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Conflict Analysis of Physical Industrial Land Development Policy Using Game Theory and Graph Model for Conflict Resolution in Markazi Province

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Abstract: Industrial growth and development are among the integral components of economic development in developing countries such as Iran. Markazi province in the central part of Iran is one of the most prone areas for industrial progress due to its geopolitical location, proximity to the capital and major cities, and access via Iran's western corridor. Over the last few decades, the concentration of major industries in combination with a lack of environmental safeguards have led to major environmental concerns, such that the province's industrial development faces serious challenges going forward. This paper analyzes how to resolve these challenges through strategic analysis of stakeholder interactions using a Graph Model for Conflict Resolution, i.e., a non-cooperative model of game theory. Results indicate that, from a strategic point of view, the main cause of the conflict is over physical industrial land development in Markazi province by way of rationality and organizational benefits from stakeholders. It was shown that the insistence from the Industry and Mining Organization on industrial development and the Department of Environment on the preservation of natural resources and the environment, on the one hand, and the prevention of their further destruction, on the other, have made it difficult to find a cooperative solution. The findings further unveiled that in a non-cooperative scenario (i.e., the current situation), the equilibrium point of the conflict is status 16 (i.e., among the 18 situations) and no unilateral progression from either party can be detected. Via the equilibrium point, if the current preferences of the parties cannot be resolved, the conflict will remain at a deadlock leaving the environment at risk of further degradation.

Keywords: land development; environmental dispute; conflict resolution; stakeholder interaction; model development; non-quantitative approach; Iran

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1. Introduction

Land is a major requirement of physical industrial development. This finite resource is central to the welfare and livelihood of human beings. Rapid urbanization over the past century has resulted in land scarcity and escalation of its prices [1]. It has also led to widespread land use change through urban expansion and industrial land development. Urban, rural, and industrial development can, to a large extent, have profound effects on the surrounding environment. Such effects can defeat the object of development, such that the disbenefits may outweigh the benefits [2]. To date, game theory has been used in many strategic studies on land development [1,3–9], i.e., from rural to urban areas up to changing the nature of land use and developmental policy. Industrialization has the potential to help develop a variety of social objectives, such as employment, poverty eradication, gender

equality, labor standards, and greater access to education and healthcare. At the same time, industrial processes can have negative environmental impacts, causing climate change, loss of natural resources, air and water pollution, and extinction of species. These factors threaten the global environment as well as economic and social welfare [10]. The creation of many new industrial products poses a considerable challenge in terms of regulation and control. Their emission is often neither regulated nor qualified, leading to unknown effects on the environment and health. For instance, the global emission industry standard has increased pollutant emissions between 1990 and 2014 [11]—prompting widespread air pollution alertness around the world.

In the developing world, many economic and social decisions that directly affect infrastructural development have negative influences on the environment [12]. When land use management in a certain region fails to integrate economic development, food security, and ecological protection, imbalances in land use structure and regional landscape patterns emerge. These imbalances manifest as spatial conflicts caused by land users competing for land resources out of different interests [13]. Currently, more than 50 countries have pledged to protect 30% of the planet's land and sea area by 2030. Therefore, it is significant to study and identify land use conflicts in agriculture and ecological spaces to coordinate human–land balanced relationships for green, coordinated, and sustainable regional development [14]. Land use conflict mainly refers to the dilemma between interest groups. This dilemma is signaled by multiple, functional demands of social development or industry objectives with the resulting conflict siding towards the land's functionality and, ultimately, its utilization. Indeed, land use conflicts represent the effects of the dissatisfaction of one group or part of the community with the actions initiated or planned by another group, i.e., their neighbors, public authorities, or private investors [15]. In the scientific literature, land degradation and scarcity of arable land have been incorporated into the broader academic debate on the relationship between climate change, resource scarcity, and violent conflict [16].

The term game theory derives from the interactivity of collective decision-making situations to familiar parlor games, such as poker, monopoly, and chess [17]. Because of its emphasis on conflicting inclinations, game theory is frequently defined as a theory of conflict [18,19]. Aumann [17] suggested that it refers to the 'Interaction Decision Theory' since, in larger sense, it is more accurately described in the context of a focused theory [18]. In a modern context, game theory originated from Borel's [20] and von Neumann's [21] work in the 1920s. However, following the seminal research conducted by von Neumann and Morgenstern [22] that triggered interest, particularly among economists and mathematicians, the theory became an established idea. Game theory, from then, has since had a foothold in other fields, such as the natural sciences, including physics, information technology and communication, and biology, as well as the social sciences, including geography, psychology, philosophy, and political science [23–26]. Concerning land development processes, game theory applications to date are limited [27,28]. This lack of interest can be explained, perhaps, because property development, land, and spatial planning are typically context-oriented. The ideas of complexity, pluriformity, and interdependency have generally been focused on urbanization, and the like, in the contemporary land development literature [29–32]. Modeling those processes sometimes makes little sense since the interactions of the actors involved are undeniably too complex and often overly dependent on land-specific conditions. To argue, hence, in favor of modeling industrial land planning methods in simplified models may then come across as unorthodox; however, a case can be made since there is a gap in the literature as noted by Ball et al. [33]. Their review supports the argument that an analytical tool-oriented perspective of studying land and property development processes in conjunction with game theory is a promising approach for the development of the discipline.

Game theoretical modeling, like any modeling, implies an abstraction and simplification of real-world scenario design [34]. However, in some disciplines, e.g., economics, the conversion of the real world into a model is accepted and valued. Mathematical meth-

ods of complex circumstances have changed over time as a field of study of its own [35]. Regarding the limitations to modeling complexity, additional reasons game theory can be used is as a decision support system tool [36]. This can be very useful for the analysis of land development and planning exercises. First, a key benefit of using game theory is that the construction of a complex land development model necessitates very precise assumptions regarding the complex reality overlayed within the model. In this respect, game theory allows one to see how conclusions can be followed by certain assumptions. As such, the assumptions should be looked at closely and the game theoretical modeling outcome precisely communicated [37,38]. Besides that, complexity, as one moves away, will try to create a more argumentative general structure that may also impact transferability of development and planning strategies [39].

