

# Climate Control, Kaziranga Poaching, Mega Dam, etc.: From the eyes of a Game Theorist

by Surajit Borkotokey - Monday, June 26, 2017

<http://gonitsora.com/climate-control-kaziranga-poaching-mega-dam-from-the-eyes-of-a-game-theorist/>

## Background

I will try to describe some tit-bits of Game Theory in the most non-mathematical way. Game Theory as the name suggests originated from various recreational games played by human beings since time immemorial. Later evolved as an umbrella term that described rational human behavior under conflicting situations, Game Theory now enjoys a much higher reputation from both academicians and practitioners of almost all the disciplines of Science and Humanities. Game theory is a study of strategic decision making. Formally, it is "*the study of mathematical models of conflict and cooperation between intelligent rational decision-makers*". Game theory has ample applications in the fields of economics, management, political science, psychology, logic and biology. It is also found to have sufficient scope to be applied in Quantum Physics. The subject was initiated with the famous zero-sum games, where one person's gains exactly equal net losses of the other participant(s). Today, however, game theory has gained popularity for effectively addressing logical issues of science, that includes both human and non-humans, like computers. The bottom line is that Game Theory provides a sense of balance in conflicting situations, where each person has found or developed a tactic that cannot successfully better his results, given the other approaches.

The games studied in game theory are well-defined mathematical objects. Thus, a game models situations where more than one rational agents, we call them players with selfish motives, make decisions so that their profits or losses arising out of such decisions effect each other. Think about a narrow neighborhood, where the only proud owner of a car can maneuver into any direction as there is none in the vicinity to obstruct him with another car. If a second person from the same neighborhood buys a car, the freedom of the first person is brought to limits as the pathways in the neighborhood can accommodate only one car at a time. A solution in this paradigm is to find an equilibrium so that each man can decide to drive his car without obstructions from the other. Even though the notion of Game Theory was formalized by *von Neumann* and *Oskar Morgenstern* in their 1944 book "*Theory of Games and Economic Behavior*" the idea is traced back in the Talmud, the holy book of Judaism written between 200 AD and 500 AD. The problem posed in this book was about a dying man who leaves an estate for the creditors but the value of the estate is not enough to repay the loans to the creditors. The problem is: how much the creditors should get? The solution of this problem given in the Talmud was later proved to be true by two renowned Game Theorists, R. J. Aumann and M. Maschler in their paper "*Game Theoretic Analysis of a Bankruptcy Problem from the Talmud*" ([Journal of Economic Theory 36 \(1985\), 195-213](#)). Game Theory however evolved as an important discipline of studies in the 50's of the last century after the seminal contributions of [John Nash](#) (June 13, 1928 - May 23, 2015) and [Lloyd Shapley](#) (June 2, 1923 - March 12, 2016). Interesting enough that the most two significant papers of these two stalwarts in two separate branches of Game Theory (Non-cooperative and Cooperative games) appeared in the same year i.e., in 1953.

In Game terminology, the participating agents are called players. Each player has a set of strategies out of

which she chooses the one that ideally gives her the best profit. Based on how players involve in a game, Game Theory is broadly divided into two branches: Non-cooperative and Cooperative Games. In either branch it is assumed that the players are selfish and choose the strategy which will give them the maximum profit. However, in non-cooperative games, they don't have any binding agreements among themselves and therefore can choose a strategy based on their own preferences. On the other hand, in cooperative games players make coalitions that is expected to benefit all of them over the individual plays. A solution in non-cooperative games is to find the equilibrium strategies for all the players which adopted simultaneously, will be no worse than any other strategies. In cooperative games, when the value is generated due to the synergic action of all the players together, a solution will rationally distribute this value among the players. [John Nash](#) was the pioneer of obtaining solution concepts in non-cooperative games: The Nash Equilibrium while Shapley developed the most popular solution concept of cooperative game theory: the Shapley value. With these at the background let us describe in the following some very interesting cooperative and non-cooperative games that describe complex human behavior.

