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The Tragedies of Resource Overuse and Resource Underuse: Systemic Insights on the Tragedies of the Commons and Anti-commons

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ABSTRACT
This paper overviews a range of resource-related problems that have been given metaphorical identity as tragedies of the commons, and tragedies of anti-commons. Using the representational tools of qualitative systems dynamics used by Senge (2006) to describe and identify the common systemic structure for the tragedy of the commons, the paper similarly describes the systemic structure for the tragedy of the anti-commons. In doing so, it originates a conceptualization of the anti-commons tragedy as a systems archetype. The paper briefly outlines how the systems representation may help identify leverage points where intervention strategies as levers may best address the tragedies.

KEYWORDS: Tragedies of the commons, resource overuse, tragedies of the anti-commons, resource underuse, systemic structure, systems thinking, organ donation, native land.

INTRODUCTION
In a world of finite and scarce resources, issues of overuse, often unwitting overuse, can lead to unwanted and unanticipated consequences associated with the phenomena first labelled as the tragedy of the commons by Garrett Hardin (1968, 1998), catalogued by Elinor Ostrom (1999a) and her colleagues (1999b), and later conceptualised as the tragedy of the commons systems archetype by Peter Senge (1990, 1999). Whilst such phenomena have often been associated with environmental and ecological sustainability, they have been increasingly recognized as existing in the social, scientific, technological and economic domains as familiarity with Hardin’s and Senge’s conceptualisations has grown. As a consequence, it has also been possible to identify how to address such problems with a variety of interventions spanning regulation, privatisation, co-operation, collaboration etc.

In a world of scarce resources, issues of underuse are of similar concern. However, the erstwhile lack of recognition of any common systemic structure underlying such underuse situations, allied with lack of conceptualisation has meant that not only do many such problems remain undetected, but also unaddressed. The work of Michael Heller (2010, 2011, 2013) in labelling, detailing and cataloguing such underuse problems as tragedies of the anti-commons, how they arise, how they relate to different forms of ownership structures, and how they may be addressed, has catalysed the recognition of further problems in a variety of domains relating to land use and land rights - indigenous people’s land use, in particular; telecommunications; transportation; science, medicine and the pharmaceutical industry; and matters as particular as property and patent rights, organ donation, creativity in the arts etc. Indeed, Heller’s original labelling, description and conceptualization of situations as tragedies of the anti-commons has engendered greater awareness, attention and recognition of such matters and their relationship to different forms of ownership.
The paper first outlines examples of resource overuse situations as tragedies of commons, and portrays systems representations using the causal loop diagrams (CLDs) of qualitative systems dynamics. The paper continues with CLD representations of some resource underuse situations considered as typical of tragedies of the anti-commons, and seeks to demonstrate the mirror-like systemic symmetry of overuse and underuse tragedies.

RESOURCE OVERUSE AND UNDERUSE TRAGEDIES

In this paper, the notion of resource is not restricted to tangible materials which may be finite in nature, but may include the intangible and seemingly inexhaustible. As such, what may be considered as resource overuse is not restricted to the depletion or exhaustion of resource, or just being ‘too much’. Instead, overuse is better conceptualized as non-optimal use in pursuit of specific objectives. Similarly, resource underuse is better conceptualized as non-optimal use rather than wasteful non-use of available resources. In both tragedy situations, resources are considered as entities accessible to all, no matter, for example, whether those resources are as seemingly different as carbon stocks or eco-authenticity.

Tragedies of the Commons

The tragedy of the commons is sometimes characterised as individual instrumentalism in the short term undermining individual and collective benefits in the long term. In general, it relates to over-use, and possible eventual depletion of a common resource. Typical examples include the over-grazing of common land; the over-fishing of fishing stocks which may lead to population collapse or extinction; use of motorway systems which lead to gridlock or traffic holdups; over-prescription of antibiotics, which can lead to the evolution of drug-resistant strains of bacteria; or surfing the internet, where overuse may lead to slow download speeds or systems failure.

