EVALUATING EXISTING STRATEGIES IN ENVIRONMENTAL CRISIS OF ZAGROS FORESTS OF IRAN[1]

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Abstract. Zagros vegetation region is located in the west and southwest of the country of Iran. Nowadays, these forests are in severe quantitative and qualitative environmental dangers due to various climatic reasons, uncontrolled exploitation, overgrazing of livestock and lack of knowledge about management requirements and have become seriously affected. In the last 6 years, there have been numerous reports about the decline of oak trees in the central and southern Zagros forests. In this research was evaluated existing policies in decline crisis of Zagros forest of Iran with game theory. The research process has been conducted in several sections. In the first section of the research, key players of the decline crisis game in Zagros forests were examined, in order to evaluate strategies for crisis. In the second section of the research, the main strategies of the key players in decline crisis management were determined. Thereafter, the benefits of different strategies for key players were quantitatively evaluated with game theory. The result shows that it is clear from the diagram of the evaluation result of players in crisis game in Zagros forests that mode of results is in the executive management and local people of Zagros forests. Executive management has been having protection of forest resources and rainfall saving strategies. In reaction, local people has been having corporation and lack of corporation strategies. It can be extracted from the game theory model in this research that the game has 2 Nash Equilibriums (NE) in combination of protection of forest resources with lack of corporation of the people and combination of saving rainfall with corporation of the people. Based on the results there is no useful role for rainfall saving in Zagros forest of Iran. The way out of this impasse is to design appropriate policies in Zagros forests for the balance of rainfall saving and protection of forest resources, in a way that it follows the local community cooperation.
Keywords: *game theory, decision making, local resident, participatory management, nature conservation*

Introduction

Zagros vegetation region is located in the West and Southwest of the country of Iran. Nowadays, these forests are in severe quantitative and qualitative danger due to the following: climatic reasons, uncontrolled exploitation, overgrazing of livestock, and lack of knowledge about management requirements (Samari et al., 2012; Pourhashemi et al., 2013). The people living in these forests have complex and difficult lives when compared to those living in other parts of the country (Imani Rastabi et al., 2015).

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Traditional exploitations to meet the needs of local communities are common in almost all of the Zagros forests, despite the objections of the executive management (Samari et al., 2012; Zandebasiri and Parvin, 2012). In the past few decades, changes in climate, ecology, management conditions, and the outcomes emanating from them have affected the Zagros forest ecosystem. One of the key problems of the Zagros forest ecosystem has been the decline of oak trees in arid and semi-arid parts of central and southern Zagros (Hosseinzadeh and Pourhashemi, 2015). Forest decline is death of forest trees and retrograde motion of forest stands (Fan et al., 2012). During the last 6 years, several researchers have written numerous reports about the decline of oak trees in the central and southern Zagros forests. This resulted to crown dieback and decay of tree trunks and after a while destroys the life of forest ecosystems as a pest. The growth of infected tree reduces and due to the interaction between biological and environmental stresses, a secondary pest attack is created. Based on the latest examinations in Zagros region, over one million four hundred thousand hectares of forest area in Zagros have died or are at risk of death. This level of death is mainly observed in the provinces of Ilam, Lorestan, Kohgiloye and Boyer Ahmad, Kermanshah, Fars, Chaharmahal and Bakhtiari, and Khuzestan. The most important measures taken in deterioration management and reforestation of Zagros forests which has been done by executive management over the past few years are identification, classification and identification of contaminated surfaces, management based on protection for livestock grazing, sampling the contaminated surfaces, foods and farm operations such as pruning infested trees, cutting and removing completely dead and infested trees (Iranian Forests, Rangelands and Watershed Organization, 2013). The conditions prevailing in these forests are critical due to the interruption of vital activity in Zagros forest ecosystems, environmental wastes and abundant material damages. There is no ability to restore power waste in critical conditions; systems or parts of it are disturbed and system stability unsettles. Most researches in the field of Zagros forest decline are based on structural and geological examinations (Hamzehpouer et al., 2012; Hoseini et al., 2012; Hoseinzadeh et al., 2015; Mahdavi et al., 2015). The result of these researches has been in line with the structural weaknesses of the mass, that is, the lack of the people’s involvement in organizing the masses. Researchers equally looked into the drought and famine experienced in the region of central and southern Zagros forests. However, in spite of these researches, no research has been carried out on the terms of policy making about this event in Zagros forest. Thus, the purpose of this research work is to examine existing policies in critical conditions in order to find ways out of the existing situation.

