Game Theory Approach to Decision Making Processes in International Forestry Policies

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Abstract

Game theory, especially in economics, is an analysis of multi-person decisions in which each player thinks what the others will do assuming that the players act rationally. It aims to determine the "what to play" situation. It has been the purpose of game theory since its beginnings in 1928 and has been applied to various situations in relation to economics, politics, and business and phenomenon such as war, etc. In the meantime, the relationship between forestry and game theory has been limited due to the shortage of resources in the international literature. The aim of this study is to introduce the game theory approach in the decision-making processes of the International Forestry Policy. The will in the hands of policymakers causes them to be under the influence of concerns encompassing both the national and international levels during the decision-making processes. It is assumed that other decision-makers have a limited view and do not respond to the assumption of common knowledge. In some cases, this situation results in questioning the impact of the decision. Lacking in terms of effectiveness, efficiency, feasibility, timing, and foresight in these decisions may afford decision-makers political satisfaction, but only temporary and one that would be considered as politically incorrect after decades. Thus, understanding the implications of alternative political/institutional designs requires a game-theoretic treatment rather than a decision-theoretic one. For these reasons, incorporating the concept of game theory into the decision-making processes on forestry policy, which aims to realize sustainable utilization, can make decisions more consistent.

Keywords: *Sustainability, Theory of Games, Policy Makers*

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I. INTRODUCTION

Game theory, which is founded in 1928, is a multi-person analysis of a decision problem, where each player thinks about what the others do [1]. This method, in which the movement of one of the players affects the movement and income of the other, is an inference situation that lists the best responses that the parties can give each other by increasing their own income.

The main purpose of the concept of game theory is to determine the "what to play" situation, assuming that the players behave rationally. In game theory, there is a problem to be solved, in which multiple players act independently or dependently from one another within certain strategies. A game is a set of rules in which players plan their strategies within these rules, that is, they plan the actions they will implement in each situation they encounter. They think and act rationally while making this plan. Rational behavior means that all players want to optimize their payoffs [2].

This concept has also been echoed in John Nash's Ph.D. thesis [3]. In 1950, John Nash said and proved that there is a balance in every game organized under certain conditions. It is assumed that this approach came as a discipline with Neumann and Morgenstern after 1944 and made great progress in the 1980s [4]. The concept has been used in many fields, including mathematics, economics, politics, and business [2]. Although forest management is related to biology, economics and other social sciences, the use of game theory in the field of forestry has been limited to very few publications in the world [3].

In the last 30 years, 178 million hectares of forest areas have been damaged and have gradually disappeared in the world [5]. Although this is a known issue to people, the world's forests are still rapidly disappearing. For this reason, various economic and political approaches are directly related to the sustainability of forests. The results of the changes made in forestry policies emerge years later [6]. Therefore, it is necessary to be careful to anticipate the consequences of policy changes made in the past and to make better predictions for the future [7]. The purpose of

this study is to introduce the game theory approach in decision-making processes of International Forestry Policy for greater inclusion.

II. MATERIALS AND METHODS

In this study, the aims and tools of forestry policy were used as material, and the decision-making processes of game theory were used as a method. Policy in forestry was utilized used to reach the aforementioned goal [8]. The game theory method was also used to answer a problem. In this method, three basic information are needed to define a game: sets of players, strategies, and payoffs. To determine and interpret these three information, qualitative and quantitative research methods should be applied together. While quantitative research involves collection of numerical data, the qualitative research interprets the obtained data with the use of words and meanings [9]. The game theory uses both quantitative and qualitative methods because it requires abstract data and other needed information, which in some cases need to be digitized.

