those 12 factors in the other group (effect-group). Hence, this allows for deeper engagement by policymakers on the strategic decision-making process of committing scarce resources to those factors in the cause-group and ignoring those in the effect-group. Focusing on “environmental pollution” ( $F_2$ ), this study recognizes that there has not been major environmental pollution in this region. However, there exist instances that raise concerns of the people and even researchers and must not be overlooked. The government should continue to engage and involve the people in the affected communities in its plans for environmental safety. One important factor, “restricted fishing activity” ( $F_9$ ) by the government since the production of oil in this region has been a sensitive situation as (1) the main occupation that supports the livelihood of the people, farming, has been restricted, and (2) no new jobs are created by the government to make up for this. This situation has increased the cost of living in this area.

Contingency plans that directly reflects other job alternatives ready to absorb displaced farmers should be proactively implemented at the inception of the oil production. Since this wasn’t done, alternative entrepreneurship programs must be rolled out to the benefit of the affected community. Also, attempts by the government in name-calling fish farmers as though they are uneducated about their profession and hence, omitted in the decision-making body in resolving this conflict isn’t

**Table 5** The total direct influencing matrix of group decision making  $T = (t_{kl})_{25 \times 25}$

$F_1$	$F_2$	$F_3$	$F_4$	$F_5$	$F_6$	$F_7$	$F_8$	$F_9$	$F_{10}$	...	$F_{21}$	$F_{22}$	$F_{23}$	$F_{24}$	$F_{25}$	
$F_1$	0.0796	0.1023	0.1186	0.1162	0.1127	0.0989	0.1122	0.0965	0.1043	0.0992	...	0.0992	0.1088	0.0865	0.0917	0.0788
$F_2$	0.0842	0.0421	0.0760	0.0895	0.0761	0.0946	0.0783	0.0677	0.0719	0.0624	...	0.0749	0.0808	0.0785	0.0744	0.0742
$F_3$	0.0831	0.0870	0.0527	0.0811	0.0979	0.0700	0.0768	0.0668	0.0718	0.0768	...	0.0787	0.0674	0.0663	0.0625	0.0623
$F_4$	0.0849	0.0555	0.0812	0.0577	0.0889	0.0577	0.0908	0.0812	0.0735	0.0782	...	0.0648	0.0935	0.0793	0.0528	0.0642
$F_5$	0.1005	0.0743	0.0909	0.1027	0.0511	0.0672	0.0662	0.0706	0.0864	0.0702	...	0.0990	0.0580	0.0734	0.0516	0.0530
$F_6$	0.0587	0.0465	0.0404	0.0545	0.0456	0.0232	0.0524	0.0413	0.0502	0.0340	...	0.0403	0.0373	0.0341	0.0227	0.0206
$F_7$	0.0957	0.0384	0.0845	0.0864	0.0573	0.0641	0.0468	0.0631	0.0539	0.0620	...	0.0815	0.0641	0.0614	0.0582	0.0577
$F_8$	0.1043	0.0640	0.0961	0.0831	0.0936	0.0615	0.0899	0.0420	0.0972	0.0529	...	0.1006	0.0554	0.0466	0.0451	0.0377
$F_9$	0.1030	0.0565	0.0977	0.1009	0.0933	0.0707	0.0904	0.0567	0.0475	0.0686	...	0.0882	0.0691	0.0675	0.0509	0.0513
$F_{10}$	0.0920	0.0774	0.0768	0.0802	0.0737	0.0681	0.0762	0.0664	0.0705	0.0378	...	0.0735	0.0666	0.0650	0.0616	0.0609
$F_{11}$	0.0719	0.0592	0.0797	0.0693	0.0652	0.0624	0.0672	0.0468	0.0624	0.0573	...	0.0651	0.0598	0.0485	0.0552	0.0548
$F_{12}$	0.0390	0.0321	0.0252	0.0379	0.0352	0.0449	0.0374	0.0323	0.0340	0.0309	...	0.0360	0.0328	0.0318	0.0303	0.0166
$F_{13}$	0.0804	0.0638	0.0759	0.0792	0.0736	0.0656	0.0734	0.0641	0.0725	0.0618	...	0.0723	0.0649	0.0637	0.0600	0.0602
$F_{14}$	0.0571	0.0375	0.0550	0.0565	0.0533	0.0374	0.0541	0.0372	0.0394	0.0360	...	0.0407	0.0370	0.0359	0.0336	0.0335
$F_{15}$	0.0364	0.0303	0.0467	0.0368	0.0336	0.0312	0.0340	0.0302	0.0321	0.0166	...	0.0331	0.0303	0.0296	0.0155	0.0153
$F_{16}$	0.0928	0.0635	0.0873	0.0817	0.0843	0.0548	0.0864	0.0763	0.0818	0.0506	...	0.0744	0.0533	0.0643	0.0765	0.0469
$F_{17}$	0.0940	0.0562	0.1002	0.0932	0.0862	0.0562	0.0893	0.0797	0.0723	0.0522	...	0.0877	0.0551	0.0678	0.0497	0.0747
$F_{18}$	0.1030	0.0470	0.0840	0.0956	0.0747	0.0930	0.0820	0.0550	0.0843	0.0530	...	0.0868	0.0558	0.0660	0.0616	0.0744
$F_{19}$	0.0611	0.0394	0.0496	0.0574	0.0426	0.0388	0.0580	0.0370	0.0623	0.0377	...	0.0408	0.0377	0.0361	0.0340	0.0335
$F_{20}$	0.0850	0.0629	0.0806	0.0749	0.0790	0.0679	0.0722	0.0512	0.0561	0.0501	...	0.0813	0.0633	0.0615	0.0706	0.0571
$F_{21}$	0.0792	0.0607	0.0692	0.0739	0.0564	0.0634	0.0833	0.0617	0.0646	0.0598	...	0.0425	0.0622	0.0602	0.0574	0.0567
$F_{22}$	0.0730	0.0572	0.0539	0.0780	0.0639	0.0476	0.0658	0.0583	0.0515	0.0592	...	0.0515	0.0333	0.0449	0.0414	0.0542
$F_{23}$	0.1016	0.0752	0.0785	0.0973	0.0696	0.0735	0.0763	0.0707	0.0730	0.0606	...	0.0773	0.0818	0.0416	0.0661	0.0781
$F_{24}$	0.0512	0.0522	0.0716	0.0484	0.0566	0.0534	0.0835	0.0408	0.0301	0.0384	...	0.0670	0.0423	0.0410	0.0243	0.0239
$F_{25}$	0.0663	0.0595	0.0581	0.0974	0.0554	0.0629	0.0736	0.0617	0.0656	0.0468	...	0.0675	0.0622	0.0606	0.0328	0.0324