Hardin (1968, 1998) and Heller (2010, 2011, 2013) have suggested that the cause of such tragedies relate to instrumentalism, and the existence of rights of access and use of resources without the property rights of ownership which may lead to individual or collective responsibility for stewardship of the resources. Whilst Heller offers a view that private property/ownership rights may induce individuals to take a long term view, Ostrom (1999a) disavows the notion that individualism, instrumentalism and the absence of property rights are the root cause of such tragedies, and suggests that changing the ‘rules’ of governance and engagement in such tragedies may offer a better solution than addressing instrumentalism through property rights and incentives. For its stated purpose on this occasion, this paper follows the path of Heller in setting out the following cases as a basis for discussion.

The Roads for People Case

Most people like the convenience of using their own transport. However, whilst any individual’s use of the road system may hardly to overload it, the incremental use of roads simultaneously by multiple others leads to congestion, delays and inconvenience. In essence, congestion happens because the resource of effective road capacity diminishes with each extra road user. In this section, we provide an illustration of how relationships embedded in the Roads for People case may be framed using a Causal Loop Diagram (CLD) to provide a macro or ‘helicopter’ view of the situation. In doing so, the case situation has been stylized to allow for its illustrative depiction as a CLD, and to offer an illustrative narration of the relationships within the system as represented; of individual behaviors within the system; and of systems behaviors that are both impacted by, and impact individual behavior. The stylized depiction/representation also involves just two individuals, and how their
interaction/interdependence impacts on systems behavior and systems outcomes. However, we suggest that such a representation of the system, and our interpretation of systems behavior, has scalability to situations with many participants. Usually, a CLD is developed by a process of surfacing variables as contributory causes or consequential effects of existing entities, and then by building on and extending links in iterative fashion until a sense of systemic wholeness and understanding is achieved. The CLD shown in Figure 1, and developed in this manner, displays a loop R1 which can be narrated and interpreted as follows:

“an improvement in travel convenience experienced by individual A can lead to further demands or expectations of convenience by A, thus increasing pressures for additional vehicles within the family of A, which in turn will boost the travel convenience experienced by individual A - as the loop closes.”

We note how an initial improvement in travel experience will lead to a further boost in travel experience as we complete the cycle through the loop – a phenomenon that we describe as associated with a reinforcing loop – R1 being labelled a virtuous reinforcing loop. By contrast, loop B1 displays the characteristics of what is termed a balancing loop, narrated as follows:

“an improvement in travel convenience experienced by individual A can lead to further demands or expectations of convenience by A, thus increasing pressures for additional vehicles within the family of A, which in turn will increase the number of cars on city roads, creating further traffic problems, lowering the travel convenience experienced by individual A - as the loop closes.”

As such, an initial improvement in travel convenience will lead to lowering the travel convenience, as we complete the cycle through the balancing loops B1 and B2. Of course, these loops and their associated behaviors play out over time to reflect the dynamic time-based nature of an evolving situation. Initially, we would observe loops R1 representing individual behaviors as dominating within the system. However, over time, as the aggregate effects of individual behaviors accumulate, the balancing loops B1 and 2 would take dominance – reflecting the overuse and saturation of the roading system that causes congestion gridlock!

Figure 1: Tragedy of the Commons – Roads for People? Overuse of the Roading System?
We note that the CLD convention requires entities to be described in neutral mode, where possible. The +S and –O annotations then allow relationships to be described in the context of starting or changing conditions. The +S annotation indicates that the more we do the action X at the tail of the arrow, the more the effect Y at the head of the arrow. By contrast, the –O annotation indicates the more action X, the less the effect Y.

As such, the CLD draws our attention to the nature of the various reinforcing and balancing loops; how the loops may interact; how the dominance of loops changes over time; how systems behaviors are impacted by individual behaviors and vice versa; and also suggesting which points in the system – leverage points – could best be subject to intervention that seeks improvement and address any adverse systems outcomes that are predicted.