## The Prisoners' Dilemma

Two individuals are arrested for allegedly committing a crime. The district attorney (DA) does not have enough evidence to convict them. The two suspects are put in two separate jail cells, and are told the following: if one confesses and another does not confess, then the confessed suspect will be rewarded with a light sentence of 1 year, while the prisoner who does not confess will be sentenced to 10 years; if both confess, then both will be sentenced to 5 years; if neither confesses, then the DA will still have enough evidence to convict them for a less serious crime, and sentence each of them to jail for 2 years. The game is mathematically depicted below:

|                |           |                |
|----------------|-----------|----------------|
|                | Confess   | Do not confess |
| Confess        | (-5, -5)  | (-10, -1)      |
| Do not Confess | (-1, -10) | (-2, -2)       |

Each player has two possible strategies: "*Do not Confess*" or "*Confess*". What strategy will each player choose?

[John Nash](#) tried to solve this problem with his famous Nash equilibrium solution concept as follows. A Nash equilibrium is such that no player finds incentive to deviate from her strategy prescribed by the Nash equilibrium. It seems that the best strategy for both the players is not to confess as this would award them less punishment. However Nash analyzed differently keeping the fact that anything one can control is her own strategy not other's. Therefore if keeping player 2's strategy to be "Confess", player 1 does not have an incentive to deviate from "Confess" to "Do not Confess" as then he will get more term. Similarly for player 2 we have the same logic. But keeping player 2's strategy of "Do not Confess" fixed, player 1 can always deviate from "Do not Confess" to "Confess" as then he will be punished with the least term. This is the case for the other player as well. Thus the "(Confess, Confess)" is the Nash equilibrium in this problem and has been verified experimentally as well. The Prisoners' dilemma has been applied to explain

many conflicting situations and also to obtain solutions to many unsolved problems dealing with international politics, Economics, Management, Adhoc networks, Biological networks, etc. to name a few. One of the very significant applications is the "Tragedy of Commons" which is explained in the following.

## **The Tragedy of Commons**

The idea and the name first occurred through an essay written in 1833 by the economist William Forster Lloyd, who used a hypothetical example of the effects of unregulated grazing on common land (then colloquially called "the commons") in the British Isles. In 1968, "*The Tragedy of the Commons*" was widely published through an article by famous ecologist Garrett Hardin. Hardin's idea was that when no one owns a resource, it is overused because no one can control its usage and each person has an incentive to use it before others do. This insight has helped us understand much human behavior and has led people to advocate either having the resource privately owned or having it controlled by government. This phenomenon can be analyzed through the lenses of Nash equilibrium of the Prisoners' dilemma. Recall that Nash says that people will adopt that strategy from which she does not have an incentive to deviate. In using the common pull of resource also, the best practice would be not to use it as that will keep the resource intake. This is similar to the (Do not Confess, Do not Confess) strategy in the Prisoners' dilemma. Equivalently we can term it as people cooperate. However the rational man finds no incentive to deviate from "use" to "do not use" the common resource when every other person has already used it. Therefore (use, use) (equivalently (Do not Confess, Do not Confess) or (Do not Cooperate, Do not Cooperate)) is a Nash equilibrium and every rational human being would adopt this strategy. So following Nash, Tragedy of Commons is a natural human behavior. However through the works of Elinor Ostrom, the Nobel Laureate of 2009 in Economics, it was found that there are still some discrete regions in the world where local properties are successfully managed by local commons without any regulation by central authorities or privatization, meaning: no tragedy of commons! Ostrom applied rational choice theory and development economics to explain such ecological preservation. Nash equilibrium fails to rationalize the actions in these societies. An immediate question one can ask: Is Nash wrong in analyzing the tragedy of commons in these communities? Or these communities who manage their resources without resorting to a tragedy: are they irrational?

