Competitive scenarios, community responses and organisational implications

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Abstract

We analyse four scenarios commonly encountered in social processes undergoing competitive pressures: resource depletion by individuals acting greedily ('tragedy of the commons'), wasted opportunity due to over protective players ('tragedy of the anticommons'), crowd following ('majority wins') and competition for niches ('minority wins'). We show that these scenarios are extremes of a continuous resource exploitation problem and that complex and counter-intuitive behaviours are found at the transitions between 'pure' scenarios. We discuss the likely community behaviours and under what conditions a centralised management intervention may play a role in the resource and community resilience.

Introduction

It is common practise to view many organisational and social processes in the light of competition: human organisations, communities and societies compete for resources, niches, information, supremacy etc. However, the life of individuals (that is the members of such groups) comprises a delicate balance of a wide range of interactions which include competition as much as collaboration and altruistic behaviour.

The Darwinian interpretation of such an apparent paradox is that seemingly unselfish behaviours provide for indirect advantages within the context of complex and larger human interactions. This view presupposes the existence of different levels at which the dynamics of human affairs develop and leads quite naturally to complexity theory: interactions at one level (the individual, say), via a chain of feedback effects may result in group competitive advantage whose subtleties may remain obscure to the group members themselves; at the next level, a mix of competitive and collaborative interactions between groups may give similarly unexpected advantages to larger communities, which in turns may feedback to the level of individuals. Similar nesting may progress for many levels, in principle including all forms of life from single cells up to mankind as a whole. The keyword here, albeit a slippery one, is emergence: local interactions (reduced competition and increased collaboration) may result in unexpected global outcomes (improved competitive advantage).

The purpose of this work is to discuss some of these phenomena and to show how counter-intuitive behaviours may arise even under simpler settings. We model only two levels (individuals and a single community), a simple interaction process (exploitation of a common resource) and unintelligent, emotionless, rule-based agents who follow stochastic strategies. By simply changing the way we model the resource availability and distribution we can analyse several competitive scenarios we encounter in our daily business and private life.

The relevance of this work is two-fold; we want to understand, and thus possibly predict, the broad response of communities under different competitive challenges as a function of the strategies they decide to adopt. At a management level, we would also like to anticipate what challenges a community (a business organisation for example) may face and what behaviour (competitive versus collaborative, centralised versus de-centralised) should be fostered in order to respond to such challenges. One of the main lessons we draw from this work is that not only may the scope for intervention change depending on the details of the challenge, but also that, in certain specific circumstances, global management intervention may be a crucial factor in determining the efficacy of strategies at an individual level.

These insights are the outcome of work we have carried out over a number of years (Boschetti 2007; Boschetti and Brede 2008; Brede and Boschetti 2008; Brede, Boschetti et al. 2008; Brede and De Vries 2008) using a game-theoretical and evolutionary economics framework (Gintis 2000). Here we intend to summarise the results and infer some general conclusions from tests carried out under different model scenarios. Our discussion is purposely non technical and results are presented qualitatively while we refer to our previous papers the reader interested in the details of the mathematics, modelling implementation and numerical results of the specific experiments.

The scenarios

Let’s consider a community of individuals who compete for a renewable resource. This could be a natural resource (a farmland or a fishery), a business opportunity (niche in a market) or a non-monetary commodity (access to a natural park or a restaurant). The individuals desire to access as much of a resource as possible, in other words they are naturally selfish (but not necessarily competitive; we will address the difference below). We also assume each individual has a physical, economic or legal limit to how much resource he can access, which may represent a fishing quota, an anti-trust regulation or the maximum space he can occupy in a restaurant. In this section we illustrate a number of scenarios which can arise as a function of resource availability and distribution and the implications these different scenarios have on the individuals’ likely exploitation strategies, whose outcomes will be the focus of the rest of the paper.

Homogenous resource

Here we assume the resource can be accessed at a single location or via a single process or approach; in other words individuals do not need to try to outcompete each other by searching for least exploited niches.

Suppose the resource is plentiful in comparison to the community demands so that each individual can satisfy his wishes. This is a trivial case to analyse: whatever behaviour or strategy an individual employs will be successful. In the rest of the paper we call this a ‘Promised Land’ scenario. Now let’s imagine the resource is scarce in comparison to the community demands so that, if shared equally, no one can satisfy his wishes. Obviously competition will occur and most individuals, if not all of them, will be left unsatisfied. If no additional regulation is in place and if the resource is not fully renewable, the resource will be over-exploited and most likely crash leaving no further resource for future utilization. In this situation, despite the inevitable outcome is obvious to everyone, no structure is in place to limit exploitation since it is still convenient to each individual to extract the little resource available rather than seeing it exploited by others: competition is inevitable, collaboration uneconomical and disaster unavoidable. This scenario is known in the literature as ‘tragedy of the commons’ (Hardin 1968) and has attracted attention for a several decades with regards to global exploitation of world resources (Ostrom 1990; Sethi and Somanathan 1996; Batten 2007).