Just as we may build an understanding of how some initial individual behavior can drive systems behavior, we also note possible intervention or leverage points where we may attempt to drive more desirable systems behavior. Here, we illustrate two different leverage points – one, intervening to reduce the number of cars in the city and two, to reduce traffic problems by increasing the capacity of roading infrastructure. The leverage for reducing the number of cars in the city is shown in Figure 1 to be achieved through the lever of lifting parking fees and providing Park n Ride schemes, and in this way, to reverse the impact of the balancing loops B1 and B2 – ie reducing traffic problems, thus increasing travel convenience. It is suggested that not only are such points of intervention or leverage more readily observed with the CLD system representation, but the impact of leverage may be more readily assessed in a systems context.

A second case also relates to a form of congestion, but in a very different setting.

The Eco-Tourism Case

It has been reported (Parry, 2010) that Mt Fuji, typical of environments that provide the ultimate experience of eco-authenticity, is being overwhelmed by individuals who seek to the experience a bucket-list mountaineering challenge. A decade ago, 200k people a year made the attempt. In 2008m there were 430k climbers. Part of the reason is an improvement in facilities, including mountain lodges and toilets. There are 17 toilets on the Yoshidaguchi path, for upto 12k climbers per day, but only one is on the way down! Cleaning the environmentally toilets, using micro-organisms to speed up decomposition, costs NZ$166k pa.

The consequence is “a tsunami of rubbish and human ordure” generated by the number of recreational tourists. The climbers who tackle the 3,660m volcano are frequently reduced to a shuffling column, with a shortage of toilets along the route generating hour long queues. Lovers of Mt Fuji have been known to complain that the hundreds of thousands of visitors are ruining the atmosphere of the mountain which is sacred to the Shinto religion. The tranquillity and solitude that many were seeking to experience have been badly affected!

Whilst this situation may be immediately recognized as redolent of a tragedy of the commons, we set out below the CLD representation of the problem (Figure 2); and seek to provide a relevant narrative to accompany the CLD that aids the development of insight of how individual and systems behaviors may interact and behave over time.

Figure 2 displays for loop R1 how:

“a lift in the benefits experienced by Tourist A can enhance value placed on eco-tourism derived by Tourist A, increasing Tourist A’s tourism activity, which in turn will further raise the benefits experienced by Tourist A - as the loop closes.”
We note how an initial lift in the eco-tourism experience can lead to a further raise in eco-tourism benefits as we complete the cycle through the loop – a phenomenon we describe as associated with a reinforcing loop – R1 being a virtuous reinforcing loop. As before, and by contrast, loop B1 displays the characteristics of what is termed a balancing loop, illustrated as follows:

a lift in the benefits experienced by Tourist A can enhance value placed on eco-tourism derived by Tourist A, increasing Tourist A’s tourism activity, which in turn will increase the number of visitors to the eco-tourism venue, adversely impacting the essence of the eco-tourism site, growing negative effects on solitude, tranquility, authenticity and uniqueness, and lowering the benefits experienced by Tourist A - as the loop closes.

Figure 2: Tragedy of the Commons – Eco-Tourism - Overuse of the Environment

As such, an initial lift in the benefits experienced by Tourist A will lead to a decline in those benefits experienced by individual tourist A, as we complete the cycle through the balancing loops B1 (and then B2). As in the Roading System case, we would observe loops R1 representing individual behaviors as initially dominating the system behavior. However, over time, again, as the aggregate effects of individual behaviors accumulate, loops B1 and B2 would take dominance – reflecting the overuse of the eco-tourism system that harms the essence of the eco-venue!

Once again, the CLD draws our attention to the nature of the loops and how they interact; how systems behaviors mutually impact individual behaviors with shifting dominance over time; and also suggests potential leverage points which could best be subject to intervention to seek desired change.

