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SCIENTIFIC ADVANCEMENTS

The Tragedy of the Commons, and how to dodge it

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We were returning from a line-transect, again without any animal sighting, through the mid-day heat of April 2010 in a wildlife sanctuary in Madhya Pradesh. We came across a woman who had cut an entire Tendu tree (*Diospyros melanoxylon*) and was dragging it. Puzzled, we inquired about it, and she replied, *"I'll collect leaves of the tree to sell for making Bidis."* And why did she cut the whole tree instead of just collecting leaves from the tree? "*It is too hot out here, so I'll take this tree under shade in front of my house*", she replied and walked off, leaving us in complete disbelief. A senior in the group muttered, "*This is the Tragedy of the Commons-live in action.*" Coming just out of university after my Master's, this was the first time I understood the concept in its actual meaning.

In 1968, Garrett Hardin introduced a profound concept in a beautifully composed essay titled 'The Tragedy of the Commons' published in Science. He argued that if a resource is commonly shared by everyone, a commons, giving equal accessibility to all without regulations, it becomes vulnerable to overuse. Each rational user acts in their self-interest and seeks to maximise personal gain by extracting the resource as much as possible. However, since the cost of depletion is shared among all users while the benefit is individual, no single user is incentivised to restrain consumption. Over time, this leads to overexploitation, resource degradation, and eventual collapse. Hardin summed it up grimly, "Freedom in a commons brings ruin to all." He worked out a couple of examples to illustrate the concept, which I've summarised below.

Imagine a pasture open to all, where each herder naturally wants to raise as many animals as possible. The pastureland remains sustainable until disease, poaching, and conflict keep the numbers of herders and their livestock below the carrying capacity of the land. But once society stabilises, any further increase in the number of animals would deplete the grazing resources. Now, each herder, rationally seeking maximum personal gain, can calculate that adding one more animal yields full profit from its sale. But the negative consequences of overgrazing are shared among all, costing them only a fraction of the overall cost. If everyone follows this logic, they will keep adding more animals, repeatedly making the same rational decision in a shared system with no checks. The system will eventually degrade the pasture to a state of collapse.

The problem of pollution is another example. In an unregulated world, individuals and industries can freely discharge their waste into the shared environment. Hardin argued that "the rational man finds that his share of the cost of the wastes he discharges into the commons is less than the cost of purifying his wastes before releasing them." Each polluter benefits individually from avoiding cleanup costs, while the negative impacts, such as polluted air or water, are distributed among everyone. Since the costs are shared but the benefits are private, there is little incentive to reduce pollution voluntarily, leading to continued degradation of the environment. Hardin also argued that the problem of pollution is also a problem of population. As the number of polluters rises, it breaks down nature's ability to repair itself. A river cannot clean itself under extreme discharge of wastewater. Unchecked growth of the human population is another tragedy of the commons. When individuals act in their own reproductive self-interest, increasing the individual benefits of having more children while sharing the societal costs, they collectively overburden shared resources like land, water, and food. Each additional person represents a small individual gain but contributes to a cumulative environmental strain that affects everyone.

Hardin's framework opened new ways of thinking about and explaining the management of the commons. In creative interpretations, it has

been used to explain how parasites behave in a host body. Trying to maximise individual gains, parasites end up killing the host, leading to the collapse of the very system they depend on (Dionisio & Gordo 2006). Schuster *et al*. (2017) experimented with a microbial system, where 'cooperative' microbes produced an enzyme to externally digest nutrients, which can be used by everyone. But when 'cheater' microbes, focused only on their own growth without adding the enzyme to the system, were also present at the beginning of the system, both the microbes eventually died out. The tragedy here unfolded due to the breakdown of cooperation. Similarly, Rankin & Kokko (2006) documented cases of extreme sexual conflict, where males competing for mating resources, i.e. females, ended up harming and even killing the females. In an effort to increase individual short-term mating success, the collective survival of the species is undermined, again mirroring the tragedy of the commons.

Beyond evolutionary biology, Hardin's essay has had an extraordinary influence across disciplines, including health care, ecology, conservation and environmental management, philosophy, ethics, sociology, population studies, economics, governance, and global policymaking. For example, it influenced debates on managing digital and information commons, such as Wikipedia, Open Science, and data-sharing networks. When only a few contribute, but many consume and possibly distort, the quality of shared knowledge degrades. Hardin's argument was also used by many governments in population control policies to justify state interventions to limit individual rights for collective benefit. Climate Change is also framed as a collective commons problem where each nation benefits from emitting greenhouse gases, while environmental costs (rising temperature and extreme weather) are shared by all. This framing has inspired international efforts like the Kyoto Protocol and the Paris Agreement, though enforcement and compliance remain difficult.