III. RESULTS AND DISCUSSION

Forests have many functions. Erdönmez (2020) exemplifies these functions as the production of wood and non-wood forest products, socio-economic and cultural functions (tourism and recreation, supporting rural development, protecting cultural values, or so on), environmental-ecological functions (such as protecting biological diversity, water and soil). Turkey's national forest policy objectives are generally stated as conservation and development of forests, sustainable production of wood and non-wood forest products, maintaining environmental services by conserving biodiversity. The tools used in doing this include "Forest Ownership", "Regulatory Tools", "Organizational Tools", "Economic Tools", "Informational Tools", and "Certification". Forest ownership is important for determining the policy, regulatory tools for the legal basis regarding the interventions in the forest, organizational tools for the realization of regulation and planning activities, economic

tools for creating economic resources, information tools for the production-dissemination and using the information, certification for the classification of forests according to certain standards. In this study, the game theory can be integrated into each of these tools separately.
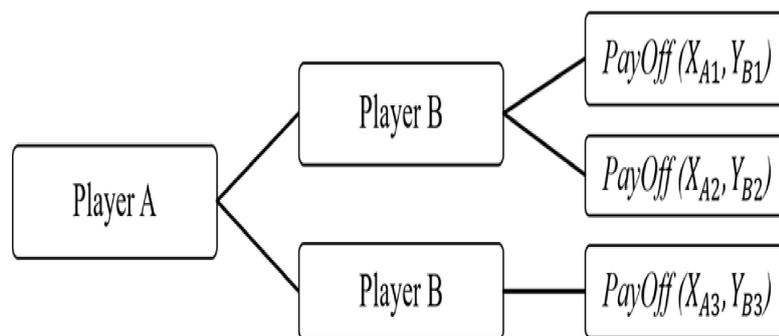

Figure 1. A Standard Form of a Game.

Game theory is examined under four headings as "Static" and "Dynamic" according to its time, "Complete Information" and "Incomplete Information" according to benefit structure [1]. In static games, the players make their decisions simultaneously, and the game is played once only. However, in dynamic games, players play orderly. In this way, second player makes his own move after seeing the first player's decision. Also, in dynamic games, the game does not have to be played once. Complete information models, regardless of the time, are games that players know each other's movement patterns and payoffs. Incomplete information models are games in which at least one of the players does not know either the payoffs or movement structure of the other player. All four types of games might be played in the decision-making processes of the International Forestry Policy. Kant and Kumar (2014), stated that "some of the most often-used classes of games are cooperative and non-cooperative games, strategic and extensive (sequential) games, perfect information and imperfect information games, symmetric and asymmetric games and zero-sum and non-zero-sum games". However, choosing a type depends on the players and the structure of the game. Therefore, this study examines some examples of a game theory.

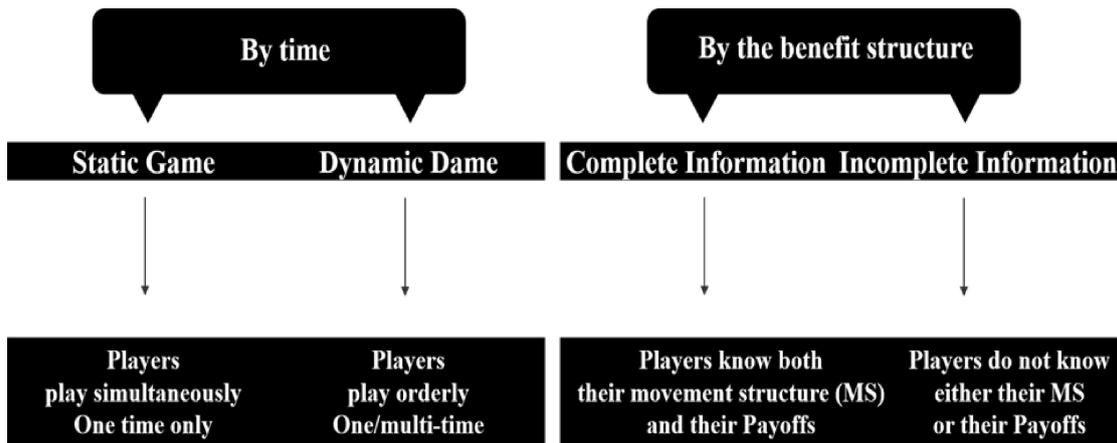| By time		By the benefit structure	
Static Game	Dynamic Dame	Complete Information	Incomplete Information
Players play simultaneously One time only	Players play orderly One/multi-time	Players know both their movement structure (MS) and their Payoffs	Players do not know either their MS or their Payoffs

Figure 2. Game Types [1]

One of the game types is the ultimatum bargaining game. This type has been suggested by Güth et al., in 1982 [10]. In the ultimatum bargaining game, there is someone who distributes the assets in hand, which is called authority. Other players may accept or reject this distribution [11]. In this way, the game will be completed. For the result, the players' strategies are effective. In this type of game, the strategic advantage lies in the playmaker, that is, in the distributor of the assets.