Materials and methods

The examined local area

The examined local area is the catchment of Tange-solak in the province of Kohgilouye and Boyerahmad. Tange-solak forest is located in Likak city, which is approximately 15 km south of Kohgiloye and Boyer Ahmad province. This forest has an area of 1000 hectares. There are also agricultural and horticultural lands in this region. The main agricultural products include wheat and barley. Also, natural cypress trees form unique stand of cypress-oak. The existing forest has a high scientific value and it can be called living fossil. Most people residing here have relocated from the region due to lack of facilities and low income. While the rest of them left behind do not have permanent residence in the forest; these migrate to tropical regions in the period of

October to late winter. In the current situation, forest preservation plan is applied for the region with a focus on forest resources protection by the executive management. The people still living here get drinking water from a spring which is in Tange-solak itself. Effect of dieback and decline has started in the region in previous years.

Research method

The research process has been conducted in three sections. In the first section of the research, key players of the crisis game in Zagros forests were examined in order to evaluate strategies for crisis. Seven experts, specialized in Zagros forests and its crisis, were selected. A Reputation Approach (RA) was used in the selection of experts. RA includes the use of privileged experts in decision-making processes (Zandebasiri and Ghazanfar, 2010). The total scores of each of the players were calculated based on opinions of experts in the form of Likert scale. Likert scale was used to determine the key players; this was developed by one of the management scientists, Rensis Likert (Zandebasiri and Adjari, 2012). This scale is composed of a number of statements and answer options. Likert scale normally consists of 5 equal sections and it is one of the most used scales in the evaluation of elite experts' attitudes in forest management. An example of a Likert scale is presented in *Table 1*.

Table 1. *Likert scale with numerical values.*

Answer options	Numerical value of scale
Completely disagree	1
Disagree	2
Apathetic	3
Agree	4
Completely agree	5

In the second section of the research, the main strategies of the key players in decline crisis management were determined based on the collection of resources, documentary research, interviews with the expert's team. After determining the strategies, a set of advantages for each of the strategies was presented.

In the third section of the research, the benefits of the different strategies for key players were quantitatively evaluated. Likert scale was used here. Again, the opinions of experts were used in this stage. The average score of each of the players were calculated based on opinions of experts in the form of Likert scale. So that in the output of this section, input model of game theory for providing the numbers of decision matrix is decided. Based on the numbers of decision, matrix Nash Equilibrium (NE) and combined equilibrium of the game were examined. Due to the fact that the application of game theory in forest management is new, a short explanation of this theory will be presented.

Game theory

Game theory is a set of bilateral relations where there is interdependence and reciprocity between the decision of the two sides (or more). In other words, whenever the process of decision making is not only influenced by the efforts of decision maker but by decisions of other party, then this process is called game. It was first introduced

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in 1921 by Emile Borel and developed in 1944 –1947 by John von Neumann and Oskar Morgenstern (Mohammadi Limaei, 2010; Abdoli, 2012). *Table 2* shows the 3 categories of decision-making processes that have been discussed in forest management based on the information structure (Zandebasiri, 2014).

Table 2. *Status decision based on the information.*

Uncertainty	Taking Risks	Certainty	Decision-making status
Unknown outcomes	Known possible solutions	Known outcomes	Type of Information

