http://silvaworld.org

SilvaWorld

e-ISSN: 2822-6127

https://prensip.gen.tr

RESEARCH ARTICLE

Contributions of Game Theory to Economic and Political Rationality in Forestry

Hüseyin Çalışkan[1*] • Sezgin Özden[2]

[1]Çankırı Karatekin University, Graduate School of Natural and Applied Sciences, Çankırı/Turkey
[2]Çankırı Karatekin University, Faculty of Forestry, Department of Forest Economics, Çankırı/Turkey

ARTICLE INFO

Article History
Received: 15.09.2022
Accepted: 22.09.2022
First Published: 23.09.2022

Keywords
Decision making
Forest management
Game theory
Rationality
Sustainability

ABSTRACT

Political and economic decision-making processes take into account the rationality criteria of forests such as productivity, profitability, and economy. While these criteria in developed countries in the sense of forestry have positive values, such values of developing countries are fluctuating. In Turkey, only wood-based and non-wood forest products of forests are included in national balance sheets. Therefore, it is thought that the real value of forests could not be calculated. However, calculating the actual values will change all balances. Thus, the discussions on the capacity of forests are moved to a more mathematical ground. The fact that the capacity of the forests is not enough to meet all the needs causes the forest assets to be endangered and therefore requires rationality in using. The concept of rationality is based on rules and obtaining reasonable results, and it has been used frequently in recent studies of game theory modeling initiatives. Effective use of this approach in forest policy and economics will contribute to the development of forests, villagers and the country's economy by obtaining more rational results, and will also be beneficial to eliminate some problems between decision makers and the public. In the last 20 years, the 10-fold increase in forestry-based game theory modeling researches in the world indicates that the game theory approach has begun to be included in decision-making processes aimed at achieving sustainable forestry. As a consequence, the game theory approach seems a new and effective tool that will contribute to the economically and politically rational management of forestry.

Please cite this paper as follows:

Çalışkan, H., & Özden, S. (2022). Contributions of game theory to economic and political rationality in forestry. *SilvaWorld*, *1*(1), 33-38. https://doi.org/10.29329/silva.2022.462.04

Introduction

Forests are communities that need to be managed in order to be transferred to future generations in an efficient and sustainable manner. Political and economic results of management are output of the implementation and management characteristics (Elkin, 1985). According to Akyol and Tolunay (2011), forest resources have been operated with an understanding of sustainability for many years, but since this understanding is understood as the sustainability of wood raw material production, the fact that the forest is a complex ecosystem has always been ignored (Akyol & Tolunay, 2014). However, Political and economic decision-making processes must take into account the rationality criteria of forests such as productivity, profitability, and economy (Alkan, 2009; Türker, 2016). While these criteria in developed countries in forestry have positive values, such values of developing countries are fluctuating.

The problem which forms the basis of this research is that the capacity of the forests is not enough to meet all the needs, and it causes the forest assets to be endangered, therefore requires rationality in using (Çalışkan & Özden, 2021). To explain the concept of rationality, it is defined by some authors as the behavior that brings the most satisfaction to the individual (Bulutay, 1982; Kanlıoğlu, 2019), while according

* Corresponding author
E-mail address: hcaliskanphd@gmail.com

to some authors it is defined as an effort to maximize interests (Doğan, 2012; Can Kamber, 2018). When these definitions are applied to the Sustainable Forest Management Criteria and Indicators (OGM, 2020), the rationality of other items will show negative values when it is aimed to maximize profit from only one item, for example, only wooden raw material production, without considering other criteria. For this reason, instead of seeing forests only as a source of raw material, they should be considered as ecosystems (Akyol & Tolunay, 2014) and the rationality of the entire ecosystem should be considered. This study examines the contribution of the game theory to rationality in order to contribute to the economically and politically efficient management of forests within the framework of the concept of rationality.

