Applications for water resource conflict

Doug Deweese & Stuart Gillies

Introduction

Game theory: A branch of applied mathematics that provides tools for analyzing situations in which parties, called players, make decisions that are interdependent. This interdependence causes each player to consider the other player’s possible decisions, or strategies, in formulating his own strategy. A solution to a game describes the optimal decisions of the players, who may have similar, opposed, or mixed interests, and the outcomes that may result from these decisions.

-Encyclopedia Britannica

Game Types

Numerous game types exist; below are four games suitable for water resource issues.

Prisoner’s Dilemma

Two prisoners are held in separate rooms and given an opportunity to make a deal. If both remain silent, then each get minimum sentences. If both confess, they both go to jail for a normal sentence. If either confesses while the other remains silent, then the one who confesses gets a reduced sentence, and the other remains in jail for the minimum. This is a model of aggression in which two contestants compete for a resource of value V by persisting while constantly accumulating costs over the time t.

Example: Groundwater pumping (Prisoner’s dilemma)

Two landowners must each choose how much groundwater to pump. If they both pump at a high rate, they will reduce the sustainability of the aquifer, but increase profits. If they both choose a lower rate, sustainability is increased, but profits decreased. If they do not cooperate, then one user maintains higher pumping and profits, with lower sustainability costs, while the other user maintains lower pumping and profits, with higher sustainability costs.

This game is useful for situations where the incentive for non-cooperation is higher than cooperation, even if cooperation benefits the system as a whole.

Example: Environmental flows (Stag hunt)

Two surface water rights holders must decide to release a portion of their water for environmental flows. If both rights holders release water, then the combined amount will be adequate for environmental flows, but that quantity of water if both decide to withhold water, then they eliminate flows, but can each use the water elsewhere. If they diversify, then one rights holder loses water which has an inadequate effect on flows, while the other rights holder can use the water elsewhere.

This is useful for analyzing cooperative situations with two equilibriums. The choice of equilibrium is based on trust between players.

Example: Rio Grande allocation (Chicken game)

Both Texas and Mexico are allocated water from the Rio Grande River as a result of international treaty. Each entity must also ensure release of water from tributaries into the Rio Grande. Mexico chose to build dams along the Rio Concho tributary, thereby reducing its contribution to the Rio Grande. Despite the treaty, the US was reluctant to enforce the treaty because that would cause an international dispute. Texas then lost water availability, because the US yielded. Both parties could yield and provide their legal amounts of water, but it was advantageous for Mexico to break the treaty, for short-term benefits.

This game is useful for describing situations where anti-coordination dominates. Sharing of the resource will create negative externalities (costs). This is opposite of coordination games which create positive externalities (benefits) through sharing.

Example: Urban vs. rural (War of attrition)

Projected growth in Texas shows greater population increases for urban regions compared to rural regions. Increasing populations translate to increased water demand for urban regions. Projections show municipal demand rising as agricultural demand declines. With greater demand and more wealth, urban regions must continually acquire new water supplies and have the financial resources to do so. This means that rural water rights holders may be unable to fend off attempts by municipalities to acquire water. (i.e. San Antonio expanding into surrounding counties, and DW exploring options in East Texas.)

References

• Water For Texas 2012 State Water Plan (2012)