In terms of ‘Certainty’, there are enough information about area of decision making. With regard to ‘Taking Risks’, the outcomes of options are identifiable but identification of outcomes takes place in possible conditions and not precise conditions. For ‘Uncertainty’, the decision making area is completely obscure and the outcomes of selecting each option is not even probabilistically predictable (Kurtilla et al., 2000; Nordstrom et al., 2010; Jonathan Catron et al., 2013). Game theory has been proposed in the completion of the above three conditions for decision making in terms of conflict and tension. Conflict occurs when 2 or more decision makers are in competition with each other to gain certain advantages. In other words, there is a fourth condition called "conflict" that arises for the completion of above-mentioned decision conditions. In the case of conflict selecting, the appropriate option for decision making depends on other forces affecting the decision makers. This condition is easily observed in the real world. Forces, individuals, and organizations that have the ability to influence the decision of a decision maker are called rival or opponent. When a decision is made by an individual or an organization, it affects the decision of rivals and it usually takes effect from the decision after it. Thus, a game takes shape in the form of a set of decisions (Mohammadi Limaei, 2010; Colivan et al., 2011). In the game theory, each of the decision makers is called a player. The Executive management and research institutions in the decision making environment or in cooperation with local communities always evoke a set of decision as a game between expressed players. An environment where there are interactive responses of players in the decision-making process is called strategic environment. Options available and the development of each player are called his strategies. Due to the role of a player in this theory, the term of tactics (solution) is never used, but the term strategy is always used for selecting a player. The win or lose size and incomes of a player at the end of a game are called outcomes. One number can be attributed to each player for each result which is called the outcome. Higher number indicates better status or result for such players (Mohammadi Limaei and Lohmander, 2008).

Displaying the game

The first step in examination of the games is displaying a game. A set of players in an N-player is shown as N = {1, 2 ... n}. Strategies of i-th player are shown as Si = {S_1, S_2... S_n}, where S_1 to S_K are different strategies and i € N. Display messages in a matrix form is common, because the dimension of matrix is equal to the number of players; the rows and columns show the strategies of each of the players. *Table 3* shows a matrix for a 2-player game.

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Table 3. *A matrix for a 2-player game.*

Efficiency matrix	S_{1B}	S_{2B}
S_{1A}	(a_{11},b_{11})	(a_{12},b_{12})
S_{2A}	(a_{21},b_{21})	(a_{22},b_{22})

In the *Table 3,* S_{1A} is the first strategy of the player and S_{2A} is the second strategy. Strategies of player B is defined in the same way. The above example is a 2-player game. Numbers (a_{11}, b_{11}) show that if the combination of S_{1A} and S_{1B} strategies are applied by 2 players, Player A benefits as much as a_{11} and player B benefits as much as b_{11}. The matrix elements of decision making are defined in a similar way. The above matrix, which indicates a quantitative benefit for players, is called efficiency matrix.

Equilibrium

In a state of equilibrium, each player uses a strategy which has the best response to selected strategies of other players. In the state of equilibrium, each player will not certainly achieve the greatest outcome; rather, they use the best strategy related to decisions of opponent. This occurs to other players so that all players apply the best response for the other players and an equilibrium forms here.

Classification of games

Games are classified by different methods in this research, such as static and dynamic, incomplete, and complete.

Static and dynamic games

In the dynamic games, one player acts, thereafter the other player acts. Unlike dynamic games, none of the players are aware of the strategy proposed by their opponent.

Games with complete and incomplete information

In games with complete information, the outcome of choices are clear for players, but in games with incomplete information, the outcome of a strategy is unknown to at least one of the players. Since the opinions of experts could lead to several outcomes, the game of this research was considered as static with complete information. Equilibrium in static games with complete information is called Nash equilibrium. Games that do not have equilibrium or have 2 Nash equilibriums are called combined strategic equilibrium. Combined strategic equilibrium calculates the probability of selecting strategies for each player. The ability to believe in form of possibility is from the fact that a player cannot surely say what strategy his opponent will choose (Shahi and Kant, 2007).

Results

The result of the first section of the research in evaluation of players in the crisis game in forest management of region is as shown in *Figure 1*.

The results of the section showed 2 groups of Players. They are the executive management and the local people. These stakeholders are the main players of forest decline and crisis management in Zagros forests.

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The results of the second section of the research in document evaluations revealed that the most important executive management strategies are protection of forest resources and saving rainfalls. Thus, strategies for cooperation and non-cooperation were considered for the local community in accordance with these strategies. The results of the third section of the research revealed the evaluation of positive outcomes of each strategy of executive management and local people; these are shown in *Table 4* and *Table 5*.