Materials and Methods

The concepts of rationality and Game Theory are the two concepts used as method in the basis of this study. Karabacak says that the concept of rationality has a multidimensional development process extending from Greek philosophy to today's modern philosophy and science world, and the concept of rationality has been defined in different disciplines such as economics, political science, sociology, psychology and biology, and has been the subject of some debates, theses, and books (Karabacak, 2017). Accordingly, the definition of rationality at the level of strategic games is similar to rationality used in economic terms. So, rationality means that each player wants to maximize his payoffs.

On the other hand, game theory is a multi-person analysis of a decision problem, founded in 1928, where each player thinks about what the others do (Gibbons, 1992). In game theory, strategies need to be determined after players have been identified. On the basis of game theory, strategy is the path that a player will follow in order to obtain optimum payoff. Players may choose fixed or mixed strategy. In this study, it is predicted that the players will determine a mixed strategy, that is, they will be able to benefit from more than one strategy to a certain extent. Gibbons (1992) defines mixed strategy as the probability distribution of players' strategies. Research shows that game theory and its strategies may be applied to almost every field. The use of this method on forest policy and economy has become widespread recently. This study was carried out by scanning past researches, documents, information and statistics on game theory, forest policy and economy.

Results and Discussion

Forests have many ecological and economic values besides meeting the need for wood raw materials. The concept of rationality discussed in this research is the use of the values attributed to the forest within the framework of rationality and thus its contribution to the sustainability of the forests. The general assumption in determining the value of natural resources is that every asset has a value and this value is not high to be measured (Türker, 2020). According to Türker, the economic values of forests are divided into two parts as active and passive values. Active values include direct and indirect uses, while passive values are specified as existence and inheritance values.

The benefit obtained by the active use of forests means the direct or indirect use of natural resources. The use of timber and firewood, which are wood-based forest products, falls within the definition of direct use in terms of forestry. Some researches in this area (Atmış, 2020; Kömürlü, 2020) show that the use without limiting or by stretching for all kinds of wood production has a negative effect on the dominant species number, species diversity and sustainability, and therefore on rational use.

The thought that the sustainability of forests may be endangered affects not only the direct use but also the indirect use of these assets. People indirectly benefit from the recreational properties of forests. In addition to all kinds of psychological and spiritual benefits, forests have many indirect benefits such as soil protection, prevention of air pollution, water purification and preserving biological diversity that are not noticed by non-experts. Indirect use features are the social services of forests (Akyol & Tolunay, 2011; Gümüş & Kaya, 2021). However, a large part of such benefits provided by forest ecosystems are seen as non-monetary benefits, which causes damage to forests which is caused by misuse of these resources. (Geray & Eker, 2006; Özüpekçe, 2021).

In addition to the active values of forests, there are also passive values such as existence and heritage (Türker, 2017). Türker characterizes these values as values that individuals acquire without expecting any benefit from them. Because future generations have the right to use forests as much as we do. Our decisions should not affect future generations, "because future generations do not vote" our decisions (Brundtland, 1987). For example, a study conducted in Turkey, determined the total economic value of Turkey's forests and it was concluded that 41.99% of these components are wood-based products (Türker et al., 2005).

National balance sheets include only the first two (50.02%) of the values given in Table 1, wood-based products and non-wood forest products (Türker, 2020). Therefore, it is thought that the real values of forest resources are not calculated. It is clear that the balances will change if these values are observed and considered.

The concept of game theory discusses the consequences of a problem. It enables the players to maximize their returns/benefits by predicting different results that may arise with some different perspectives and keeping the decisions made in a rational framework. Assuming that the percentage sum of the values in Table 1 is 1 (one), the integration of this situation into the zero-sum game can be exemplified.

