

MANAGEMENT STRATEGIES FOR COUPLED COMMON-POOL RESOURCES – A GAME THEORETICAL PERSPECTIVE

How can we protect the common pool resources? This question becomes increasingly important as we observe intensification of harvesting pressure on many of them, such as ocean fisheries, forests, and water resources. Our approach towards the management of these resources may make a difference between the welfare on the global scale or extreme poverty.

Unfortunately, the problem of this kind is not easy to solve. The idea of the "tragedy of the commons" shows us that users, when competing, tend to overharvest the resource. These actions may lead to the complete depletion of the common good.

Another obstacle points to the resources themselves. Natural ecosystems are an intricate web of interconnected species that also interact with their environment. Therefore, the management of such resources is a complicated task. One cannot concentrate on one species or aspect of such a system but must take into account its complexity and dynamics.

This research project is going to address this problem using game theory. As the base, it will use the predator-prey model of the two interconnected populations. This type of representation is relatively simple but yields significant complexity. For example, a large population of prey can result in a surge in numbers of predators. On the other hand, the same interconnection can lead to the complete collapse of the ecosystem if there are too many predators. These types of systems, depending on starting conditions, can reach stable equilibrium, where populations do not change or express oscillating behavior where their numbers change periodically. Of course, other possible outcomes are the extinction of one or both species.

In this research project, this type of system will be expanded by adding resource users and conservation measures. These additions introduce further complexity to the problem. People involved in the dilemma not only interact with the coupled system but also can compete with each other. The possibility of complex interactions may lead to sophisticated harvesting and conservation strategies employed by users. Sensitivity analysis will show how changing parameters of the system, as well as the strategies available for the actors, may shape the cooperative and competitive solutions to the dilemma. It may answer the question of which situations and actions lead to the collapse of the ecosystem and which ensure the long-term sustainable use of the common good.

New algorithms will be developed and programmed for this research to find these solutions in complex systems. These methods will use a special representation of the evolution of the system in time and adapted Dijkstra algorithm to reduce the computational complexity of the problem. This approach will ensure finding solutions efficiently and within a reasonable time.

Even though the models used in this project are quite simple, their analysis can unveil critical mechanisms that affect the outcomes of the system. Despite being simplified representations of the real-life situations, they can bring to light complex, unconventional management strategies. Analysis of such actions is an excellent opportunity to reflect whether these types of behavior can be implemented in actual ecosystems.