Here, we illustrate two different sets of leverage points and levers – one, where intervention seeks to reduce the number of eco-tourism visitors by increasing the econ-tourism venue taxes and usage fees, and two, protecting the essence of the eco-tourism venue by enhancing the resilience of the eco-tourism site to human visitors – see Figure 2, and as such, to reverse the impact of the balancing loops B1and B2 – ie reducing the number of eco-tourism visitors and further protecting the essence of eco-tourism. We again state that not only are the points of
leverage more readily observed with the CLD, but the impact of leverage may be more readily assessed in this systems context.

**Tragedies of the Anti-commons**

Since Heller (1998) first defined the metaphorical term *anti-commons* (Heller, 1998), it has been suggested that more than a thousand examples have been documented in different settings such as drug patenting, telecom licensing, climate change, compulsory land purchase, oil field unitisation, music and art copyright, housing, car sharing, accommodation sharing etc. In the simplest of terms, the tragedy of the anti-commons relates to the wasteful or non-optimal under-use of a common resource. According to Heller (2010), it refers to any setting in which individual inability to act or engage in a process, undermines individual and collective benefits in the long term. It also refers to any setting in which too many people (or laws or regulations) can block each other from creating or using what may be a scarce resource. Heller (2013) has asserted that, conceptually, ‘underuse in an anti-commons mirrors the … problem of overuse in a tragedy of the commons.’ However, he does not clarify the nature of that mirroring. Using the cases set out below, we seek to do so by first revealing the systemic structure of the anti-commons scenarios, and then by making evident the mirror-like systemic structure of the systems archetypes that characterise each tragedy.

**The Organ Donation Case**

We first examine the case of Organ Donation, and why, when the deceased may have favored donation, a relative may delay, obstruct or prevent the donation process which would have led to the avoidance of death of others from organ failure. This worldwide phenomenon has not only been documented by medical authorities such as the British Medical Association (BMA 2014), but also subject to commentary and advice about appropriate remedies by Thaler and Sunstein (2009) referring to similar situations in the US. A recent briefing for the Scottish Parliament by the BMA has indicated that whilst “70 to 90% of the population are willing to donate their organs after death …”, however, “… less than half of Scotland’s population is registered on the NHS Organ Donor Register.” In addition, and adversely impacting the availability of organs for donation, it has been reported that in such circumstances, the de jure rights of relatives together with uncertainty about the deceased’s wishes often results in relatives refusing donation (NIHCE, 2011).

Here, using the same representational protocols of Figures 1 and 2, we again represent the situation with just two individuals exercising rights independently, whilst advising of the scalability of the represented situation to many individuals.

The mirror-like systemic symmetry of Figures 1, 2 and 3 is evident. However, the essential difference in distinguishing the commons tragedy from the anti-commons tragedy is that for the latter, the causal loops (R1, R1a) reflecting behaviors relating to Individual A are both reinforcing loops. The importance is captured in the following narrative, which is first provided for the virtuous cycle (R1) where awareness of *awareness of the benefits of organ transplant surgery* begins to grow or is growing.

“As awareness of the benefits of organ transplant surgery grows, de facto support for the rights of surviving relatives of the deceased diminishes, undermining relative A’s ability to block organ donation, thus increasing the likelihood of Individual A’s organ donation being realized, and building further awareness of the benefits of organ transplant surgery as we close the R1 as a virtuous reinforcing loop.”

We suggest that as the R1 loop is replicated for other individuals, the dominance of systems behavior begins to be reflected more by the reinforcing loop R1a, narrated as follows:

“As awareness of the benefits of organ transplant surgery grows, de facto support for the rights of surviving relatives of the deceased diminishes, undermining
relative A’s ability to block organ donation, thus increasing the likelihood of Individual A’s organ donation being realized, and adding to the common pool of organs available for donation, allowing more transplant surgery interventions, boosting the number of patients benefitting from organ transplant surgery, and creating further awareness of the benefits of organ transplant surgery as we close the R1, again, as a virtuous reinforcing loop.”