Table 1. Total economic value and components of Turkey's forests (Türker, 2020)

Component	Type	Percent (%)
Direct Using Value	Wood Based Products	41.99
Direct Using Value	Non-wood Products	8.03
Direct Using Value	Grazing	21.00
Direct Using Value	Hunting	3.35
Direct Using Value	Recreation	0.18
Indirect Using Value	Carbon Sink	14.78
Optional Value	Medical Use	10.5
Existence Value	Conservation of Biodiversity	0.12
Total Percentage (%)		99.95

A zero-sum game is defined as a situation where one player wins and the other loses (Çubukçu, 2016). That is, one player's gain means the other's loss. We can define this situation to a balance of scales or a tug of war game. While there is a contrasting relationship between zero-sum games which is defined as perfect competition and the goals of environmental protection and economic growth, the production process incurs significant social costs (Orhan & Karahan, 2003; Karabacak & Akdeve, 2021). To put it more clearly, environmental resources are rapidly consumed by increasing the process of capitalist production based on natural resources, and the emission that occurs in the same process also destroys the environment or natural life as a whole. Therefore, if it is desired to reduce the social costs or the negative effects in the environment, it is necessary to impose restrictions on the production process. To turn this situation into a game, we set up a matrix by identifying two different players. Assuming that one of the players, *Player A*, intends to produce only wood and non-wood products with the full capitalist approach strategy, it can be assumed that the other player, *Player B*, adopts a more social approach.

During the determination of the game, the rules must be set first, because the concept of rationality is based on rules and obtaining reasonable results, and it has been used frequently in recent studies of game theory modeling initiatives (Held, 1977; Dekel & Gul, 1997). For this game, *Player A* is assumed to be the government. Because, for example, for Turkey, forests are almost entirely owned by the state in terms of ownership. Since the decision-making authority in this matter is entirely with the state, each action creates a net burden on the forests. The extent of this burden is determined by the laws enacted and the policies implemented. Also, in this study, Player B was considered to be the public. Because the public will be adversely affected in terms of recreation and weather in the absence of forests.

In countries where forests are managed by the state, the decision is made by the managers. Therefore, *Player A* mentioned in this game has a dominant role and he plays first. While determining the utilization strategies of the players for a certain forest area, let's assume that player A adopts the “Wood Based Products” and “Non-Wood Based Products” production strategies in Table 1 as the first strategy, S_{1A}. *Player B* wants to focus on more social benefits with his first strategy S_{1B}. This means that *Player B* will want to take advantage of the recreational, carbon sequestration and other benefits in that area. Of course, there are S_{2A} and S_{2B} strategies that express the opposite of the same situation. This is illustrated by the extensive-form game in Figure 1.

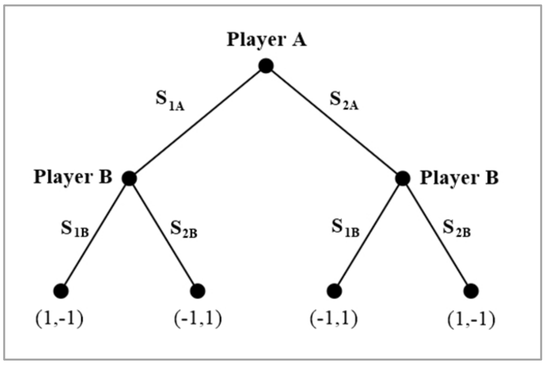

Figure 1. Extensive form of the game

The illustration in Figure 1 shows that each decision of *Player A* affects the behavior and strategy of *Player B*. When this situation is considered in terms of a country, it is clear that the decisions of the country, and the government affect the people. However, when we put these strategies and revenues in the game theory matrix to get a clear picture, a situation like Table 2 emerges.

Table 2. Zero-sum game matrix with a capitalist and social approach

		Player B	
		(S_{1B})	(S_{2B})
Player A	(S_{1A})	(1,-1)	(-1,1)
	(S_{2A})	(-1,1)	(1,-1)

Table 2 shows us that *Player A* focuses on the S_{1A} strategy, namely "Wood Based Product" and "Non-Wood Based Product" production, and *Player B* is negatively affected socially by this strategy. However, this cannot be a rational approach as it is not possible for the country and the government to completely abandon wood production from natural forests. Instead, the mixed strategy approach of game theory comes into play where each player does not pursue only one strategy, but partially adopts both strategies. In this case, each probability will be seen in Table 3.