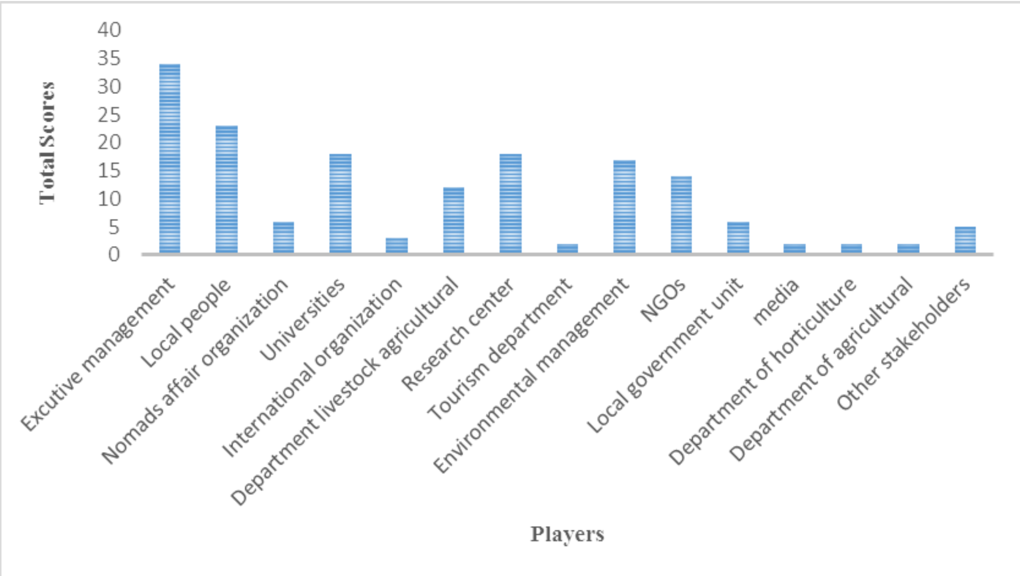

Figure 1. *Evaluation result of players in the crisis game.*

Table 4. *The positive outcomes of each strategy of executive management.*

Protection of forest resources in cooperation with people	**Saving rainfall in cooperation with people**
Benefits for executive management	**Benefits for executive management**
Opportunity to revive the natural regeneration in the future	Controlling erosion
Controlling risk factors in tree's dieback	Preventing tree's dieback
Average Total Score: 1.75	Average Total Score: 1.75
Protection of forest resources in non-cooperation with people	**Saving rainfall in non-cooperation with people**
Benefits for executive management	**Benefits for executive management**
Output reports about forest conservation activities	Output reports about rainfall saving activities
Achieving compiled instructions	Achieving compiled instructions
Performing administrative duties	Performing administrative duties
Average Total Score: 3.75	Average Total Score: 1. 5

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Table 5. *The positive outcomes of each strategy of local people*

Cooperation of people in storing rainfall	Cooperation of people in protection of forest resources
Benefits for local people	**Benefits for local people**
Temporary employment for the local community	Prevention of executive management fines
Increase the income of agricultural products Average Total Score: 2.75	Average Total Score: 1.5
Lack of cooperation of people in storing rainfall	**Lack of cooperation of people in protection of forest resources**
Benefits for local people	**Benefits for local people**
Relying on domestic community patterns of precipitation in the storage	Providing livelihood dependence from forest
	Excessive harvesting of forest resources
Average Total Score: 1.5	Average Total Score: 4

Based on the scores of *Table 4* and *5*, the result of the crisis game model between executive management and the local community in the forests of the Zagros is shown in *Table 6*.

Table 6. *Result of crisis game model between executive management and the local people.*

Efficiency Matrix	S_{1B}	S_{2B}
S_{1A}	(1/75, 1/5)	(3/75, 4)
S_{2A}	(1/75, 2/75)	(1/5, 1/5)

In *Table 6*, S_{1A} is the first strategy of executive management (protection of forest resources) and S_{2A} is its second strategy (saving rainfall). In a similar way, S_{1B} is the first strategy of the local community (Cooperation) and S_{2B} is its second strategy (lack of cooperation).