Figure 3: Tragedy of the Anti-Commons - Under-use/Wasteful Use of Potential Organ Donation

By contrast, we now demonstrate the negative outcomes that can arise or be associated with the reinforcing loops (R1, R1a) becoming vicious cycles of systems behavior. We restrict our narrative to the R1 loop for brevity.

“As awareness of the benefits of organ transplant surgery diminishes, de facto support for the rights of surviving relatives of the deceased may increase, strengthening relative A’s ability to block organ donation, thus reducing the likelihood of Individual A’s organ donation being realized, and further diminishing awareness of the benefits of organ transplant surgery as we close the R1 as a vicious reinforcing loop.”

As before, the CLD draws our attention to the nature of the loops; how they interact; how the mutual impact of individual and systems behaviors evolve over time; and also the potential leverage points for intervention and improvement.

In this case, we note two essentially different leverage points – one, intervening to boost the awareness of the benefits of organ transplant surgery and to drive the reinforcing loop as a virtuous cycle; and two, intervening through legislation to reduce the legal rights of surviving relatives. Whilst these interventions may have surfaced under different circumstances, they are readily identifiable as potential levers given the systems representation.

Of course, such interventions have been advocated by medical authorities, as is evident in the work of the BMA mentioned above and others (NHSBT, 2012). Nevertheless, whilst such advocacy is supported in these cases by empirical results, the systems representation using the CLD provides a systemic and underpinning rationale for such advocacy. Indeed, whilst knowing that in aggregate, “family support for organ donation more than doubles” when people know about their relative’s wishes is important, understanding how and why systems behaviour
arises from the systemic interaction of individual choices and factors affecting individual behaviour is critical.

The Native Land Case

Our second example of anti-commons relates to the relative under-use and consequences of under-use of a very different common resource - land – specifically American Native Land as described by Heller (2010). In 1920, 1m Afro-American families owned farms, but by 2010, fewer than 20k owned farms. He suggests that reasons for this decline may be attributed to a number of factors. Here, we shall take his focus on inheritance law and its impact on how the ownership shares of land being passed to successive multiple heirs/family members multiplied in number (even reaching into the thousands of shares) - but diminished in size as generations passed. Whilst the law, in theory - allowed family members to aggregate shares, courts often refused to partition land into identifiable areas with boundaries. In many cases, courts required the land to be auctioned, but all auction sales had to be settled in cash, which was not a possibility for most Afro-American families. The consequence came to be known as Partition Sales, with much land passing into the ownership of wealthy business people.

Figure 4 affirms the prior supposition of mirror-like systemic symmetry of Figures 1, 2 representing tragedies of the commons and Figures 3, 4 representing tragedies of the anti-commons. Once again, the essential difference is that for the anti-commons tragedy, the causal loops (R1, R1a) reflecting systems relationships involving Individual A within an extended family grouping are both reinforcing loops. We use the following narrative to first illustrate the virtuous cycle (R1) where increases in development opportunities for land in ownership by Individual A begins to emerge.

“As development opportunities for land in ownership by Individual A increase, the value of land in ownership increases, boosting Individual A’s ability to aggregate ownership shares into parcels of land rather than maintain shared ownership/title. Then, as the area of Individual A’s land in shared ownership switches into larger aggregated parcels, development opportunities for land in ownership by Individual A is boosted.”

We suggest that as the R1 loop is replicated for other individuals within the extended family grouping, once again, the dominance of systems behavior begins to be reflected more by the reinforcing loop R1a, as follows:

“As development opportunities for land in ownership by Individual A increase, the value of land in ownership increases, boosting Individual A’s ability to aggregate ownership shares into parcels of land rather than maintain shared ownership/title, enlarging the volume of aggregated parcels of land in individual title, thus boosting development opportunities for land in ownership by Individual A.”

By contrast, we again demonstrate the negative outcomes associated with the reinforcing loops (R1, R1a) if and when they become vicious cycles of systems behavior. We restrict our narrative to the R1 loop for brevity.