Table 3. Mixed Strategy Zero-sum game matrix with a capitalist and social approach

		Player B	
		(S_{1B}) (n)	(S_{2B}) (1-n)
Player A	(S_{1A}) (p)	(1,-1)	(-1,1)
	(S_{2A}) (1-p)	(-1,1)	(1,-1)

Table 3 shows that *Player A* will play strategy S_{1A} with probability p, and strategy S_{2A} with probability $1\text{-}p$. Likewise, *Player B* plays S_{1B} with probability n, and plays S_{2B} with probability $1\text{-}n$. Here, the game theory approach aims to find a common balance so that both players may get the optimum payoffs. Here the players earn their income by using *Pure* and *Mixed Strategies* in Table 2 and Table 3. Since it is not possible for governments to completely abandon wooden production from natural forests, it is necessary to find out which strategy to adopt and how much, and the expected payoffs by using the mixed strategy. According to Table 3, Expected Payoffs of *Player A* and *Player B*, E_A and E_B, is calculated as follows.

$$E_A = [pn + p(1-n)(-1)] + [(1-p)n(-1) + (1-p)(1-n)] \quad (1)$$

$$E_B = [np(-1) + (1-n)p] + [n(1-p) + (1-n)(1-p)(-1)] \quad (2)$$

These equations are formulated considering the probability distribution whose sum is 1, since the game is zero-sum. Therefore, the sum of A's strategy distribution should be 1 which is calculated as $1 - p + p = 0$. The same is true for Player B, $1 - n + n = 0$. The expected payoffs of the players are calculated by multiplying the strategies they have determined with their probabilities.

In this case, while calculating the expected Payoff of one of the players, the strategy probabilities of the other are also considered. The fact that these strategies and probabilities are in the multiplier position indicates that the more benefit a player using *Mixed Strategy* expects from an area, the less the other player's expectation will be. For this reason, the application of *Mixed Strategy* games to political and economic decisions is useful to see which strategy or which policy is effective or harmful in reality.

Decision making is not easy for policy makers in uncertain situations and it is important for decision makers to make decisions based on scientific principles by using models (Kıral, 2015). As a result of this study, using and spreading of the game theory approach in forest policy and economics will enable decision makers to see the strategies they implement and their results more easily, by eliminating some uncertain situations. Thus, the future of our forests may be further guaranteed by adopting more rational and beneficial decisions and strategies. As a result, there will be a further interaction between the scientific and academic community and decision makers, and the future will be seen more clearly and mathematically, and conflicts will diminish. Thus, policy makers will rarely be criticized, and since the effectiveness of the decisions will be foreseen, the ground will be prepared for the research of more effective and scientific applications.

Game theory isn't just about zero-sum games. There are many types of games that require different strategies in the decision-making stages such as, bargaining or auction. Most of the academic research reviewed in this paper indicates that game theory is widely used in the non-forestry sciences. Adapting the game theory concept to forest policy and economics, as in almost every field, will increase the success of academic research, and will pave the way for the emergence of more well-known, effective and sought-after publications at the global level.

As game theory considers the strategies and choices of other players, it will be possible to restore the benefits that the public did not derive from the recreational use of forests. Therefore, the resulting win-win situation will lead to more rational returns. In cases where scarce resources such as forests are in question, transferring these assets to future generations means making their lives healthier. Therefore, the social benefits obtained today and in the future are also benefits for decision makers.

The effective use of game theory method in forestry, as in other branches of science, will help to find the most effective and reliable choice in solving complex problems that need to be social and objective in the real world. Thus, more rational decisions may be taken, free from political ideology.