Equations 1, 2, and 3 show the results of calculation of combined strategies:

$$1.5p + 2.75(1-p) = 4p + 1.5(1-p) \rightarrow p = .71 \ \& \ 1-p = .29 \quad \text{(Eq.1)}$$

$$1.75q + 1.75\,(1-q) = 3.75q + 1.5(1-q) \rightarrow q = .11 \ \& \ 1-q = .89 \quad \text{(Eq.2)}$$

$$N(G) = (p, q) = (0.71, 0.11) \quad \text{(Eq.3)}$$

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In the above equations, N(G), is combined strategic equilibrium and sizes of p and q determine the possibility of selecting players' strategies.

Research discussion

Key players

The result evaluation of the players in crisis game in Zagros forests (*Fig. 1*) showed that the mode of results is in executive management of Zagros forests. The executive management includes: Forests, Rangelands and Watershed organization of the country and in lower hierarchy, the department of natural resources. The executive management was the most relevant factor involved in the crisis in the forest due to legal liability and options available; while the second most relevant factor is local people. With regard to the role of local people in management of Zagros forest and socio-economic problems in these forests (Ghazanfari et al., 2004; Valipour et al., 2014), it was observed that the local residents were the most effective in dealing with the crisis in executive management activities. Universities and research centers are the third most relevant factor, because they function in the production of information. The Environmental Protection Agency and the Department of the Environment are in next places of importance due to protection functions. The importance of the environment departments and the research centers and production of information revealed the need for analyzing factors involved in decision-making processes of Zagros forests (Zandebasiri and Adjari, 2012). The international organizations and the media are in poor position in this study as 2 major players in extra-territorial crisis. International organizations should have higher priority in crisis management due to the extra-territorial relations. Also, the media had an important place in the production of information, but it is less relevant in the current situation of crisis management of Zagros forests.

The game's equilibrium

The game theory model in this research revealed 2 Nash equilibriums: combination of protection of forest resources with lack of corporation of the people and combination of saving rainfall with corporation of the people. Results of *Table 6* expressed that by selecting S_{1A} strategy by player 1, the best response of player 2 is S_{2B}. In case of selecting S_{2A} by player 1, player 2 selects S_{1B} strategy. When player 2 starts the game and selects S_{1B} strategy, player 1 apathetic in selecting S_{1A} or S_{2A} strategies and if he selects S_{2B} strategy, player 1 selects S_{1A} strategy. The equilibrium of this game was achieved in facing S_{1A} and S_{2B} strategies; that is, the combining protection of forest resources strategies and lack of corporation of the people. Equilibrium was also achieved in facing S_{2A} and S_{1B}; that is, the combination of saving rainfall strategies and corporation of the people. Given that the game had 2 Nash equilibriums, it became a combined strategy. The result of Equation 1 showed that P=0.71. This means that the executive management believed in selecting strategies for protection of forest resources with the possibility of 0.71 and believed in selecting strategies for rainfall saving with the possibility of 0.29. While saving rainfalls could play a greater role in the current conditions. The quantitative value was obtained from recourse protection reports in executive management. Results of Equation 2 showed that q=0.11; meaning the local community selected cooperation strategy with the possibility of 0.11 and selected the lack of cooperation with the possibility of 0.89. The cooperation of the local community

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with future projects was predicted to be very poor if there were no changes in Zagros forest policy making, while the lack of cooperation was predicted to have no positive point. But with the score of 4 in combination protection strategy in the opinions of experts (result of *Table 5*), the high value of this combination was mostly hidden in report parameter of output system by executive management.