“As development opportunities for land in ownership by Individual A diminish, the value of land in ownership drops, undermining Individual A’s ability to aggregate ownership shares into parcels of land rather than maintain shared ownership/title, adversely impacting the volume of aggregated parcels of land in individual title, thus reducing development opportunities for land in ownership by Individual A.”

Once again, we take note of the mutual impact and interdependence of individual behavior and systems behavior. In addition, we note a leverage point perhaps involving the lever of external private or public capital to boost development opportunities for land in ownership; and another to intervene using legislation as a lever to boost any Individual A’s ability to aggregate ownership shares into parcels of land rather than maintain shared ownership/title.
It is suggested that the value of the CLD in representing the dynamic nature and evolving impacts of mutually interacting individual behaviors, causal loops, and systems behaviors, has been appropriately demonstrated by these cases. The following discussion will draw together further strands of insights and benefit that can be associated with recognizing the systemic structure of the various tragedies.

**DISCUSSION AND CONCLUSIONS**

This paper has provided examples of how the finiteness of resources; the scarcity of resources; the overuse of resources leading to depletion or extinction; the underuse of resources leading to lost opportunities for wider benefit - all impact on the sustainability of ecological, environmental, science, business and commercial environments. Addressing these matters has immediate and inter-generational value. Developing the conceptual frameworks to recognize the common systemic structures embedded in such underuse and overuse situations is a precursor to how they may be effectively addressed.

This paper has used the systems representation tools of qualitative systems dynamics to demonstrate the underpinning systemic structures of the seemingly different resource overuse and resource underuse situations, known respectively as tragedies of the commons and anti-commons. As such, the systems approach demonstrated in this paper differs from that of Heller (1998, 2010, 2011) and Ostrom (1999a,b). Indeed, whilst the work of both authors is imbued with the holism and system-wide perspectives redolent of, and necessarily embedded in a systems approach, their descriptive and analytical frameworks do not capture or represent the systemic structure underpinning resource overuse or resource underuse in the same way. Furthermore, whilst Heller conveys, stresses and refers to the commonality in the nature and structure of resource underuse situations, the systemic nature and archetypical structure of such situations is not as evident in Heller’s descriptive framework as is with use of the CLD as a means of identifying and representing systems relationships, mutual dependencies.

Senge (1999, 2006) has previously identified the unique common systemic structure of the resource overuse problem situation as a tragedy of the commons systems archetype. This paper adds to the body of knowledge by similarly identifying and defining a new common
systemic structure and systems archetype for the phenomenon of the tragedy of the anti-commons. The systems archetype is set out in Figure 5.

In addition, the paper has shown that whilst the two classes of resource overuse and underuse tragedies are different, they have related mirror-like symmetric systemic structures. In the case of the tragedy of the commons, resource use benefitting individuals leads to further reinforcing of that resource use by a growing number of individuals (Loops R1 in Figures 1 & 2), until limits on the resource or resource capacity begins to deter such individual usage (Loops R1a).

For the tragedy of the anti-commons, an inability to use existing available resources in a cooperative or collective manner, perhaps reflecting the same kind of instrumentalism or self-interest that leads to the tragedy of the commons, may become so embedded as individual behavior (loops R1 in Figure 1, 2 & 5) that, overtime, it may virtually remove the opportunity to build a beneficial community resource that could be used for greater collective benefit or utility (loops R1a).

With respect to methodology, the paper has illustrated the benefits of using the systems representation tools of qualitative systems dynamics for not only building systems representations of those underuse and overuse situations; for not only recognizing and identifying common systemic structure as systems archetypes; but also in identifying points of intervention (leverage points) and intervention strategies (levers) relevant to such communality and systemic structure.

In addition, the paper prompts questions of how best to share insight about the emergence of such different tragedies, and about how tragedies may be addressed to ameliorate or reduce tragedy effects. As such, these questions could provide a fruitful area of investigation to further develop systems and other methodologies that would provide appropriate frameworks for research, and also to conduct research on substantive resource and policy issues.

REFERENCES

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donation/organ-donation-scotland-parliament-briefing