Now let’s assume some individuals decide to address the doom scenario and impose constraints on the resource exploitation. This may take the form of an exploitation tax or a ban on some exploitation gear. Alternatively, some individuals may develop a very effective exploitation tool but prevent others from using it by the use of patents. In other words an individual may try to limit resource access to others and, in order to account for some sort of self-regulation, such resource limitation comes at a cost to the individual. This may work initially, but should the use of such constraints be itself uncontrolled (for example every individual may impose some ban on others or tax grow to be excessive) then it may become impossible or not economical for anyone to access the resource. This will prevent resource crash but also any economic benefit from its use. This scenario is known in the literature as ‘tragedy of the anticommons’ (Heller 1998; Heller and Eisenberg 1998; Benkler 2004).

To our knowledge the tragedies of the commons and anticommons have been mostly analysed independently. In (Brede and Boschetti 2008) we discussed them as two extremes of a continuum determined by the amount of regulation individuals (or a system manager) may decide to impose: for zero regulation we have a tragedy of the commons and for extreme regulation an anticommons. The behaviour at the transition between these extremes and the implications for a management team which attempts to maximise resource exploitation are insightful and will be discussed below.

Distributed resource

So far we assumed that the resource can be accessed at a single location, that is, individuals do not need to choose where to access the resource. The dynamics change considerably if the resource is distributed so that a choice needs to be taken. Here for distribution we intend either a spatial division (fishing in two separate zones, farm in two separate land allocations, choose in which restaurant to dine) or virtual division (deciding which market niches to target).

Let’s assume the resource can be accessed at two locations (extension to more locations is trivial) and the individuals have the same exploitation capacity so they need to share equally the amount of resource at the location they chose to target. In this setting, it is convenient for an individual to target the least exploited location, that is the location chosen by the minority of the individuals: the resource will then be shared with fewer people and the return will be higher. This scenario is known in the literature as ‘minority game’ (Arthur 1994; Challet and Zhang 1997; Zhang 1999) since the ‘minority wins’.

As for the commons and anticommons situation, the ‘minority wins’ setting has mostly been studied in isolation, though this does need not be so. Suppose we have a resource equally distributed between two locations (each location has 50% of the resource); now suppose we smoothly reduce the amount of resource at one location (location A, say). While the resource at location A diminishes, it becomes less profitable for individuals to target it, even if they are in the ‘minority’. When the resource at location A reaches zero, all individuals need to target location B since they have no alternative choice, however the amount of resource (50% of the original amount) is insufficient to satisfy all requests and we end up in a ‘tragedy of the commons’.

Summarising this section, we described 4 scenarios:

1) a ‘Promised Land’ where nothing can go wrong since there is enough resource for everyone whatever strategy individuals adopt;
2) a ‘tragedy of the commons’ where there is not enough resource and still individuals have no options but overexploit such resource;
3) a ‘anticommons’ in which over-regulation prevents anyone from exploiting a healthy resource;
4) a ‘minority wins’ situation in which individuals try to target the least exploited among several resources.

In the following we study the smooth transition among these 4 scenarios, analyse the likely community behaviours, their likely outcomes and management implications.

Scenario Outcomes

From Commons to Anticommons – amount of regulation

As we have seen, communities face a ‘tragedy of the commons’ or ‘anticommons’ when resources are scarce compared to the potential demand. Two types of regulations naturally arise when a decision to intervene and manage a resource is taken: de-centralised regulations, which are implemented and controlled by the individuals and centralised regulations, imposed and managed by a resource administrator or community representative. Here we discuss and summarise the analytical and numerical work we carried out in (Brede and Boschetti 2008), to which we refer the reader for further details.

Let’s first address a de-centralised regulation and let’s suppose it is implemented by an individual’s limiting the use of certain strategies or tools (via patents for instance) or by lobbying the resource management body for certain kinds of interventions. The global amount of regulation can thus be quantified by the number of individuals imposing the regulation. Its effect on the community is described with the aid of Figure 1 which gives a sketch of the relation between the amount of regulation (X axis) and the income (Y axis) arising from the resource exploitation (for precise numerical plots, see (Brede and Boschetti 2008)).