Second, many scholars have criticized the notion of rational or payoff maximizing players within the underlying structure of how game theory works. As such, recent contributions to game theory seem to offer new opportunities to increase level of applicability. In the past decade, game theory has been capable of developing more realistic decision-making models, including bounded rationality models, models taking account of emotions and intuitive decision-making, models with incomplete information, and models with asymmetric information positions. In this vein, game theory is leaving its mathematical background and is becoming increasingly a behavioral theory of decision-making, leading to much experimentation and theory development [40]. Applications of game theory to industrial land development and planning can take advantage of these advancements. The benefit of this method is that it formulates circumstances in a clear and simple manner. Hence, as initially noted, it can raise our awareness of the decision-making and problems being considered, and following this process, refine and extend sophistication as well as model the real world to make better sense of it.

Third, findings from previous studies demonstrate the possibility of testing and validating, i.e., analytically, the consequences of game theoretical modeling [41]. The validation of stakeholder preferences and the testing the game outcomes played can aid to augmenting the application's usefulness in terms of outcomes in a more general way. There are three key components to a strategic game that should be considered: (1) set of players, (2) set of actions (i.e., for each player), and (3) preferences over the set of action profiles (i.e., for each player) [42]. The emergence and diffusion of advanced digital production technologies, such as artificial intelligence, big data analytics, cloud computing, the Internet of Things, advanced robotics, and additive manufacturing, have been radically altering the nature of manufacturing production. Under the right conditions, the adoption of these technologies in developing countries can foster inclusive and sustainable industrial development and the achievement of the United Nations Sustainable Development Goals [43].

As demonstrated, decision-making processes, in particular land development, are complex [44–46]. First, different groups of stakeholders are involved in the process, e.g., property developers, landowners, investors, governmental departments, non-governmental organizations (NGOs), and other various end-users. Second, they can react to each other in different ways—especially if the interaction is in an international context (e.g., people from different nationalities) [35]. This complexity is the first point for the analysis of the decision-making process in this paper. The interactions among stakeholders in industrial land development processes can be investigated by case study analysis. Geographically, one of the important drivers of industrial land sprawl stem from the country in question. This paper explores case research from Iran since it stands out as a country that continues to lack a unique industrial planning scheme, e.g., a national industrial land use planning strategy and its instability via government policies and programs to properly strategize its industrial sector. These shortcomings, together with severe climate change such as droughts and floods, have significantly increased the risk of industrial activity [47] and accelerated land degradation. Accordingly, the main drivers of industrial land development in Iran can be simplified into four factors, i.e., economic, social, political, and environmental. Currently, the government has pursued three main groups of policies against unnecessary develop-

ment in industrial land use: (1) protection of national lands in the form of protected areas, (2) organizing semi-used and industrial centers and zones, and (3) preparation of economic justification reports and environmental impact assessment (EIA) before allocating land for industrial use. Despite such preventive policies, one still might ask why an assessment problem continues and why industrial land use continues to sprawl outward in urban areas? The main objective of this study is to respond to this question using game theory methodology. To help define the innovation of this research, the analysis of conflict with a non-quantitative approach is used. As in many cases, although quantitative approaches can express a better and simpler management perspective, non-quantitative approaches will create a relatively better understanding of the dispute while maintaining the actual situation. Indeed, a Graph Model for Conflict Resolution (GMCR) through modeling and analysis of real-world conflicts, can be applied to actual real-world disputes. Specifically, the objectives and innovations of this paper are as follows:

1. To design a framework that supports the resolution of industrial conflicts systematically, so as to avoid unnecessary conflict escalations;
2. To model conflicts that predict the possible outcomes and show the corresponding evolutionary paths;
3. To introduce a third-party intervention mechanism if the stakeholders of the industrial dispute cannot reach an acceptable resolution by themselves.

2. Materials and Methods

2.1. Research Area

Game theory is an interdependent decision-making theory in which DMs examine conflicting predicaments and the decisions they make cannot be decided on by one actor. Although game theory is rooted in decision theory [18], they have a clear difference. Decision theory commonly analyzes decision-making processes from one player's viewpoint, while game theory highlights its analysis in the interaction among many players. Since game theory emphasizes situations and interactions that require interdependence, it can be thought of as an extension of decision theory [35]. Industrial processes play a major role in the degradation of the global environment. In industrialized countries, environmental regulation and new technologies are reducing the environmental impact per unit produced, but industrial activities and growing demand are still putting pressure on the environment and the natural resource base. In developing countries, a double environmental effect is occurring, i.e., old environmental problems, such as deforestation and soil degradation, remain largely unresolved. At the same time, new problems linked to industrialization are emerging, such as rising greenhouse gas emissions, air and water pollution, growing volumes of waste, desertification, and chemicals pollution [48,49]. In addition, industrial activities are a major source of air, water, and land pollution, leading to illness and loss of life. Industrial pollution results in environmental degradation and imposes heavy costs on society as well as on human health and safety [50]. Due to rapid economic development, environmental pollution has escalated over the last few decades. It is mainly due to manufacturing and industrial sectors, i.e., the backbone of a country's economy. The biotic and abiotic factors of the environment are severely affected due to industrial pollution. It also threatens people's safety, their lives and wealth, and causes many interrelated social problems [51]. Industrial pollution can trigger changes in the environment, such as energy patterns, radiation, and chemical and physical constituents at mineral and organic level. These factors alter water supply, which affects agricultural output directly or indirectly. It is necessary to consider industrial waste in order to lessen or eradicate pollution from the environment [38].

The study area is Markazi province, located in the central part of Iran (i.e., 34.6123° N, 49.8547° E), east of the Zagros Mountains and south of the capital city Tehran—covering an area of about 29,127 km^2 (Figure 1). The population density in Markazi province is 49.1 people per km^2, which is almost the same as Iran, while Arak (i.e., the provincial capital of the province) is 145.5 people per km^2. Due to the special geopolitical posi-

tion of Markazi province and its proximity to major cities, this relatively small province (i.e., compared to other provinces in the country) is one of the industrial centers of Iran, playing a major industrial role in developing the country's refineries, petrochemicals, aluminum, locomotive manufacturing, and the mining of sodium sulfate. It is considered the fourth industrial pole of the country [52] in which Arak is ranked 71st in the world's most polluted cities [53] and one of the most polluted in Iran. Industrial development has caused environmental (e.g., air pollution, water resource depletion, and soil erosion), social (e.g., massive immigration), and economic (e.g., Arak being the fourth most expensive city in Iran for housing, after Tehran, Isfahan, and Karaj, due to excessive demand from incoming laborers) problems [54].