As example in forestry application, in a simple bargaining game, consider players A and B as assumed owner and user of the forest, respectively. If A has three units of assets and decides to distribute a portion of it to B how many units is reasonable to give? This can be illustrated by the game theory as follows:

Table 1. An Example of a Simple Ultimatum Bargaining Game.

		B								
		S_B1	S_B2	S_B3	S_B4	S_B5	S_B6	S_B7	S_B8	
A	S_A1	(2,1)	(2,1)	(2,1)	(2,1)	(0,0)	(0,0)	(0,0)	(0,0)	
	S_A2	(1,2)	(1,2)	(0,0)	(0,0)	(1,2)	(1,2)	(0,0)	(0,0)	
	S_A3	(0,3)	(0,0)	(0,3)	(0,0)	(0,3)	(0,0)	(0,3)	(0,0)	

In game theory, players are assumed to be rational. According to this table, if A gives 1 unit to B, A will have 2 units left; that is, (S_A1, S_B1) move brings (2,1) payoff. Similarly, if A gives 2, then A's payoff will be 1 and B's payoff will be 2; that is, (S_A2, S_B1)

move brings (2,1) payoff. Table 1 summarizes all stages and strategies of played games, showing that A is completely effective in the decision-making process (provided that B makes a rational decision). Considering that A also acts rationally, one of the $(S_{A}1, S_{B}1)$, $(S_{A}1, S_{B}2)$, $(S_{A}1, S_{B}3)$, $(S_{A}1, S_{B}4)$ will be the result of the game. Even if this game is not used for a clear profit/cost calculation decision making process in forestry, it can be used to implement more abstract concepts such as policy making.

Although the use of game theory examples on forestry is not common, some studies have been conducted for its use in policy and decision-making processes [12, 13, 14]. "One of the simplest and most popular bargaining models is the ultimatum game, in which a political decision-making is often fundamentally a bargaining problem, and that the essence of strategic decision-making between states, parties or leaders is largely about who gets what and when" [12]. Weymiller and Larimer (2019) state that "to accurately understand decision outcomes requires an interdisciplinary approach, and, indeed, the discipline of political science has increasingly incorporated insights from psychology, social psychology, sociology, behavioral economics, and other social and natural sciences". This game can be used in determining national and international forestry policies for the production of forest products raw materials in countries with mostly state-owned forests. For some authors, while the concept of authority is the right to decide, it means effective control over the decision for others [15]. This control mechanism is proportional to its power to contribute to the sustainability of forests. This suggests that this type of game can be used for almost all policy and decision making, especially "ownership", "regulatory" or "economic" tools for forestry policy.

Another game that may be played in forestry policy is zero-sum game, which is a strictly competitive game wherein the sum of all players' incomes is zero [16]. If this game is played by two players or groups, the players want to maximize their returns under rational behavior, as in all games. Here, when the payoffs *(u1,*

u2) of both players or groups *(A1, A2)* are added together, it becomes zero, which means that the benefit of one player is the loss of the other player. There are studies such as Skerry (2005), Michaels (2010), Davidai and Ongis (2019), in which zero-sum games are used in different political decision-making processes [17, 18, 19].

For example, it may be possible to apply zero-sum games to international forestry policy, with the assumption that one country's policy harms the other. This situation can be shaped by an assumption that decisions of countries affect each other. For example, if country A does not approve a law accepted by the international community, and therefore does not comply with its requirements, it will harm not only that country but also other countries. It can be theoretically exemplified as follows:

Table 2. Constants in Equation 1, for Fe_3O_4 and Fe_2O_3 MNPs.