This research showed the high importance of output report of forest's protection System. What is now followed by executive management of Zagros forests is a management based on result in protection section. In the Management By Result (MBR), the system indicator is the output of system. The opposite of MBR is Management By Objective (MBO). In MBO, achieving goals is the criteria of success; that is, the operational targets are effectiveness evaluation indicators of the system (Kangas et al., 2006; Zandebasiri and Parvin, 2012). The requirement of this management style is the principled definition of targets. Targeting in the forestry systems is required to be performed with the cooperation of the local people. Cooperation of the local people in targeting leads to the presence of social demands in forestry projects (Ghazanfari et al., 2004; Salam et al., 2006). Taking into account the social demands in targets of plan design leads to elimination of some of the technical demand of forest management, but the likelihood of achieving and reaching goals increases. What is defined in the policies of operational executive management is having checkpoints to control early livestock grazing (Ebrahimi Rostaghi, 2006). The principled purpose of control in forest management is designing information feedback process from the output of the forest system, comparison of projected forestry projects' targets and achieved targets and carrying out corrective processes (Davis et al., 2001). Control must be a means to modify the local community and not used as a punitive tool. If the control is a punitive tool, then it cannot be an effective control. The main measures required in Zagros forests for resolving labor shortages and reducing tension of executive management and local community is to design a control system where the group is controlled from inside. Controlling from inside means that people control themselves. This facilitates the work of executive management. In the design of control systems within the group, controlling opportunistic gazing is done by the local community and spontaneously. Control systems within group are also called self-control. Self-control makes people more willing to carry out their duties without the existence of an external controlling factor. Thus, strengthening existing social structures is the pre-condition of self-control. Performing this target will be available only through the development of organizational culture. The corporate culture means that organization's individuals wanting to perform duties assigned to them completely and correctly in terms of culture and value. In this way, an internal factor which is a part people's values and beliefs, control their performance. Researchers divide deterioration factors into 3 categories of predisposing factors, inciting factors, and stabilizing factors (Fan et al., 2012). Predisposing factors are age, size of species, decision-making for managing masses, vulnerabilities, and location of species. Inciting factors are environmental stresses such as drought stress along with pest and insects attack. Stabilizing factors are atmospheric CO_2 and greenhouse gases. The basis of policy makings in these forests has been providing sectional policies, disproportionate with forest conditions and incompatible with the local communities living in the forest (Ghazanfari et al., 2004). This matter has provided the background for pre-oriented factors in forest deterioration factors in arid and semi-arid regions of central Zagros. Decline in open systems is a general rule in nature. Based on the concept of entropy,

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each system tends toward disorder due to inside and outside forces. In other words, entropy forces cause the system to be distracted from its main system. The intensity of entropy in different systems is different depending on the situation. In this case, the system must stand against the natural law of entropy to survive and create order in its performance and must create negative entropy in order to stop entropy activities. Thus, tendency to order in open systems is a behavioral factor. In the Zagros forests system, set of bad decisions caused by the amount of irregularities in the system will increase. What is problematic in the forest nowadays is the lack of appropriate response of these ecosystems and low amount of negative entropy to decrease the entropy. Reduced negative entropy is due to loss of balance system. Two internal and external equilibriums are considered in open systems. The internal equilibrium is the coordination and bilateral interaction of the components with each other and external equilibrium is maintaining communication between the system and the external environment. The internal equilibrium of Zagros forests is demolished due to bilateral interaction of various components within the system (lack of consistency between the decision of the executive management and the local community, alternative management plans, and the lack of fodder required for livestock). External equilibrium of the system has also put the survival of these forests at risk due to various ecological climate, drought pressures, and drought stress. Result of this research in line with the research of Ebrahimi Rastaghi (2006) shows that validating the output of the system leads to retrograde motion of system more than validating the targets of the system. Eliminating this matter and guiding policy makings of executive management to management based on target can reduce quantitative value of strategy of resource protection in combination with lack of cooperation in local community. In this case, numbers p and q can be expected to extremely change in this game. Changes of p and q numbers in this game lead to consideration of rainfalls saving as a usable strategy and not as a decorative and symbolic strategy. In this case, Nash equilibrium of the game changes into a combined strategy. The ability to provide a combination of expressed strategies, form executive management will exist; strategies that basically complete each other. Rainfall saving is always considered in relation to protection of forest resources. After rainfall saving, issue of planting seeds and forest seedlings are considered as a complement which requires protection of systems and planted seedlings. This is contrary to what was obtained in this research. Based on the results of *Table 6*, there is no useful role for rainfall saving. Way out of this impasse is designing appropriate policies in Zagros forests for the balance of the rainfall saving and protection of forest resources in a way that it follows the local community cooperation.

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