Figure 1. Markazi province's location in Iran. Note: abbreviated provinces are marked in blue (i.e., Qz = Qazvīn, T = Tehran, Qm = Qom, E = Isfahan, L = Loristan, H = Hamadān); abbreviated counties are marked in black and associated districts in orange (i.e., from top to bottom: Z = Zarandiyeh, k = Kharqan (center = Mamooniyeh); S = Saveh, n = Nobaran (center = Saveh); T = Tafresh, f = Farahan (center = Tafresh); K = Komijan, m = Milajerd (center = Komijan); Ash = Ashtian (center = Ashtian); A = Arak, k = Khondab (center = Arak); Sh = Shazand, s = Sarband, z = Zalian (center = Shazand); D = Delijan (center = Delijan); M = Mahallat (center = Mahallat); Kh = Khomein, k = Kamareh (center = Khomein).

2.2. Concept of Industrial Land Development Conflict

A country's industrial policy is to encourage the development of economic sectors that require government intervention due to national sovereignty or lack of private sector initiative. These policies include identifying existing capacities in the country and making appropriate decisions to achieve them [55]. Industrial development policies are separated according to spatial divisions, leading to the complexity of the competitive vision that has prevailed so far. Newly developed spatial and geographical economies have led to a decentralized approach to industrial policy [56]. Land is one of the most controversial issues and a major source of conflict in developing countries. In most developing countries and transitional economies, many constitutive and regulatory institutions have significant functional deficits [57,58]. Land conflicts can be categorized in terms of whether they occur at the micro-micro or micro-macro level, i.e., among community groups or between community groups and outside government, private, or civil society organizations [59,60]. Micro-micro conflicts can be further categorized into inter-conflicts and intra-conflicts. The former takes place within the group directly involved in a particular resource management

regime (e.g., a forest user group or ecotourism association). The former occurs between this group and those not directly involved (e.g., between the user group and women entering the forest to collect fuelwood). Land conflicts also increase social and political instability as well as having negative effects on individual households and the nation's economy. They also affect different groups in different ways [61].

The reallocation of natural and national land is inevitable in the study area given Markazi province's economic development. In the course of Iran's economic progress, many provinces have supported economic growth by incremental planning of industrial land development, particularly Markazi province, regarding its geopolitical position. GMCR is a tool to evaluate and understand non-quantitative strategic conflicts [62] (Figure 2). The process of this model is made up of five main steps: (1) shaping the set of DMs, (2) identifying all possible situations of conflict based on the previous step, (3) eliminating impossible situations of conflict, (4) determining the preferences of actors, and (5) implementing the model to identify possible balances and resolve conflicts [63]. One of the most important advantages of using the GMCR approach is applying qualitative and relative data. Using this model also allows the analysis of variable and diverse human behaviors that are very difficult to express in quantitative language. Conflict is a universal phenomenon in political, economic, military, cultural, and other fields. To better analyze and solve the conflict, many effective analysis models and methods have been introduced. Compared with the existing game theoretical methods, such as game theory, metagame analysis, and conflict analysis, a simple, flexible, and comprehensive approach of GMCR is used to model and analyze the conflict [64]. Specifically, GMCR represents a conflict as moving from state to state (i.e., the vertices of a graph) via transitions (i.e., the arcs of the graph) controlled by DMs [65]. It is based on game theory which presents a robust and suitable tool to analyze conflicts of parties with different interests and powers, and to systematically solve complex environmental and water resource-based issues [36]. In general, GMCR is derived from dynamic conflict resolution and is a non-cooperative game theory approach [63]; in particular, it is a precise way to describe the behavior of stakeholders in a strategic sense [66]. When stakeholders have mutual interests, the factors such as the tendency of each player to optimize their goals as well as the lack of trust and sufficient information, create non-cooperative behavior [26]. As such, GMCR produces a combination of feasible states in a conflict that reflects the interactions of players, their moves, and countermoves in a game [67].

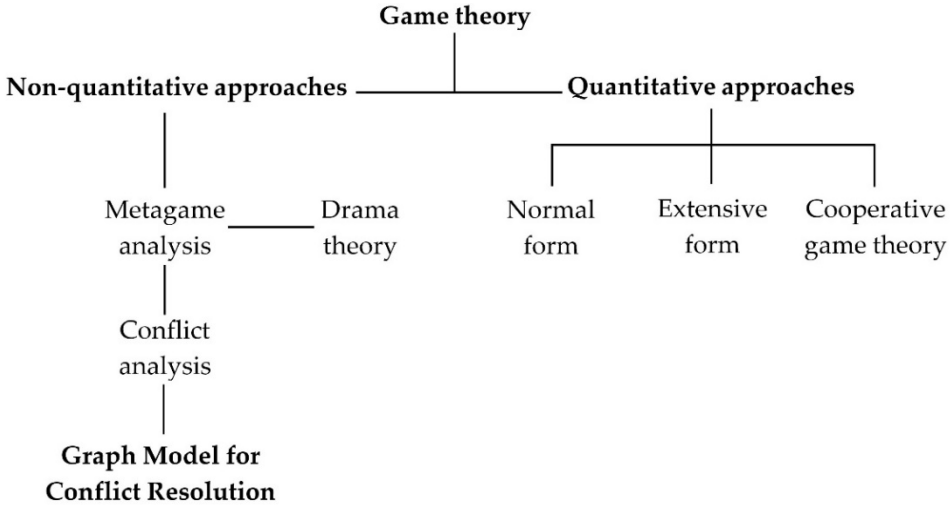

Figure 2. Classification of different models of game theory [68].

According to the specific solution step of GMCR, it can be classified into three stages: input, analysis, and output. Among them, the analysis stage is considered the most important. Thus, many stability definitions have been proposed to identify whether a state is stable (or not) in the analysis stage. There are four basic stability definitions

called Nash stability (R), general metarationality (GMR), symmetric metarationality (SMR), and sequential stability (SEQ). In general, based on the basic stability definitions, the research of GMCR is mainly to determine whether a given state is stable for each DM. This is called the forward perspective problem of the graph model. On the contrary, in some conflict negotiations, one may wish to determine all the possible preference relations for each DM, which can be used to obtain the desired resolution, called the inverse perspective problem of GMCR. It is, however, a challenge to obtain the preference ranking over states by using inverse analysis [69]. The application for the model in this paper's industrial–environmental conflict has not been previously explored. Hence, in this study, the latest version, i.e., GMCR-plus, is applied in a real case problem. The main aim of the present study is to optimize the Markazi province conflict to achieve a sustainable scenario with the minimum loss in industrial performance and environmental degradation considering the uncertainty and conflicts between DMs.