The answer is no. Another Game Theorist Robert Aumann, recipient of 2012 Nobel prize in Economics explained this through cooperative game theoretic understanding. This behavior of the communities who defy the tragedy of commons can be explained by designing a new game where Nash equilibrium is shifted to cooperation. Thus it is the game that should be changed, not the Nash equilibrium. Nash equilibrium still stands high in its own place. The game that was defined to model the Tragedy of Commons earlier was based on common perception and could never be claimed to be universally true for all societies. Now in Ostrom's studies, the game pertaining to the communities that prove to weather the tragedy of commons has different rules, different payoffs so that people won't get incentives to deviate from cooperation. There are some recent studies in Adhoc communication networks where nodes do not want to cooperate to allow data packets to pass through them. Nevertheless, the problem can be solved by designing a new game with different set of payoffs where nodes do not find incentive for not cooperating. This area of studies falls under the broad discipline of Mechanism design.

## **The Issue of Cooperation**

When people collaborate we expect that their cooperation leads to better payoffs as a result of synergy over their individual involvements. This can be understood by looking at the coalitions formed by the different political parties who alone can never form a government, or the functioning of NATO or that of the European Union. Now, once the coalition is formed and some value/payoff/resource is generated as a result of this formation (viz., formation of a government), it is the time for designing a rational and stable mechanism to distribute this value/resource among the participating players, viz., distributing the ministerial berths to members of various parties in a coalitional government. There are basically two approaches not necessarily mutually exclusive found in the literature to tackle the situations: Designing a fair allocation rule that can be characterized using a set of rational axioms and/or a stable allocation rule that accounts for all players to be satisfied and ensures that no player has any incentive to leave a coalition: thus stability assured! The former solution was first proposed by Lloyd Shapley in 1953 which was later called as the Shapley value after his name. The later solution is called the core solution proposed by D. B. Gillies in 1959. The basic objective of a core solution is to ensure that the players be rewarded for not being isolated but for their cooperation. Thus one can immediately tie up the two concepts of cooperation and non-cooperation in defying the tragedy of commons and the shifting of the Nash equilibrium in the Prisoners' dilemma.

In the following, we try to explain few of the very recent phenomena in the light of the above discussions. Our intention is not to rationalize these activities but to show the games so designed to explain these phenomena are ill defined from a social perspective.

## **Applications**

### **Donald Trump Withdraws from the Paris Climate deal**

America's withdrawal from Paris climate deal has managed to gather top priority in the international media for the last couple of days. The Economic Times writes off the decision by the US president Donald Trump and considers it as a huge setback to multilateral efforts to slow down global warming. It further says that the decision is a disastrous abdication of America's responsibility at a time when collective international action is desperately needed to save the battered environment. Most of the media follows the same footsteps of Economic Times. From the societal point of view, the decision is dangerous: there is no doubt about this. The great physicist Stephen Hawking has already given up the livability of the earth within the next 30 years and suggested that man should search for an alternative settlement in the moon and Mars. However, the Game Theorist can easily justify the decision of Trump both from non-cooperative and cooperative view point. Let us look at the issue from a non-cooperative view point, where every nation is an individually rational and selfish player. Let us find out what America has to offer to the developing countries in return to the protection of its own environment in the future. Trump says that the compensations to be made by the US would help India and China for the next 10 to 20 years whereas these are the two countries from whom the US has faced the highest internal and external threats in terms of employment, volume of trades, friendship with strategic competitors (China with North Korea and India with Russia, etc.), etc. assuming that the world is an anarchy. This is a tussle between global and individual rationality. Therefore it is not hard to design a game where the Nash equilibrium stands for the US to decide a withdrawal from the Paris climate deal. However there are many other reasons and eventually the strategies arising out of those reasons that would make the game much more complex. Our intention is only to illustrate a part of the entire story. Looking at the issue from a cooperative framework, we can see that the allocation of resources: here it is the amount to be paid by

the developed nations to the under developed nations to stop their industrialization process is not a core solution according to Trump (I have serious doubts whether he can think this way or not; this is just as a matter of the rational beliefs). He feels that he can manage alone without cooperating with the other nations to mitigate climatic adverses if at all they exist! Thus he has an incentive to get detached from the coalition of the world body. The same rational can be posed for his stand against NATO as well.