Most research on forestry or sustainability (Akyol & Tolunay, 2011; Başkent, 2015; Hakverdi, 2020; Uygur Erdoğan, 2020) generally deals with the individuals who directly or indirectly benefit from forests. For example, forests have been among the most important resources for human beings throughout history (Hakverdi, 2020), and people have used the forest continuously for many of their needs, including firewood and shelter (Başkent, 2015). As a result of this pressure that has been going on throughout history, it has been seen that ecological problems are caused by the damage caused by humans to the ecosystem (Uygur Erdoğan, 2020). The game theory approach may contribute to the establishment of a more rational basis for academic studies with a sustainable development approach while creating development projects. Thus, it can be mathematically predicted where the players, namely the villagers or the people of the region, will reach at the end of that project. Decisions made with these predictions will contribute positively to the country's economy, the regional welfare and the income of individuals. In this way, an effective and realistic war may be waged against inflation either directly or indirectly.

In the last 20 years, the 10-fold increase in forestry-based game theory modeling researches in the world indicates that the game theory approach has begun to be included in decision-making processes aimed at achieving sustainable forestry. As a consequence, the game theory approach is a new and effective tool that will contribute to the economically and politically rational management of forestry.

Acknowledgment

This paper was presented and its abstract was published at 1st International Karatekin Science and Technology Conference held in 1-3 September 2022.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

Akyol, A., & Tolunay, A. (2011). *Sürdürülebilir orman yönetimi ve su kaynakları yönetim politikaları*. TMMOB Orman Mühendisleri Odası 2023'e Doğru 2. Doğa ve Ormancılık Sempozyumu. Antalya.

Akyol, A., & Tolunay, A. (2014). Modelling of sustainable forest management criteria and indicators for Turkey. *Turkish Journal of Forestry*, *15*(1), 21-32.

Alkan, H. (2009). A review on the confinement and privatization effort of state forest nursery enterprises. *Turkish Journal of Forestry*, *7*(1). 62-74

Atmış, E. (2020). Türkiye orman varlığıyla ilgili değişimler ve nedenleri. In K. Ok (Ed.), *Türkiye Ormancılar Derneği'nin 95. kuruluş yıldönümünde: Orman varlığımız ve ormancılık üretim faaliyetleri* (pp. 9-25). Türkiye Ormancılar Derneği.

Başkent, E. Z. (2015). Locomotive of forestry sector; Planning. *Anatolian Journal of Forest Research*, *1*(1-2), 1-7.

Brundtland, G. H. (1987). *Report of the World Commission on Environment and Development: Our common future*. Oxford University Press.

Bulutay, T. (1982). Rasyonalite ve belirsizlik üzerine. *Ankara Üniversitesi SBF dergisi, 37*(3), 25-60.

Can Kamber, S. (2018). Behavioral economics and rationality assumption: Literature review. *Journal of Economics and Management Research*, *7*(1), 168-199.

Çalışkan, H., & Özden, S. (2021). A forest policy evaluation of meeting the raw material demand in forest products industry from natural forests. *Anatolian Journal of Forest Research*, *7*(2), 152-160. https://doi.org/10.53516/ajfr.993908

Çubukçu, H. A. (2016). *Oyun teorisi ve bir uygulama* (Master's thesis, Akdeniz University).

Dekel, E., & Gul, F. (1997). Rationality and knowledge in game theory. *Econometric Society Monographs, 26*, 87-172.

Doğan, N. (2012). International relations and rationality: The contribution of bureaucratic politics to the field and the importance of the rationality assumption in predicting the future. *Dokuz Eylul University the Journal of Graduate School of Social Sciences*, *14*(3), 85-103.

Elkin, S. L. (1985). Economic & political rationality. *Polity*, *18*(2), 253-271. https://doi.org/10.2307/3234949

Geray, A. U., & Eker, Ö. (2006). *Ormanların su üretim işlevinin ekonomik analizi*. TMMOB Su Politikaları Kongresi. Ankara.