2.3. Players

In line with the conflict, three stakeholders were categorized (i.e., players) in Markazi province regarding its industrial land development (Figure 3):

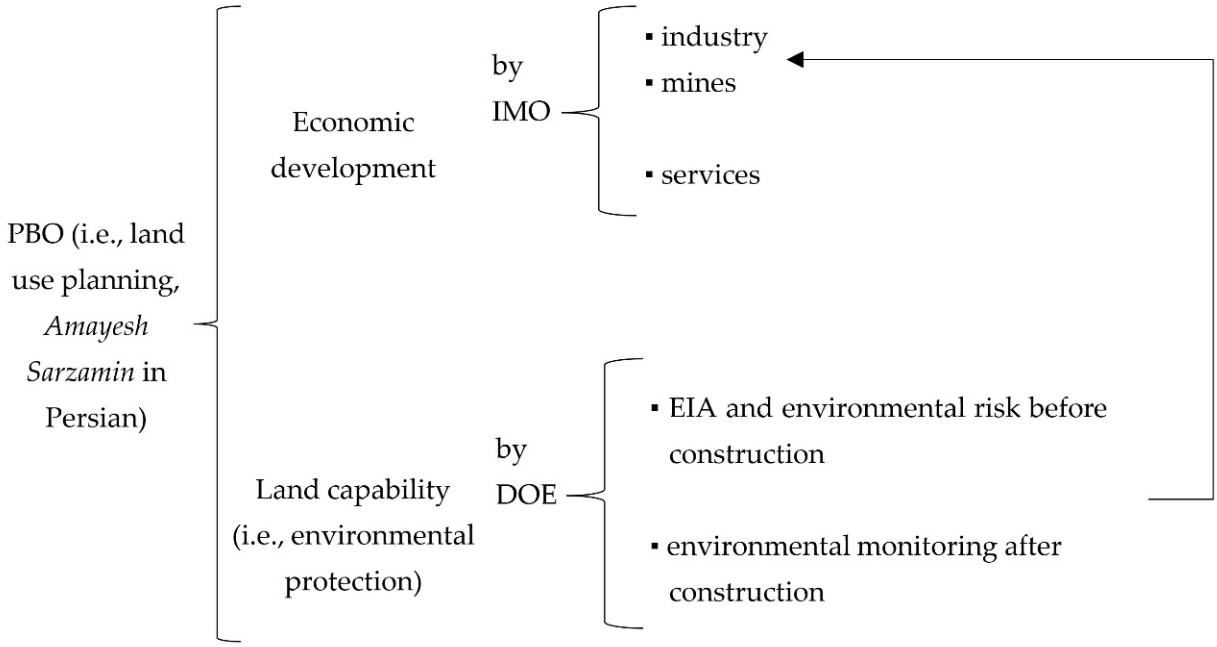

Figure 3. A simple game tree of industrial development conflicts in Markazi province.

1. Department of Environment (DOE)—main role is to protect the country's natural ecosystems and restore past adverse effects on the environment and prevent environmental degradation and pollution;
2. Industry and Mining Organization (IMO)—main role is to prepare and compile programs related to the development of provincial industrial activities within the framework of its upstream policies;
3. Planning and Budget Organization (PBO)—main role is to review, prepare, and compile long-term, medium-term, and short-term economic, social, and cultural development plans.

In reality, the process of industrial development involves more actors, such as the provincial government, pressure groups such as NGOs, small industries and industrial town organizations, landowners, and developers in other competing locations. However, in this research, only those three were considered because they are the crucial stakeholders in this process. Moreover, in real situations with large development locations, there is

usually more than one DOE, IMO, and PBO. However, for the sake of simplification, we have assumed a small location with only these three stakeholders.

The information used in this study (i.e., players, preferences and their priorities, etc.) was prepared in the spring of 2021 and is based on the study of upstream documents, such as the Land Use Goals of Markazi province, EIA reports, and feasibly studies of previous major projects on industrial development in Markazi province as well as periodic goals and perspectives on related organizations, especially, via DOE, IMO, and PBO. In order to increase the accuracy of the data, informal interviews with the environmental NGOs and experts of these organizations were conducted and the research process has been reported back to them, in so that the accuracy of the information and, consequently, the research process has high reliability.

3. Results

3.1. Payoffs

In the game model performed in this study, we have assessed the payoffs at the interval level for every conceivable outcome in the game. To this aim, we first conceptualized the goal of the industrial development process considered by IMO in three sub-goals, which are in line with payoff maximization. These sub-goals are (1) the financial result of the development process, (2) the fair distribution of opportunities in all parts of Markazi province, and (3) the period of time in which the plan will be implemented (i.e., 'the sooner, the better'). However, the relevance of these three different payoffs varies for the different players. For DOE, 'distribution of opportunities' and 'time' are believed to be more important than 'financial result', while for the developers, this is likely to be vice versa. The reason is that DOE believes that due to the many environmental problems in the province, there is no room for further industrial development. Thus, it considers organizing the current situation to be more important than other options. The role of PBO, as a mediator, is strategic planning and monitoring of Markazi province's development; it does this by performing scientific studies to improve planning as well as budgeting systems with long-term objectives in mind. Overall, PBO has taken a conservative approach to industrial development in Markazi province. The reasons are that, first, PBO is seeking the economic growth and development of the province. Second, due to the poor performance of the province's industries targets and the issues they have created to date, it seeks more pressure on the environment and, consequently, the people of the region.

These differences are assigned with different weights, comparatively, via the three sub-goal features for every player. Each player was to assess all outcomes compared to the three sub-goals based on their preferences. For this assessment, every player had to use different variables according to their preferences and reflect the relevance of those variables relative to each of the three sub-goals of land and property development. These variables are presented in Table 1.