		B	
		S_B1	S_B2
A	S_A1	(1,-1)	(-1,1)
	S_A2	(-1,1)	(1,-1)

Finally, the prisoner's dilemma game is one of the games that is frequently used in international politics with the examples of researchers such as Snyder (1971), Grieco (1988), Plous (1993), Kim (2011), Sterescu (2018) [20, 21, 22, 23, 24]. "By distinguishing between game payoffs and state utility, an Amended Prisoner's Dilemma model can depict both the relative-gains element of state preferences and the relative-gains problem for cooperation" [21]. "The results show that the model can robustly account for the learning of cooperation observed in the experiments when players are aware of the strategic nature of the game and make choices over immediate actions" [23]. Although these games are not widely used in forestry policy, there are some examples in similar sciences. For example, Sterescu (2018) applied the Prisoner's dilemma game in environmental policies in his study. Here,

Sterescu showed his thoughts on whether to reduce the carbon emissions of the two countries with the matrix, and stated that theoretically, both countries in the study would implement policies not to reduce emissions (Table 3).

Table 3. One-Shot Prisoner's Dilemma Pay-Off Matrix [24]

		B	
		Reduce Emissions	Do not Reduce Emissions
A	Reduce Emissions	(3,3)	(1,4)
	Do not Reduce Emissions	(4,1)	(2,2)

Game theory applications in industry, politics, and economy had already been investigated in USA, China, and Canada [3, 25,26, 27, 28, 29]. Other studies that combine the concepts of forestry and game theory are reported by Vach et al. (2021), Béal et al. (2021), Ebrahimi-Khusfi (2021) originated from France, Czechia and Iran, respectively [30, 31, 32]. In Turkey, the game theory has not been applied politics or economy in forestry, although there are already studies along this concept, such as Kavzoğlu and Teke (2022) [33].

The concept of game theory has some applications in economy and politics, and the application of these concepts to forestry seems possible by taking the concept of rationality as a basis. Kumar and Kant (2014) stated that since the early 1990s, game theoretical models have been used to explain some aspects of timber markets or forest economy. They stated that "these applications are reviewed and future directions of applications, such as applications to analyze nonmarket and multiple-stakeholder interactions, and inclusion of uncertainty, imperfect information, sequential game forms and evolutionary equilibrium concepts, are suggested" [3].

IV. CONCLUSION AND RECOMMENDATIONS

The relevance of game theory in forestry policies can be examined in two contexts, nationally and internationally. First, in national policy, countries can use this concept to predict whether their decisions are beneficial for the future. To facilitate the appli-

cation of this concept, results obtained from policy and decisions making should be digitized under certain rationalities and placed in the matrix with the appropriate game form.

In forestry practices, the results are seen decades later. Today, many calculations and formulas are applied specifically for forestry policies in order to predict the results. However, the fact that forests are still decreasing, requires the use of different theories for international forest policies in addition to these applications. One of the results of this study is that it would be beneficial to use the game theory approach in addition to the existing methods in national and international forest policies. Thus, changes and mistakes in existing forestry policies may be predicted. This situation depends on the determination of the right game, it is required to make more research and to practice on this subject.

Governments have important duties for forest management to move towards sustainability. Since governments represent the concept of authority, it is appropriate to apply one of the game theory approaches examined in this study, the ultimatum game, for forest policies. On the one hand, governments of countries with state forests may use this type of game for sustainable use of forests. On the other, countries with predominantly private forests may discuss and enact the use of game theory among sustainable management practices.

It is clear that the production and profit obtained from forests, also cause many damages to the earth such as global warming, erosion, and water and soil pollution, if the area is not reforested. For this reason, the application of zero-sum games to forestry, where the damage can be exemplified just like the seesaw technique, would be beneficial in terms of sustainability.

Among these games discussed, the prisoner's dilemma is undoubtedly the most famous. Using this type of game outside of countries such as the USA, China, and Canada will be beneficial both for the sustainable use of forest assets of countries and for securing the forests of future generations.

Predicting the loss of forests, which should be managed with factors such as efficiency, profitability, economy, and ration-

ality, is easier with applications of game theory that also deal with rationality. Besides, the contribution of countries to sustainable development at the local and international levels may be determined more effectively with this method.

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