

Can humankind escape the tragedy of the commons?

Selfish resource exploitation threatens societies and livelihoods. But there could be ways for nations and communities to circumvent narrow self-interest in favor of the common good.

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Consider a simple pasture, common land where anyone may let their cattle graze. Any rational, self-interested person wants to increase their livelihood. So each adds to their herd, one more animal at a time, until eventually the common land can't sustain any more cows. The pasture is overgrazed and all of the cattle die.

This bleak picture, sketched out in an 1833 pamphlet by the British mathematician William Forster Lloyd, remained an obscure snippet of social science until 1968, when ecologist Garrett Hardin picked it up.

In his profoundly influential paper, "The tragedy of the commons" (1), Hardin wrote, "Ruin is the destination toward which all men rush, each pursuing his own best interest in a society that believes in the freedom of the commons. Freedom in a commons brings ruin to all."

It has proved to be a powerful idea. To Hardin and others, the same grim logic was behind many of our biggest problems. Common resources, such as fisheries, forests, and even the air are threatened by selfish individuals and nations taking what they can, even



Many environmental calamities, from exhausted fisheries to climate change, are caused by nations and individuals using resources without heeding the long-term consequences. Image courtesy of Dave Cutler (artist).

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Unchecked use of resources eventually leads to a depletion that harms all parties. Image courtesy of Dave Cutler (artist).

though they know the resource will be wiped out if everyone does the same. Hardin's solution was to cede our freedoms to the state, to be bound by "mutual coercion mutually agreed upon" (1).

This brand of tragedy is particularly urgent today as our population and technology put more and more strain on limited nature.

On the global stage, the greatest tragedy of the commons is climate change. Despite knowing of this looming threat, countries have delayed taking real action for decades, quarreling over costs and responsibility, failing to build trust, all the while continuing to pour greenhouse gases into the atmosphere. Even in the wake of the Paris Agreement, the 2016 United States election has placed the status of a major player in doubt. Lacking any higher authority to rein in the selfishness of nations, are we doomed?

Maybe not. As later researchers pointed out, the picture is more complicated than Hardin (1) allowed. Although some resources are abused, others are often managed well without state intervention. Recent interdisciplinary work offers hope that the tragedy is not so inevitable after all. Instead, governments and institutions can design systems to help people control their selfish impulses, join collective schemes, and protect endangered resources. The global stage is more troublesome, but insights from game theory point to a possible way out of the climate change coma and other seemingly tragic situations: We just need to change the game that nations play.

Commons Misconception

Since Hardin's alarm call (1), a field has sprung up to study the tragedy, bringing together anthropologists, social scientists, economists, mathematicians, and engineers. People soon recognized that Hardin's hard-line perspective was limited. Historically, pastures and forests have often been well managed by local users. In fact, when states have stepped in to regulate these commons, they have often spoiled the system in place. "States may lack the information acquired by local users over thousands of years," says economist Partha Dasgupta at the University of Cambridge in the United Kingdom. "Sending round a bunch of bureaucrats to look at the problem was often not very useful."

The question was, what do these self-governance success stories share? At Indiana University in Bloomington, Elinor Ostrom brought many strands of research together (2). "She synthesized all this work in way that still inspires people today," says commons researcher Arun Agrawal at the University of Michigan in Ann Arbor.

Among many other things, Ostrom suggested that commons usually had some sort of regulation, unlike Hardin's depiction. She also helped to clarify what had been inconsistent and confusing terminology, for example defining the crucial term "common-pool resource": a resource that is both difficult to fence off and that is reduced by use. Common-pool resources may be tangible goods like fish stocks and timber, or more abstract things, such as antibiotic effectiveness. Over-use of antibiotics by individuals leads to populations having to deal with resistant strains of bacteria, which threatens to cripple modern medicine, not only allowing bacterial diseases to spread but making surgical operations unsafe.

By standardizing the terms and variables that researchers used, Ostrom and her colleagues could analyze whole sets of studies to look for patterns. For example, Shui Yan Tang, then at Indiana, examined case studies of 47 irrigation systems, some owned by farmers and some by governments (3). Tang measured the effectiveness of their water supply, levels of maintenance, and how well users followed the rules of the scheme. Among the government-owned systems, he found that 43% performed well. However, farmer-owned systems did better, 72% performing well, despite generally being low-tech constructions, in contrast with what Ostrom called the "fancy engineering" of the government systems (2).

After sifting through data on a range of commons problems, Ostrom identified a set of design principles for managing resources sustainably. For example, decisions must be made collectively, letting most users give their say. There should be graduated sanctions: so if you break the rules by taking too much water or grazing too many cows, you face mild censure at first, followed by increasingly stiff punishments for further offenses. One of the most vital design principles is that users should have a way to make their own rules.