Stakeholders, variables, and the basis of the analysis of Markazi province in industrial land development conflict are components of the GMCR conflict model. In Tables 1 and 2, the acceptance and rejection of the option by each DM is denoted by Y (i.e., Yes) and N (i.e., No), respectively. The total number of conflict situations is also obtained from the relation of the total number of conflict situations: 2^n. In this case, 'n' is the total number of conflict variables. Therefore, according to the number of options on this conflict (i.e., 8), the total number of conflict situations will be 256. To eliminate the infeasible status according to the stakeholder's variables, it was assumed that each player had to make at least one difference in the basic situation. The base position cannot be the same (i.e., all Y or all N), and this matter is among the excludable situations and the basic principles of this conflict.

For example, it does not make sense for DOE to not select any of the basic situations or to select all of them. The types of infeasible status are presented in Table 2. Thus, the number of possible conflict situations used in other stages of modeling and analysis is 18 (Table 3). The preferences of stakeholders will be formed by continuing these steps and creating the model of the conflict (Table 4).

Table 1. Stakeholders, variables, and basis of analysis of Markazi province in the industrial development conflict.

Stakeholder	Variable	Basis of Analysis
DOE	1. Approval of industrial development in case the observed, desired environmental reform are cleared	Y
	2. Complete opposition to industrial development	N
	3. Complaint to the judiciary for temporary suspension of industrial projects until approval is authorized by DOE	N
IMO	1. Abolition of industrial development (i.e., organizing the current situation)	N
	2. Industrial development based on the environment	Y
	3. Industrial development without taking into account the environment	N
PBO	1. Financing of industrial development projects if the development is approved by DOE	N
	2. Financing of industrial development projects without development approval by DOE	Y

Table 2. Infeasible states in the industrial land development of Markazi province.

Eliminated States	Infeasible Type	Description
(YY- - - - - -)	Mutually exclusive	DOE cannot agree to industrial development if considerations are taken and, at the same time, demand for abolishing of industrial development
(Y-Y- - - - -)	Mutually exclusive	DOE cannot agree to the implementation of industrial development if considerations are taken and, at the same time, sue the court to order the suspension of development projects until the amendments are observed (i.e., referral to the court is only reasonable if the environmental considerations are not observed)
(- - -YY - - -)	Mutually exclusive	IMO cannot cancel industrial development and, at the same time, implement industrial development with environmental considerations
(- - -Y-Y - -)	Mutually exclusive	IMO cannot cancel industrial development and, at the same time, implement industrial development without observing environmental considerations
(- - - - YY - -)	Mutually exclusive	IMO cannot implement the required environmental considerations and, at the same, time carry out industrial development without observing the reforms
(- - - - - - YY)	Mutually exclusive	PBO cannot allocate credit to industrial development without any conditions and make the allocation of credit conditional on the approval of the DOE
(Y - -Y- - - -)	Mutually exclusive	It is unreasonable and impossible that PBO cancels the industrial development, but DOE approves the project with environmental consideration
(- - - - - YY-)	Mutually exclusive	It is not reasonable for the PBO to make the allocation of credit to industrial development conditional on DOE approval, and, at the same time, IMO implements industrial development without DOE approval
(NNN - - - - -)	Infeasible condition	It does not make sense for DOE that does not choose any of the options available to it (i.e., it must have chosen one of the options at each step)
(- - - NNN - -)	Infeasible condition	It does not make sense for IMO that does not choose any of the options available to it (i.e., it must have chosen one of the options at each step)
(- - - - - - NN)	Infeasible condition	It does not make sense for PBO that does not choose any of the options available to it (i.e., it must have chosen one of the options at each step)

Coalition progress is defined as the secondary status, i.e., it is more preferable for all members of the coalition than the primary status, and if it is preferable only for some members of the coalition, it will not be a coalition progress. Therefore, the logic of stakeholder movements in GMCR is that the set of these movements continues for each DM until the player reaches a situation that is stable for them based on the concepts of non-cooperative solution. The equilibrium point of the conflict will be defined as a situation that is stable for all DMs (Figure 4).

Table 3. Feasible states in the industrial development of Markazi province.

Stakeholder	Alternative	Feasible States																	
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
DOE	Conditional approval	N	N	N	Y	N	N	N	N	N	N	Y	N	N	N	Y	N	N	N
	Opposition	Y	N	Y	N	Y	N	Y	Y	N	Y	N	Y	N	Y	N	Y	N	Y
	Complaint	N	Y	Y	N	N	Y	Y	N	Y	Y	N	N	Y	Y	N	N	Y	Y
IMO	Cancel the development	Y	Y	Y	N	N	N	N	Y	Y	Y	N	N	N	N	N	N	N	N
	Obedience the reforms	N	N	N	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	N	N	N	N
	Disobedience the reforms	N	N	N	N	N	N	N	N	N	N	N	N	N	N	Y	Y	Y	Y
PBO	Conditional permit	Y	Y	Y	Y	Y	Y	Y	N	N	N	N	N	N	N	N	N	N	N
	Unconditional permit	N	N	N	N	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Table 4. Preference rating of possible conflict situations for each stakeholder from maximum to minimum.

Stakeholder	Maximum Preference																	Minimum Preference
DOE	1	3	8	10	2	9	5	7	12	14	4	6	11	13	16	18	15	17
IMO	15	17	16	18	11	13	12	14	4	6	5	7	3	2	1	10	9	8
PBO	11	12	13	14	15	16	17	18	8	9	10	4	5	6	7	1	2	3

Note: The cells that do not have a column between them have the same preference (i.e., value). For example, situations 11 to 18 have the same preference for PBO.