helpful and will hurt the entire country at the end. As suggested by [28], a win–win framework for the co-existence of fisheries conservation, petroleum extraction, and national development should be envisioned. Moreover, over the years the government of Ghana has initiated several youth employment programs, such as National Youth Employment Program (NYEP) and now Ghana Youth Employment and Entrepreneurial Development Agency (GYEEDA). But both have failed in alleviating hardships by the youth; and the failure could be the result of the disconnection with the actual situation on the ground. On this note, dealing with a specific case study in the Western Region, this study advises a shift from “general” employment intervention approach to “specific” employment interventions that relates to exactly the real situation. Others in the cause-group are “rent-seeking” ( $F_{18}$ ) and “Dutch disease” ( $F_{17}$ ) factors. The government of Ghana makes profits from the oil resource without much to give to the society in return or producing wealth to the “affected” communities and this is fraught with danger by the affected community. Focusing on “local infrastructure development” ( $F_{16}$ ) that specifically reflects the social, economic and environmental needs of the affected communities can help offset agitations caused by rent-seeking. Hence the government should ensure equal distribution of oil revenues to reflect in the development of the affected communities.

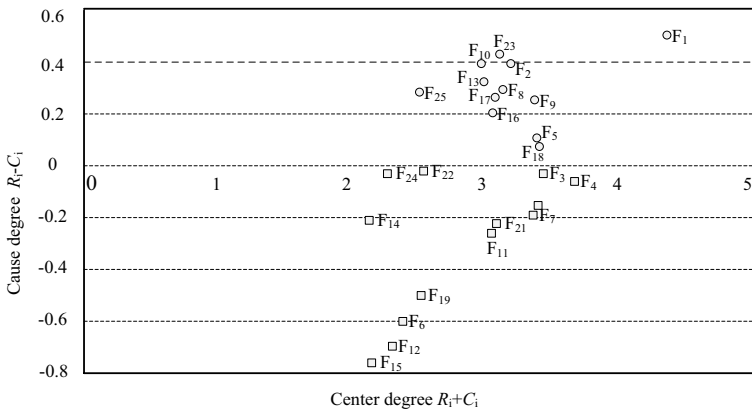
Also, with the issue of “Dutch disease”, the negative effect is already visible. Since the extraction of oil resources, the country’s foreign direct investment (FDI) has increased much yet not much affect on the high cost of living. Some local manufacturing jobs cannot compete due to the high cost of production. Additionally, non-resource-based companies suffer due to increased wealth generated by resource-based industries. All of these have contributed to unemployment as well. Measures that ensure an equal distribution of the oil resource to be accounted for directly by the people must be implemented. According to the Petroleum Revenue Management Law of Ghana, the National Oil Company (NOC) receives about 55% of the carried and participating interest of the oil revenue received by the Country under the Petroleum Holding Fund (PHF); and about 70% of this revenue goes into a budget known as, annual budget funding amount (ABFA). The ABFA is distributed to the Ghana Infrastructure Investment Fund and the Public Interest and Accountability Committee (PIAC) as a priority. This leaves a remainder of 30% allocated to the Ghana Petroleum Fund (GPF), which then is distributed among Ghana Stabilisation Fund (GSF) and Ghana Heritage Fund (GHF) in a split of 21% and 9% respectively.