Gibbons, R. (1992). *Game theory for applied economists*. Princeton University Press. https://doi.org/10.2307/j.ctvcmxrzd

Gümüş, C., & Kaya, Z. (2021). Flora of Bartın urban forest. *Journal of Bartin Faculty of Forestry*, *23*(2), 668-695. https://doi.org/10.24011/barofd.913976

Hakverdi, A. E. (2020). Evaluation of sustainable forest management criteria and indicators in Turkey. *Turkish Journal of Forestry*, *21*(3), 332-343. https://doi.org/10.18182/tjf.691776

Held, V. (1977). Rationality and reasonable cooperation. *Social Research*, *44*(4), 708-744.

Kanlıoğlu, M. B. (2019). A new approach to economics: Behavioral economics. *Journal of International Banking, Economy and Management Studies*, *2*(1), 103-116.

Karabacak, H. (2017). *Strateji oyunları.* Optimist Yayın Grubu.

Karabacak, H., & Akdeve, E. (2021). Competitive intelligence and strategy formulation: An evaluation from the game theoretical perspective. *Dumlupınar University Journal of Social Sciences*, *68*, 326-345. https://doi.org/10.51290/dpusbe.873027

Kıral, Y. (2015). Decision in management and ethical decision making problematique. *Adnan Menderes University Journal of Educational Sciences*, *6*(2), 73-89.

Kömürlü, M. (2020). Orman amenajman planları, uygulamalar ve orman varlığımız. In K. Ok (Ed.), *Türkiye Ormancılar Derneği'nin 95. kuruluş yıldönümünde: Orman varlığımız ve ormancılık üretim faaliyetleri* (pp. 26-41). Türkiye Ormancılar Derneği.

OGM. (2020). *Sürdürülebilir orman yönetimi kriter ve göstergeleri Türkiye raporu 2019*. Retrieved Jul 12, 2022, from https://www.ogm.gov.tr/tr/e-kutuphane/kitaplik/surdurulebilir-orman-yonetimi

Orhan, G., & Karahan, Ö. (2003). *Çevre koruma ve ekonomik büyüme ilişkisinde sıfır toplamlı oyunun sonu mu?* ERC ODTÜ Uluslararası Ekonomi Kongresi VII. Ankara.

Özüpekçe, S. (2021). Drought analysis and relationship with water resources of western Mediterranean basins closed area. *International Journal of Geography and Geography Education (IGGE), 43*, 317-337. https://doi.org/10.32003/igge.790949

Türker, M. F., Pak, M., & Öztürk, A. (2005). Turkey. In M. Merlo & L. Croitoru (Eds.), *Valuing Mediterranean forests: Towards the total economic value* (pp. 195-211). Cabi Publishing. https://doi.org/10.1079/9780851999975.0195

Türker, M. F. (2016). Yeni Anayasa'da orman: Anayasa'da yer alması gereken ormancılıkla ilgili hükümler. In S. Özden (Ed.), *Yeni Anayasa'da yer alması gereken ormancılıkla ilgili muhtemel hükümlere dair gerekçeli görüşler* (pp. 97-102). TOD Yayınları.

Türker, M. F. (2017). *Girdi-çıktı çözümlemesi yardımıyla ülkemiz ormancılık sektörünün ülke ekonomisi içindeki yeri ve toplam ekonomik değer yaklaşımına göre muhtemel yerinin değerlendirilmesi*. IV. Ulusal Ormancılık Kongresi. Antalya.

Türker, M. F. (2020). *Ormancılık işletme ekonomisi*. Ormancılık ve Tabiatı Koruma Vakfı Yayınları.

Uygur Erdoğan, B. (2020). Evaluation of ecosystem services concept at watershed scale and its integration into planning. *Düzce University Faculty of Forestry Journal of Forestry, 16*(2), 196-216.