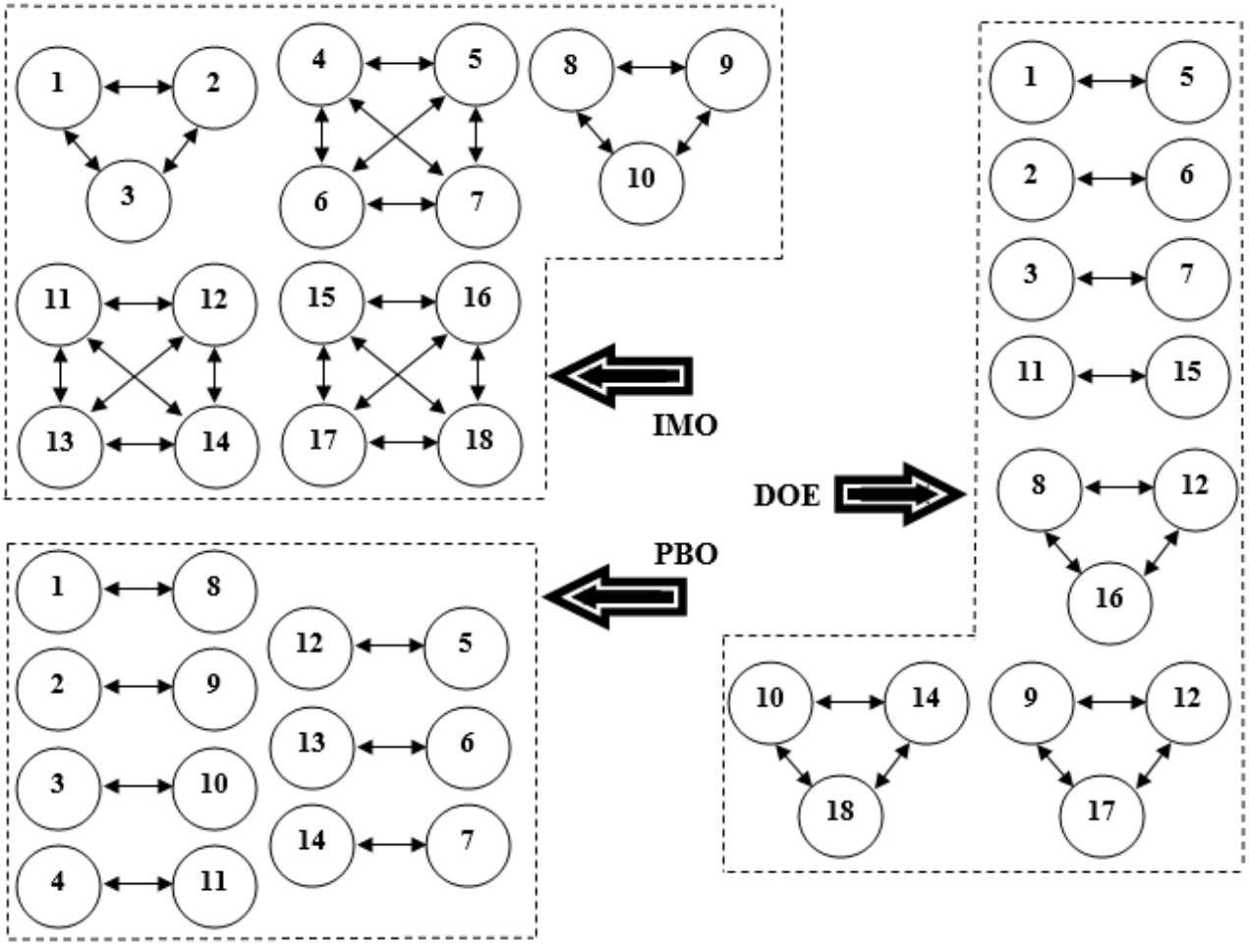

Figure 4. One-way progress graphs for Markazi province industrial land development conflict among stakeholders.

3.2. Player Preferences

At this stage, based on the goals and policies of each player, the priorities of each organization in relation to the industrial-environmental conflict in Markazi province are determined and ranked. This is necessary to better ascertain the balance point of the conflict since each DM adopted a strategy based on their organization's priorities.

3.2.1. DOE Preferences

Since DOE is not a government ministry and acts as an independent organization, it has an important oversight role in Iran in terms of protecting the quality and quantity of environmental parameters. At the same time, the natural lands of Markazi province are nationally and regionally important for the people of Iran, especially the indigenous people of the region, and the destruction of the province's environment is of national importance, such that it can weaken the role and identity of the DOE itself. Therefore, in addition to its supervisory role in protecting these valuable natural resources, DOE wants to play a greater role in maintaining its organization's status and greater effectiveness at the macro level, particularly in recent years, where Markazi province has been underscored as a hotbed for its lax environmental control. According to Tables 4 and 5, the most and least preferred options of DOE are status 17 and 1, respectively.

Table 5. DOE preferences (in order from most desirable to most undesirable conditions).

Preference Degree	Desirable Conditions	Description
1	(- - - Y - - - -)	IMO cancels industrial development completely (organizing approach)
2	(- - - - - N - -)	IMO should not ignore the considerations of the DOE
3	(- Y - - - - - -)	DOE should oppose industrial development
4	(- - - - - - Y -)	Allocation of credit to industrial development by the PBO is subject to the approval of industrial development projects by the DOE
5	(- - - - Y - - -)	IMO should carry out industrial development with due consideration
6	(Y - - - - - - -)	DOE should agree to industrial development if IMO implements its considerations
7	(- - N - - - - -)	DOE should not use the compliant option

3.2.2. IMO Preferences

IMO is the main player of policy-making and industrial development in Markazi province. The fundamental target of IMO is to balance industrial growth in all parts of the province. Although the goals and infrastructure of the organization are completed and implemented via a national model, the lack of integrated and inter-organizational industrial development policy in Markazi province has always been a complex problem for various organizations, including IMO and DOE. Moreover, since the province has faced many environmental issues during the past years due to industrial and population growth, preserving the natural resources of the province has been among the major goals of IMO. According to Tables 4 and 6, the most and least important preferences of IMO are status 8 and 15, respectively.

3.2.3. PBO Preferences

PBO of Markazi province is one of the most important organizations in the province since it acts as a distributor of financial resources province-wide. As such, steady growth and development of different parts of the province are highly dependent on corrective and effective decisions PBO must make. These decisions consider the current situation of the province economically, politically, and socially. Moreover, in terms of the environment, it strives for a balanced growth of development in various sectors and uses financial and budgetary tools to uphold environmentally-friendly action. In the industrial

land development conflict, PBO does not have environmental expertise, it integrates industrial development by using expert opinion, followed by governing trends, especially environmental degradation, and injecting or modifying financial resources accordingly. Furthermore, considering the economic recession of recent years, the issue of creating infrastructure and improving economic and social welfare has been prioritized by this organization. According to Tables 4 and 7, the most and least important preferences of PBO are status 3 and 11, respectively.

Table 6. IMO preferences (in order from most desirable to most undesirable conditions).