Unlike the Mining and Minerals Act 2006 (703) of Ghana, which makes clear provisions for the re-distribution of mineral royalties to producer district, traditional authorities and the mineral development fund, that of the Petroleum Revenue Management law does not state clearly the provision of petroleum revenue royalties to producer district and traditional authorities. This leaves tight expenditure on Metropolitan Municipal and District Assemblies (MMDAs) budget and slows the rate of local infrastructure development. An In-depth study was conducted by [29] and can be referred. However, this brings us to a second-stage problem comparing it to the Mining and Minerals Act 2006 (703) where provisions for distribution of royalties directly to the producer communities are made. Are the social, economic and environmental development issues that possibly affect resource conflict still existing in these areas? To some degree, Yes. Eventhough government initiatives, such as its



**Table 6** Influences given and received, center degree and cause degree for each factor  $R_i, C_i, R_i + C_i, R_i - C_i$

Factors	$R_i$	$C_i$	$R_i + C_i$	$R_i - C_i$	Factors	$R_i$	$C_i$	$R_i + C_i$	$R_i - C_i$
$F_1$	2.5240	1.9777	4.5017	0.5463	$F_{14}$	1.0051	1.2458	2.2508	-0.2407
$F_2$	1.8375	1.4407	3.2782	0.3968	$F_{15}$	0.7456	1.5400	2.2855	-0.7944
$F_3$	1.7960	1.8305	3.6265	-0.0345	$F_{16}$	1.7071	1.5029	3.2100	0.2042
$F_4$	1.8444	1.9298	3.7742	-0.0854	$F_{17}$	1.7662	1.4537	3.2199	0.3126
$F_5$	1.8381	1.7196	3.5577	0.1185	$F_{18}$	1.7950	1.6629	3.4578	0.1321
$F_6$	0.9212	1.5290	2.4502	-0.6079	$F_{19}$	1.0088	1.4998	2.5086	-0.4910
$F_7$	1.6172	1.8163	3.4335	-0.1991	$F_{20}$	1.6114	1.4667	3.0781	0.1447
$F_8$	1.7720	1.4554	3.2274	0.3167	$F_{21}$	1.5446	1.7248	3.2694	-0.1802
$F_9$	1.8413	1.6092	3.4505	0.2321	$F_{22}$	1.4069	1.4726	2.8794	-0.0657
$F_{10}$	1.7499	1.3532	3.1030	0.3967	$F_{23}$	1.8391	1.4124	3.2515	0.4267
$F_{11}$	1.4550	1.7308	3.1857	-0.2758	$F_{24}$	1.1694	1.2804	2.4499	-0.1110
$F_{12}$	0.8322	1.5092	2.3414	-0.6770	$F_{25}$	1.5469	1.2727	2.8196	0.2742
$F_{13}$	1.6980	1.4369	3.1349	0.2610					



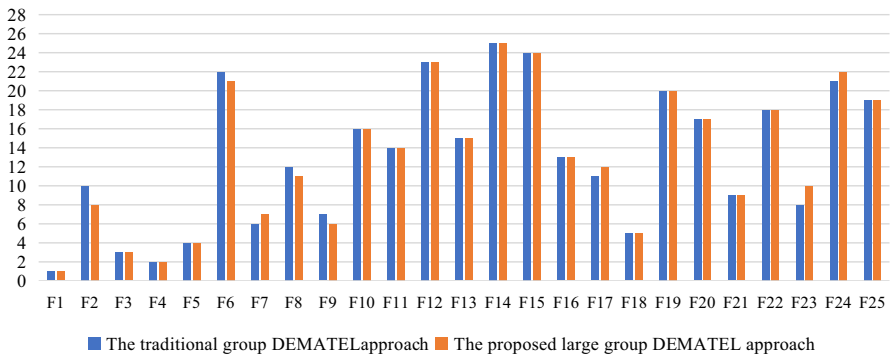
**Fig. 2** Influential relation diagram of 25 factors