Hardin proposed that the solution to the problem of the commons was either governments stepping in to control free choices for the individual by bringing in more rules and regulations, or converting common resources into privately owned enterprises so that costs aren't shared.

It was Elinor Ostrom who challenged Hardin's concept by pointing out the limitations of the model and providing empirical examples that common resources could be successfully managed by cooperating groups (Frischmann *et al*. 2019; Ostrom *et al*., 1999). Investigating the allegory of pasture management, Sneath (1998) found that community-managed pastures in Mongolia were much less degraded than privately owned pastures in China and government-regulated pastures in Russia. Similarly, the farmer-managed local irrigation systems in Nepal outperformed government-owned systems, weighing in for a third solution against Hardin's options of external regulation (state control) and private management. Ostrom's work showed that although the tragedies of the commons are real, the collapse is not an inevitable end for community-managed systems as predicted by Hardin (1998). This work won Ostrom a Nobel Prize in economics in 2009.

Hardin's model relied on players making decisions in isolation, who all act selfishly, are norm-free, and maximisers of short-term benefits. This may apply to small organisms or systems lacking effective information flow, but it is overly simplistic for complex systems. Societies, where individuals can communicate, monitor each other's actions, sanction one another, and collectively modify the rules, can evolve self-sustaining systems to manage the commons. And humans have developed and run such group governance models for centuries (Ostrom *et al*. 1999). For commons management to work out, "individuals must overcome their tendency to evaluate their own benefits and costs more intensely than the total benefits and costs for a group." A key ingredient for the evolution of these systems is to have a substantial portion of reciprocal cooperators in the population, which is easier to have when everyone knows everyone. Ethnic and local communities could attain this on a small scale, and modern technology can support the same on a global scale, where every player's actions towards the shared resource can be monitored. For instance, carbon emissions by countries are now tracked globally, enabling international scrutiny.

Crucially, successful commons management requires communities to have autonomy to self-organise without external influence. Ostrom *et al.* (1999) emphasised that "national governments can help or hinder local self-organization." When the rules are imposed by outsiders without consulting local participants who depend

on the resource, it often leads to public disengagement and resistance, changing the cooperative system to a 'cops and robbers' game. Let's take conservation of habitat as an example. An area might be declared a National Park with the government taking full control, or designated a community reserve, where local communities self-manage the habitat and its resources. When there are perceived threats of excessive exploitation to habitat and species by locals, policymakers may lean towards government control to avoid the tragedy of the commons. But can the governments be trusted to always act in the interest of the commons like nature? Across the world, both left-wing and right-wing regimes have histories of undermining nature conservation. The original dogma of Marxism and communism (left-wing) advocates for the transformation, control and subjugation of nature (Jefanovas & Davidavičius 2025), while right-wing policies across the world push for economic development at all costs to nature (do I need to specify examples in the current political landscapes?). In some cases, authoritarian governments have turned out to be more disastrous to conservation than even private exploitation. This raises some uncomfortable questions- where does environment and biodiversity conservation fit in the economic-political narrative? Who carries the onus for conserving nature? Community ownership may offer a more context-specific and resilient alternative in changing political response to conservation.

What we need to realise is that the world we live in is not all black and white, all competitive or all cooperative, all regulated or all free. We live in a world with a mosaic of all things, and there is a place and requirement for all the approaches. The best conservation outcomes may lie in the situation-specific application of all three models of commons management- externally or state-regulated, privately owned and community-managed. Quoting from Ostrom et al. (1999), "institutional diversity may be as important as biological diversity for our long-term survival."

I picked this topic for the current edition of the newsletter to, first, introduce young readers to this 50-year-old idea/concept that is now considered a classic; second, to emphasise that science is inherently integrative and one must keep learning beyond own niche subject; and third, to highlight that there is always more to the well-established theories. It is impossible to cover all aspects of a theory that has shaped human thoughts over half a century in a short article; therefore, explore further on your own.

And let this also be a reminder that science is not only about math formulas, graphs or complex analyses. At its core, science begins with sound logical models, at times described only using simple words.

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