Preference Degree	Desirable Conditions	Description
1	(- - - - - Y - -)	IMO should do industrial development without any reforms
2	(- - - N - - - -)	IMO should not give up industrial development under any conditions and should not cancel industrial development
3	(- - - - - - - Y)	PBO should issue an unconditional permit for industrial development (no need to obtain approval from the DOE to allocate funds)
4	(Y - - - - - - -)	DOE should agree to industrial development if the reforms are observed
5	(- N - - - - - -)	DOE should not seek the complete abolition of industrial development
6	(- - N - - - - -)	DOE should not use the complaint option

Table 7. PBO preferences (in order from most desirable to most undesirable conditions).

Preference Degree	Desirable Conditions	Description
1	(- - - - - - - Y)	PBO should issue an unconditional permit for industrial development (no need to obtain approval from DOE to allocate funds)
2	(- - - N - - - -)	IMO will not give up industrial development in any way and will not cancel the development (according to the financing done so far for development projects)

3.3. Conflict Analysis

In the next step of the Markazi province dispute analysis, after determining the stable positions for each player based on the defined balance definitions, the equilibrium points of the game are determined. The equilibrium point of the game is a situation that is stable for all players in exchange for a certain definition of balance. This means that players who have the characteristics of that definition of balance, accept the situation as a solution to the conflict and do not want to change it. Because different definitions of equilibrium indicate different behaviors players may exhibit during a conflict, the more stable a situation is (i.e., based on the equilibrium for all players), the greater the strength's equilibrium point in the game. As such, it is likely that players will accept the situation as a solution to the conflict. Reaching the equilibrium point will be achieved when practically none of the players, based on their preferences and the other actors involved in the conflict, will be able to advance and reach a state of inactivity.

In the Markazi province conflict, determining the equilibrium point for each DM was performed after analyzing the unilateral progress for each organization. The equilibrium point was obtained from the list of unilateral progressions, i.e., the actors of the conflict and the model created using definitions from the non-cooperative model. Specifically, the four basic stability definitions (i.e., R, GMR, SMR, SEQ) were analyzed in the GMCR software and stable positions were identified for each player. Indeed, if a situation (i.e., point) is stable for all DMs for a particular condition, it is called the equilibrium point of the conflict. After creating the conflict model, the equilibrium points or possible outcomes of the industrial land development conflict of Markazi province were determined using the current situation. According to Table 8, in the initial analysis, positions 5, 8, 11, 15, 16, 17, and 18 were identified as the most probable equilibrium points, among which status 11 was identified as

the base position of the analysis and status 16 as the non-cooperative equilibrium position. Furthermore, status 16 is stable, based on non-cooperative equilibrium definitions [63] including R (i.e., when a player can receive no incremental benefit from changing actions, assuming other players remain constant in their strategies), GMR (i.e., when a player considers possible disimprovements by the opponent players and possesses at least a two-level foresight), SMR (i.e., when a risk-accepting player allows strategic disimprovements and has at least a three-level foresight), and SEQ (i.e., when all unilateral progress of the player is blocked by subsequent unilateral movements of other players).

Table 8. Equilibrium analysis for industrial land development from conflicting stakeholders in Markazi province using the current scenario. † status 16 is highlighted to indicate the only one-sided movement for all possible DMs.

Stakeholder	Possible Conflict Status																	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16** †	**17**	**18**
DOE	R	-	-	-	R	-	-	R	-	-	-	R	-	-	-	R	-	-
	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	-	GMR	-	-
	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	-	SMR	-	-
	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	-	SEQ	-	-
IMO	-	-	-	R	R	R	R	-	-	-	-	-	-	-	R	R	R	R
	-	-	-	GMR	GMR	GMR	GMR	-	-	-	-	-	-	-	GMR	GMR	GMR	GMR
	-	-	-	SMR	SMR	SMR	SMR	-	-	-	-	-	-	-	SMR	SMR	SMR	SMR
	-	-	-	SEQ	SEQ	SEQ	SEQ	-	-	-	-	-	-	-	SEQ	SEQ	SEQ	SEQ
PBO	-	-	-	-	-	-	-	R	R	R	R	R	R	R	R	R	R	R
	-	-	-	-	-	-	-	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR	GMR
	-	-	-	-	-	-	-	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR	SMR
	-	-	-	-	-	-	-	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ	SEQ
Conflict equilibrium point																R GMR SMR SEQ		

Status 16 is the only situation in which no one-sided movement is possible for any DMs. In other words, if status 16 is considered as the source of analysis (i.e., the beginning of the conflict and stakeholders' movements), neither side will be able to move from this situation (i.e., assuming the current order of precedence of preferences in this scenario continues) to a better one. This can be attributed to the equilibrium point of this situation for the Markazi province industrial land development conflict. The choice of this situation as the equilibrium point of the conflict indicates that if the current preferences of the parties continue, the conflict will be at a deadlock and, thus, there will be no way to resolve it.

4. Discussion

Industrial advancement has played an important role in kickstarting and developing economic growth throughout the world. Many countries, including Iran, see the realization of sustainable growth and development in the shadow of industrialization. Markazi province has large industries with high technical and specialized features that have provided a suitable platform for the creation of downstream industries of industrial production chains, networks, and clusters. Some features have provided conditions that have turned the province into one of the key industrial hubs in Iran. Some unique features to its growth include its geopolitical position, proximity to cities and major consumer markets, location to major parts of the province due to safe seismicity, potential capacity in the field of conversion and complementary industries and mines, and development in terms of energy transmission and supply lines (i.e., oil, gas, and electricity) and the possibility of exploiting these lines for production and consumption. Moreover, during the past few decades (i.e., especially after the Iraq-Iran war), industrial growth and development in Markazi province without appropriate site-selection, accelerated development, non-observance of environmental considerations (i.e., at different scales), and allowed for poor organization of industries that led to the emergence of several environmental issues. In 2016, Markazi

province was ranked third in the country with an ecological footprint index of 2.316 [70], indicating the high pressure on the environment and people of the province.