Corporate Social Responsibility by multi-national companies (MNC) is established to help address some of the economic development challenges brought upon producer districts, yet faces challenges. A typical example is the Enterprise Development Center (EDC) projects in the Western Region which became unsustainable and failed to impact significantly on SMEs development in the oil industry [27]. Hence, the institutional quality of government (“poor institutional quality”,  $F_{23}$ ) is challenged. Government must revise its supervisory measures to avoid other things like political settlements that undermines the successful implementations of such projects.

Lastly, the ranking of the effect-group factors are as follows: “high cost of living” ( $F_3$ ) > “lack of transparency and accountability” ( $F_{22}$ ) > “corruption” ( $F_4$ ) > “decrease in electricity access” ( $F_{24}$ ) > “increased crime rates” ( $F_{21}$ ) > “income reduction/

**Table 7** Ranking results of two methods

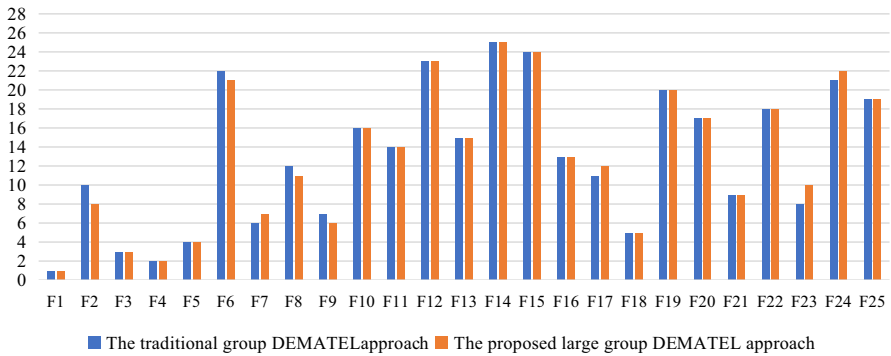
Barriers	The proposed large group DEMATEL approach		The traditional group DEMATEL		Barriers	The proposed large group DEMATEL approach		The traditional group DEMATEL	
	$r_i + c_i$	$r_i - c_i$	$r_i + c_i$	$r_i - c_i$		$r_i + c_i$	$r_i - c_i$	$r_i + c_i$	$r_i - c_i$
$F_1$	1	1	1	2	$F_{14}$	25	20	25	20
$F_2$	8	3	10	3	$F_{15}$	24	25	24	25
$F_3$	3	14	3	14	$F_{16}$	13	10	13	10
$F_4$	2	16	2	15	$F_{17}$	12	6	11	5
$F_5$	4	13	4	12	$F_{18}$	5	12	5	13
$F_6$	21	23	22	23	$F_{19}$	20	22	20	22
$F_7$	7	19	6	19	$F_{20}$	17	11	17	11
$F_8$	11	5	12	6	$F_{21}$	9	18	9	18
$F_9$	6	9	7	9	$F_{22}$	18	15	18	16
$F_{10}$	16	4	16	4	$F_{23}$	10	2	8	1
$F_{11}$	14	21	14	21	$F_{24}$	22	17	21	17
$F_{12}$	23	24	23	24	$F_{25}$	19	7	19	7
$F_{13}$	15	8	15	8					



**Fig. 3** The ranking results of center degree for each factor about two methods

poverty” ( $F_7$ ) > “high cost of electricity” ( $F_{14}$ ) > “political deceit” ( $F_{11}$ ) > “forced relocation of local citizens” ( $F_{19}$ ) > “health hazards” ( $F_6$ ) > “increased price commodities” ( $F_{12}$ ) > “high cost of house rent” ( $F_{15}$ ), as shown in Fig. 2. On the premise of cause vs effect, these factors in the effect group can be ignored. However, it is worth highlighting that “corruption” ( $F_4$ ), had the second highest centre degree (important) index score of 3.774 in the whole factor system.

In order for government to fight corruption head-on, strict measures towards institutional quality that ensures transparency and accountability approach in the decision-making process of MNC initiatives should be adopted.