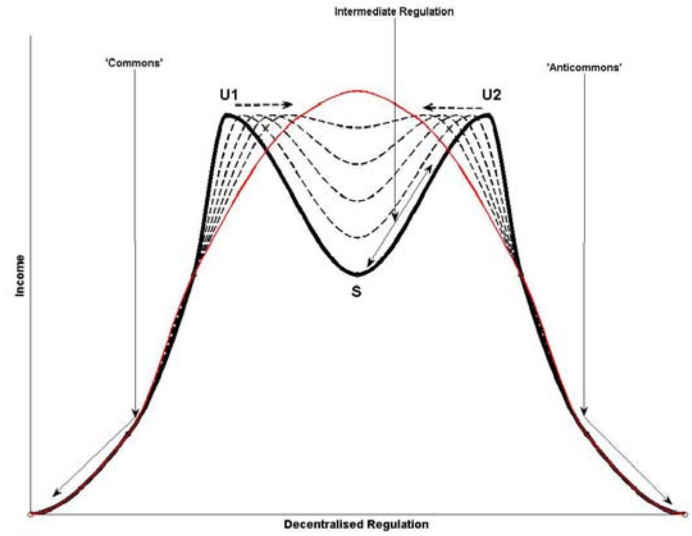

Figure 1. Transition between 'commons' and anticommons' as a function of amount of regulation.

In the figure the black thick line represents the solution surface of the dynamical process and the system will naturally tend to reach its stable points. We can envisage a number of options:

1) when regulation is very low (left-hand-side of the unstable point U1) the resource is overexploited, only few people try to impose a regulation, such regulation does not pay off and is soon abandoned. This leads to a crash and no income for the community in the long run (tragedy of the commons);
2) when regulation is very high (right-hand-side of the unstable point U2) many people try to impose regulations, the few who don’t lose out and soon will join the regulating majority until the point at which global regulation effectively prevents (on either legal or economic basis) resource exploitation and no income is possible (anticommons);
3) when the regulation is at some intermediate level (between points U1 and U2) level a number of options are possible:
   a) the community may converge towards the stable point S: here slight variations in regulation amount, resource abundance or economic value impose only local perturbations to the system which will then return to S; the economic outcome to the community is however not optimised.
   b) under economic pressure the community may strive for better outcomes at points U1 and U2; these points however are unstable and small and unpredictable oscillations in resource abundance or value could result in the system falling into a tragedy of the commons (from point U1) or anticommons (from point U2).

Let’s now analyses centralised regulations. These can be represented by the cost placed on individuals to exploit a resource (a tax) or to apply for a de-centralised regulation (the cost of lobbying) or the efficacy of the regulation itself (how extensively it is applied, how compliance is assured, etc). Alternatively, the role of this centralised regulation can be interpreted as a management attempt to optimise the overall economic return (a corporation, for example). In our work, we modelled the amount of centralised regulations as an increase in the individuals' cost of imposing regulation. This effectively changes the shape of the solution surface of the dynamical process as depicted in Figure 1 by the dashed lines. As we can see, for an increasing amount of centralised regulation points U1 and U2 get progressively closer (dashed arrows) which in turn makes point S less and less stable. Although the details of such behaviour are beyond the scope of this paper (see (Brede and Boschetti 2008)) it is eventually possible to reach a solution surface like the red line in Figure 1, for which the point S disappears altogether and the only likely outcomes from resource exploitation are a tragedy of the common or an anticommons, with no viable alternatives.

The message for these experiments can be summarised as follows:

1) de-centralised regulation can, under certain circumstances, prevent both 'tragedies';
2) centralised intervention can help the de-centralised regulation adjust towards stable configurations;
3) however, the need to optimise for economic return is likely to push the system into a configuration which inevitably leads to either the tragedy of the commons or anticommons.

As is well known in the field of sustainable and renewable resource management, strict economic optimisation and resource sustainability rarely walk hand and hand.

From abundance to scarcity in distributed resources – the concept of *impact*

The dynamics of the exploitation of a distributed resource is even more counter-intuitive than for a homogenous resource, due to a self-referential feedback loop resulting in a complex behaviour. As we discussed above, in this setting the minority wins: to be competitive an individual needs to belong to the minority. However, a competitive strategy tends to be copied in any evolutionary (=competitive) dynamics. As soon as the competitive strategy is copied one too many times (it is adopted by one too many individual) it will belong to the majority, thus will lose its own very competitive advantage and will become a losing strategy. In other words, if we find a niche market which provides wealth because unexploited, it is better not to advertise the discovery or else others will try to invade the niche making it no longer unexploited. Curiously, other niches, previously over-exploited, may be abandoned by the very competitors who switched niche and may suddenly become under-exploited and thus attractive.