Based on the results of the equilibrium analysis, GMCR was used to solve the industrial land development conflict via the current scenario with the equilibrium point of the conflict being status 16. In this situation, PBO has so far approved and allocated credit for industrial land development without any conditions. Although DOE completely opposes the implementation of current industrial development policies, IMO insists on the implementation of projects without observing any serious environmental reforms. PBO has a key role to play in the conflict. Hence, the decision of PBO to issue unconditional licenses for industrial development projects will lead to worsening conditions for Markazi province's environment. The structure of an industrial land development conflict is similar to that of a comprehensive sustainable development dispute. In such a conflict—due to the weak position of environmental groups—NGOs, organizations in the dispute, and developers often ignore the consideration of the environment in favor of the development project.

Comparatively, research from other industrial development type of conflicts using game theory methods is difficult since there is a lack of studies in this particular field. However, the study of disputes in the field of industry or natural resources using game theory does include several prominent studies. Yang et al.'s [64] work in which a novel grey and unknown preference framework of GMCR was proposed to resolve the conflict of discharging nuclear wastewater in the ocean. Furthermore, Song et al. [71] introduced a decision preference between desirable and undesirable outputs, the order and ratio of the decision preference between sub-stages, and constructs via a two-stage cooperative versus non-cooperative game using data envelopment analysis. The model is used to evaluate and compare the efficiency of the Chinese regional industrial system over the period 2011–2015 from the perspective of a two-stage cooperative versus non-cooperative game. The results show under the non-cooperative game relationship that it is mainly affected by low pollution control efficiency components, in conformity to the 'Cannikin Law', and marked differences in the overall efficiency and sub-stage efficiency of China's industries under the cooperative game relationship. Pournabi et al. [72] proposed the non-cooperative game theoretic and conflict model using GMCR to resolve internal management conflicts. According to the results, endorsing supportive ideas for farmers, improving of crop pattern, imposing crop cultivation limitation by the Ministry of Agriculture, preventing oil field expansion, and bettering agricultural water supply for integrated management of the region were identified as solutions to resolving conflicts among DMs. Dowlatabadi et al. [73] proposed an enhanced GMCR with application to an international wetland. The results indicate that the achievement of an environmental balance depends on cooperation between Iran and Iraq to persuade Turkey to release the environmental flow to the cross-border wetland. Fan et al. [74] developed an evolutionary game model to analyze the operation mechanism of local government expenditure preferences on the production behavior of industrial polluting enterprises, so as to specify the behavioral characteristics and optimal strategy of local environmental governance. The results indicated that whether the relationship between local governments and polluting enterprises in environmental governance becomes cooperative or collusive depends on their game sequence and initial endowment. Under the condition of realizing a steady state of cooperation, polluting enterprises will advance faster toward clean production if local governments distribute more environmental expenditures on cost subsidies for enterprises to implement clean production. At length, comparison with other research largely confirms the results of this paper's findings. Because common resources, especially land, are usually under a lot of pressure, and in many cases the organizational rules of the stakeholders involved in Iran cannot guarantee the resolution of the dispute, it is highly regular to resolve either through the judicial system or intervention via a mediating organization. GMCR can aid in this process by explaining the conflict preferences and illustrate DM preferences in such matters.

In total, GMCR has several advantages over the classical game theory techniques. It requires much less input information from the user and allows DMs to move in any

possible order, which is more realistic in conflict analysis. However, one of its weaknesses is determining the correct definition of the preferences of the main actors involved in the conflict. This is important since such studies, as in this one, are based on the most recent decisions made by the organizations involved, which may change completely over time if there are changes in the management system, ruling parties, or upstream rules (i.e., at the national level). Nonetheless, in the past, DMs in Iran did not pay special attention to environmental issues as they do today. With the emergence of environmental issues, consideration of the environment has become one of the most important parameters for the decision-making process. As such, determining the type of rules for each option should be based on previous studies and findings, even though it has been found that stakeholder experts may not agree. The main limitation of this study was the elimination of some players in order to avoid complexity of the model. This was performed because identifying their priorities and the interactions between them would have been very time consuming and would have greatly increased the volume of modeling. Thus, only the main actors have been satisfied.

5. Conclusions

In the current situation of the industrial land development conflict, there is a lack of policy-making tools that oblige PBO to consider the positions of DOE when allocating funds to projects with environmental impact. Such a shortcoming has limited the influence and bargaining power of DOE. Therefore, DOE cannot use any option, whether it is a complaint or opposition or conditional approval of IMO to cancel a project. This indicates that a change in the preferences and interests of the parties and, ultimately, the provision of environmental considerations depends on the reformation of the structure itself. Due to the weakness of the existing policy-making system, which is structured mostly in favor of industrial development, the lack of compromise and the insistence of DOE to achieve its maximum preference (i.e., cancellation of a project) will lead to the loss of its minimum preference (i.e., environmental reform of industrial development) and the worst environmental outcome. In particular, by proposing the need for industrial development, stakeholders in industrial land development policy can shift the preferences of IMO to industrial land development and PBO preferences to the crediting of a project.

One of the options for DOE is that even if an unconditional permit is issued for the industrial development by PBO, citing the comment of Article 104 of the Fourth Economic, Social, and Cultural Development Plan of the Islamic Republic of Iran, it can still issue a complaint at the appropriate judiciary level and demand the stoppage of the industrial development until proper environmental considerations have been sought and considered by IMO in their long-term goals and policies. This complaint is somewhat of a last-ditch effort (i.e., a national backup policy) based on Article 104 in which the construction of projects of national and regional importance needs the preparation of an EIA report and the approval of DOE. As such, in the current scenario, DOE's lack thereof, i.e., of using this option, should be taken into account and IMO's inability to implement reforms should be considered as secondary information for future research, its implementation, and the decision-making process.

Moreover, the use of a grievance option—due to the sustainable development structure of the conflict and the important role of unconditional licensing by PBO—cannot lead to the maximum preference for DOE (i.e., project cancellation). Nonetheless, even in the same situation, it can make it possible for DOE to gain minimal preference (i.e., industrial development with considerations). Therefore, in the current scenario, for DOE to achieve its minimum desirable outcome, it should give more weight to the appropriate judicial branch by using its complaint option. In all, future-based research could also combine quantitative and non-quantitative approaches in a simultaneous approach. In addition, prioritizing stakeholder preferences through fuzzy approaches and weighting them accordingly. Finally, to contribute to the richness of the research, it would be a breakthrough

to include completing and expanding aspects of the model's data bank by using artificial intelligence approaches to make the results more accurate.

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