In a recent study of forests, Agrawal's team backed up the need for local rulemaking, and also challenged a common assumption that human livelihoods must be at odds with biodiversity. His team looked at 84 forest sites in East Africa and South Asia, and found that where local users are involved in rulemaking, not

only are their subsistence livelihoods usually better, but forests also tend to be healthier in ecological terms, with more types of tree species.

Although these broad design principles seem solid, no one has been able to identify specific rules that will always lead to successful resource management. Ostrom concluded that there are no panaceas (3). A system that preserves fish off the coast of Jamaica may not be a good fit for forests in Burma. The world is complicated. Partly for this reason, she recommended “polycentric governance,” suggesting that layers of government and community oversight on different scales can deal with complexity better than one central authority. In 2009, Ostrom received the Nobel Prize in economics.

Grassroots Guidance

Many governments and other authorities remain convinced that private property rights or government-protected areas are the only ways to manage natural resources, but others have begun to take on board the idea of self-governance. “In the last couple of decades, partly because of Ostrom’s work, about 50 national governments have been decentralizing control of forests, water, rangelands, and fisheries,” says Agrawal (4).

Still, these schemes are not always well implemented. Many researchers have been trying to decipher what makes an effective self-governing group. Are large or small groups best, for example? A team based at Michigan State University in East Lansing looked at forest management in the Wolong Nature Reserve in Sichuan, China (5). Groups ranging from 1 to 16 households were given an area to monitor for illegal logging. Each group decided on its own strategies: for example, whether to take turns or to subdivide the area.

The team found that there was an optimum group size, around eight or nine households, which led to the best improvement in forest cover. The researchers suggest that in larger groups, there is more inclination toward free-riding, when households don’t bother to monitor the forest. In smaller groups, even though there’s less natural urge to free-ride, enforcement is less effective.

This kind of study is only the beginning. “We’re pretty sure that number is right for that time in that place,” says sociologist Thomas Dietz, who was a member of the Michigan State study. “If we had 50 or 75 studies like that around the world, then we could look at a distribution of results and say ‘wow, it’s the same everywhere’ or ‘hey, it varies, why does it vary?’” The problem, Dietz says, is a paucity of data.

At the core of such agreements is human psychology, and better understanding our motivations may help refine policies. What makes people treat common resources with care? Along with public policy professors Elizabeth Gerber at Michigan and Ashwini Chhatre at the Indian School Business in Hyderabad, Agrawal has examined this question using a sustainable development scheme in northern India supported by the World Bank (6). The researchers chose groups of villages where forests had been over-exploited by logging. The groups were given different kinds of incentives to manage their local forests in a more sustainable way. Some received collective material benefits, such as footpaths and water tanks. In

other cases, individual households received goods, such as livestock. Finally, there were incentives in the form of information about the program and its aims, with meetings and environmental education.

The best results were supplied by collective material incentives. Private material incentives had mixed results, some positive and some negative. Startlingly, information had a powerful negative effect: people exposed to meetings and education reported having less motivation to conserve the local forests than they had before. “I was surprised by that,” says Agrawal. This may be the result of resentment: knowing that some others were getting material gains while they had to sit through meetings. “At least this suggests we should look at the way information is delivered.” With a student in India, Agrawal now plans to test how training, meetings, and written information separately affect motivation.

So at a local scale, there are reasons to hope that we can escape the tragedy. Learning from existing

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—Scott Barrett

successes and refining our understanding of what makes people tick can be used to design more effective conservation programs.

At a global scale, the picture seems less rosy. “Global commons are unregulated even now,” says Dasgupta. States do not have the kinship and shared interests that can encourage a local community to manage their resources sustainably. They can’t benefit from the kind of face-to-face communication that boosts cooperation between human beings. And there is no government to impose rules from above. “The real problem is sovereignty,” says economist Scott Barrett at Columbia University in New York. International law has no teeth, so treaties are essentially voluntary. Even when countries decide to take part in collective conservation efforts, they can simply pull out again when they want to, as Canada did in 2011, withdrawing from the Kyoto Protocol on greenhouse gas emissions. The sovereignty of nations looks like Hardin’s fatal freedom.

Greenhouse Grazers

For the past three decades, countries have been trying to forge climate treaties based on voluntary national reductions in greenhouse gas emission. This works much like the classic cows-on-the-commons case that Lloyd described in 1833. The best outcome overall is if everyone cooperates, but each individual can do better for themselves by not joining in: let everyone else do the hard work of emissions reduction while I merrily pollute.