**Fig. 4** The ranking results of cause degree for each factor about two methods

## 7 Conclusion

First, this research analyzes the factors affecting the energy-resource conflict in the Western Region of Ghana. To be specific, we investigate how important the adoption of inclusive sustainable development approach literature could help in the decision-making process in energy-resource conflicts literature. We realize a gap in this process as adopting inclusive sustainability with a larger-group stakeholder engagement which induces complexities in decision making. Yet more, literature examinations on the energy-resource conflict in the Western Region of Ghana have been more of qualitative ones, and also the literature on ranking and selection of factors affecting the energy-resource conflict in this region is limited. So how can we overcome the decisional challenges associated with employing an inclusive sustainable approach to energy-resource conflicts on the path of strategically committing scarce resources?

Second, the sustainable development approach to managing natural resources in general has gained prominence in global research, but that of it in energy-resource conflict literature is rather inadequate. Hence, this study contributes to the nexus between two strands of literature; the energy-resource conflict as a type of natural-resource conflict and inclusive sustainable development. Lately, inclusive development has been considered at the center of SDGs which is understood in line with UNDP definition. Adopting the inclusive sustainability to the energy-resource conflict allows for larger stakeholder participation in the planning and decision-making process on the possible impact of this conflict on the social, economic, and environmental development. In this direction, our study established that inclusive sustainable development is an important approach to involve the people of the affected communities in the Western Region of Ghana in the decision-making process. This can also be adopted by other developing countries with similar problems as in the case of Ghana. Again, how can the large group participation be accounted for quantitatively?

In addressing the aforementioned two questions, this research contributes in the following ways to the existing literature. First, we extend the traditional

group-DEMATEL approach and propose a new large-group-DEMATEL. This approach is applied to rank and select factors to the energy-resource conflict in the Western Region of Ghana. Furthermore, we proposed a method for obtaining the weights of DMs and clusters, then gave a consensus method to aggregate the large group evaluation matrices, and finally obtain the sequence of factors and identify key factors based on their interrelationship.

The results are practical in the sense that, it quantitatively accounts for the views of the affected people in the community and experts in the ranking and selection. Hence, the result is close to exactly what has been happening on the ground and this can aid in the strategic decision-making process by policymakers on how to commit scarce resources to offset the key factors. Also as part of the contributions of this research, a comparative analysis of the traditional group DEMATEL and novel large group DEMATEL was made to elicit the effectiveness and advantages of the newly proposed method. In comparison, the proposed large group DEMATEL employs a new clustering technique to compute the large group evaluation matrices so as to get a more reasonable clustering result for DMs, where a formula to determine the clustering threshold and the process of clustering large group DMs proposed. Then, we present a weighting determining method for DMs and subgroups, which can take group consensus into account so as to improve the group satisfaction degree. Finally, a consensus method based on the weights of DMs and subgroups is provided, which can improve the reliability and accuracy for the result of decision making. From the results, “increased unemployment” ( $F_1$ ), “poor institutional quality” ( $F_{23}$ ), “environmental pollution” ( $F_2$ ), “weak governance” ( $F_{10}$ ), “lack of technical skills” ( $F_8$ ), “Dutch disease” ( $F_{17}$ ), “weak legal framework” ( $F_{25}$ ), “bureaucracy” ( $F_{13}$ ), “restricted fishing activity” ( $F_9$ ), “lack of local infrastructure development” ( $F_{16}$ ), “high rate of urbanization” ( $F_{20}$ ), “rent-seeking” ( $F_{18}$ ), and “lack of job creation” ( $F_5$ ) are identified as key factors, which should be focused by the policymakers. On the premise of cause vs effect, factors in the effect-group can be ignored. This research, however, also acknowledge some limitations. For example, even though we took into account a considerably large group of stakeholders, their fuzzy judgments have not been considered and will be investigated in future studies.

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## Authors and Affiliations

**Bismark Appiah Addae<sup>1</sup> · Weiming Wang<sup>1</sup> · Haiyan Xu<sup>1</sup>  · Mohammad Reza Feylizadeh<sup>2</sup>**

Bismark Appiah Addae  
visitmark05@yahoo.com

Weiming Wang  
wwmsy@nuaa.edu.cn

Mohammad Reza Feylizadeh  
feylizadeh@iaushiraz.ac.ir

- <sup>1</sup> College of Economics and Management, Nanjing University of Aeronautics and Astronautics, Nanjing 211106, People's Republic of China
- <sup>2</sup> Department of Industrial Engineering, Shiraz Branch, Islamic Azad University, Shiraz, Iran