Now the question is the following. What Trump has decided, is not it the Tragedy of Commons? What could be a solution so that the social rationality be overturned and Nash equilibrium be shifted from withdrawing to cooperating? We have to design the game in such a way that Trump or any US President has no incentive to deviate from cooperating with the world body. On a similar note under cooperative set up also the resource allocation be such that the US does not think of playing it of its own and rather go collectively. The common argument was that the fruit of industrial revolution has been enjoyed by the developed countries for more than three hundred years while the developing countries like China and India are new players. Therefore it is the duty for them to behave as big brothers. In my opinion, rather than asking them to show altruistic behavior the world body has to meticulously calculate the shares of each nation in contributing to the climate change and accordingly design who pays how much.

### **Kaziranga Poachers**

The Kaziranga World Heritage Site is world famous for its one horned rhinos. But the population of rhinos of late is under threat due to poaching. The belief is that the horn of a rhino possesses aphrodisiac qualities. The issue is still considered as a law and order problem. In some discrete incidences the poachers are eliminated by the forest guards. It is worth noting here that this issue can also be viewed through the eyes of the Tragedy of Commons. In the present context, the poachers have no other better option than poaching and therefore it is the Nash equilibrium and nobody wants to deviate from killing the animals. If we provide a better strategy for their livelihood as it is done in some cases where the hunters are assigned with the responsibility of protecting the forest in the line of what Ostrom suggested, better results would certainly come. So rather than considering it as a law and order problem, the human corner needs to be looked on and accordingly a suitable game should be designed with the desired solution concept.

### **The Mega Dam Issue**

The main concern of the mega dam issue is that Arunachal Pradesh has been constructing 400 odd dams of different volumes in its hills obstructing the rivers mostly flowing to the plains of Assam. Important enough that a large population lives on this downstream water in different capacity. While these dams are going to benefit Arunachal Pradesh and the other organizations in charge of production and distribution of the hydroelectric power in terms of resource sharing, the common people of Assam are apprehensive of the adverse effects of such constructions in places in the seismic zone of category 5 i.e., the zone of high risk of big earthquakes every now and then. So there is an eventual resistance from the neighboring people in the downstream of these rivers. It is a problem of resource sharing on account of the cooperative game so designed. The common people should be included as players in this game along with the other beneficiaries and given their due share of the resource. This could be the proper compensation, rehabilitation or alternatively reduce the benefits of the big players by switching to smaller dams, etc. Thus a cooperation among the players should be ensured in terms of the resource sharing that would further enable them for profits to all the parties. Important enough to observe here is that there is lesser

resistance from the people when it comes to building a bridge even though there arise issues related to rehabilitation, displacements, loss of livelihood etc. etc. This is perhaps due to the inclusion of those effected people in the group to whom resource is shared : the resource this time is the benefits of having a bridge which is a metaphor of improved communication, developed healthcare, spread of education, etc.

## **Concluding remarks**

The idea of Game Theory can be applied to explain any situation that involves conflicts of interests among the agents: be cooperative or non-cooperative. There is a plenty of variations of the solution concepts in both the branches of Game Theory which are problem specific and sometimes more relevant to the issues under consideration. However, considering the status enjoyed by the basic solution concepts viz., Nash equilibrium, the Shapley value and the Core solutions, we find them to be still relevant in explaining complex social, behavioral and political phenomena in a more rational manner.

---

PDF generated from <http://gonitsora.com/climate-control-kaziranga-poaching-mega-dam-from-the-eyes-of-a-game-theorist/>.

This work is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License.