In game theory, this is akin to the prisoner’s dilemma: cooperation would be best overall, but you gain by betraying the other culprit (or resource competitor) no matter what they choose to do. This game has a single Nash equilibrium—a set of strategies named after mathematician and Nobel Laureate John Nash—that rational self-interested agents will adopt. Researchers have often modeled the tragedy of the commons using a generalized prisoners’ dilemma. Along

with environmental economist Astrid Dannenberg at the University of Kassel in Germany, Barrett has set up this kind of model for climate change treaties, using both computer simulations and laboratory experiments.

The lab rats in this case are German undergraduates. Acting as national negotiators at simulated climate talks, the students are rewarded with real money so that they really care about the outcome. Their payoff falls as they negotiate are emissions, reflecting the real economic cost of doing so. But it rises with the collective total of cuts, reflecting the economic gain of protecting the climate from catastrophic change.

Barrett's experiments show that when real people communicate, they often start out in a spirit of cooperation, and many will make contributions to cutting emissions. But some opt out. Cooperators see these free-riders as depriving them of economic advantage; those cooperators start to drop out until soon none remain.

Could this arrangement work better if we name and shame those who drop out, as the Paris Accord now promises to do via its pledge-and-review system? Dannenberg and Barrett have tested this idea with experiments too (7). It makes people promise more, but hardly alters their actual contributions. Tinkering with the game doesn't help.

But suppose we could play a completely different game instead? Other international treaties have worked well. The Montreal Protocol, for example, successfully got all countries to phase out ozone-destroying chlorofluorocarbons (CFCs), and the ozone hole is now starting to close instead of growing to become a global hazard. What did Montreal get right? The fact there was a viable CFC substitute certainly helped. But there was more to it, some argue.

Starting in 1989, Barrett has been studying this issue, examining not just Montreal but other successes, like the 1973 MARPOL marine pollution convention. These successes tend to have one thing in common: each imposes trade penalties on countries that do not join or comply. Using game theory to model this situation shows that it can turn into a different kind of game, called a coordination game, in which there are two Nash equilibria. In one equilibrium, nobody cooperates; in the other, everyone does. The critical thing here is that once enough nations are on board, it hurts to jump ship and leave the treaty: suddenly you have hardly any trading partners.

"It was only in the last year that I finally understood the general point," says Barrett. "Countries are good at coordinating and bad at cooperating voluntarily" (8).

Come Together

So how do we turn climate change negotiation into a coordination game? William Nordhaus at Yale has suggested using a "climate club," a group of countries that set a common carbon price and level trade tariffs on nonparticipants (9). Others have suggested using punishments for noncompliance in climate treaties, but the punishments often "penalize the penalizer," as Nordhaus puts it: "if Europe puts sanctions on Russian energy companies, this is likely to raise energy prices in Europe," he writes (9). Tariffs, on the other hand, can benefit those who levy them. Using a game-theory model, Nordhaus shows that most countries are likely to participate in such a club for carbon prices up to about \$50 per ton; any higher and they become more reluctant. The hope is that such a climate club could mimic the success of the Montreal Protocol.

"It's worth looking into, but I'm not sure it's the right way to go," says Barrett. He thinks that it could be scuppered if countries targeted by trade measures retaliate. Nordhaus also finds that when a lot needs to be done to address climate change, punitive tariffs don't work; the incentives to free-ride dominate.

Barrett suggests that instead of trying to build one treaty that will cut emissions overall, we break the problem into pieces, building coordination treaties around green technologies such as electric cars. "Another example is the manufacture of aluminum, where switching to an inert anode would reduce emissions dramatically," Barrett says. Countries might sign an agreement to use the inert anode and import aluminum only from other signatories. As countries join, the market for low-emissions aluminum grows, leading to a tipping point where it makes sense for everyone to join.

In October, we saw a real example of this kind of piecemeal climate treaty. At Kigali in Rwanda, 170 countries signed a deal to curb the use of hydrofluorocarbons, powerful greenhouse gases now used in refrigeration and other technologies. This deal is an amendment to the Montreal Protocol, so it should have the same coordinating power. It could skim about 0.5 degrees off global warming.

Set against this hopeful development in Kigali, one in Washington, DC threatens to undermine the efforts of researchers and negotiators. President-elect Donald Trump has expressed skepticism about human-caused climate change, and suggested he wants to pull out of Paris. "If he repudiates the Paris Agreement, other countries will respond by doing less to limit their emissions," says Barrett. "It is difficult to imagine the world coordinating when the most important country refuses even to play the game."

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