The obvious consequence of this phenomenon is a continuous oscillation with strategies losing and gaining competitive edge and resource locations gaining and losing attractiveness. These oscillations never settle, even in the very long run. Important for our analysis, the amplitude of these oscillations represents lost income (Boschetti 2007; Boschetti and Brede 2008). Suppose the resource is spread equally between two locations. The best resource exploitation approach is represented by individuals splitting their effort equally among both resources: any departure from this (=oscillation) results in income loss either because of unexploited resource or because of increased exploitation cost. Ample literature shows that this income loss will not be avoided as long as individuals try to optimise their own personal gain (Arthur 1994; Challet and Zhang 1997; Zhang 1999).

The ‘solution’ to this dilemma was developed in the field of computer science and is surprisingly simple (Wolpert, Wheeler et al. 2000; Wolpert 2001; Wolpert and Tumer 2001; Wolpert, Tumer et al. 2004); its application to renewable resource exploitation and management is discussed in (Boschetti 2007; Brede and De Vries 2008). The idea is to ask individuals neither to maximise their own personal gain (= not to be selfish), nor to concern only about the good of the community (=not to be naively unselfish), rather somewhere in between: individuals should try to maximise the impact their action has on the community behaviour. This is ‘measured’ as the difference in income between what the community gains minus what the community *would* have gained *had* that specific individual *not* participated to the community action. In other words an action which results in an individual gain but no community gain is penalised. This is very much in line with the attitude towards rewarding employees based on the demonstrated benefits they provide to a company’s performance. The ethical concerns for and against this approach are significant, but beyond the scope of this work.

The ‘solution’ discussed above goes under the name of Collective Intelligence and relies on a quantity which can not be measured: the consequence of an action (absence of an individual) which did not occur. However, under certain circumstances an approximation can be computed and its numerical performance is surprisingly good (Boschetti 2007; Brede and De Vries 2008).

Coming back to the distributed resource problem, we want to study what exploitation strategy among the following is most effective for an individual:

1) he may decide not to put any effort in choosing a strategy and simply target the resource at a random location.
2) He can decide to act selfish and always target the location which appears to provide the most profitable return.
3) or he can follow a Collective Intelligence approach and try to maximise his impact on the community income.

Under an evolutionary economics framework, we also assume that the most profitable of the three above mentioned strategies will thrive and spread in the population[1]. The results are summarised in Figure 2 (for more details see (Boschetti and Brede 2008; Brede and De Vries 2008)).

[1] Notice that here for strategy we do not refer to the choosing of a location where to access a resource, rather as the criterion employed to carry out such choice.

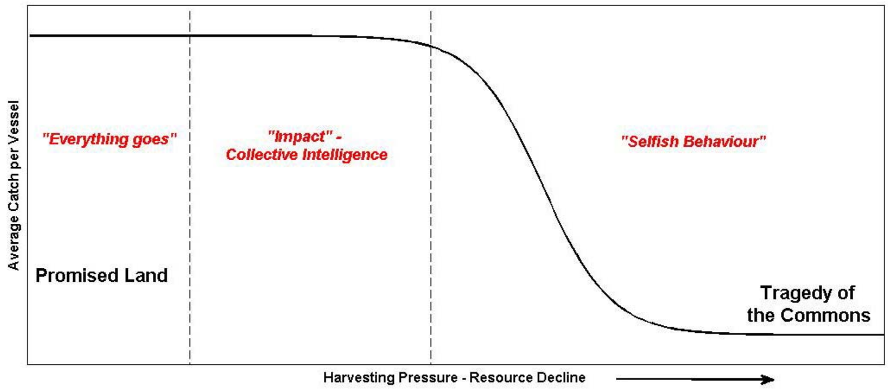

Figure 2. Transition between a Collective-Intelligence-dominated to a selfish-behaviour-dominated state as a function of resource decline

The X axis shows the global amount of resource decreasing rightward and the Y axis shows the average economic return per individual. The leftmost part of the plot represents the 'Promised Land' in which abundant income is available for anyone under any circumstance; in this setting there is no reason to strive to develop the best strategy, even a random selection of a location will deliver as much as an individual can collect ('Everything goes' in the figure). Moving rightward the resource decreases slowly; in this setting the collective intelligence approach prevents resource waste by avoiding overcrowding single locations ('Impact – Collective Intelligence' in the figure). When the resource decreases further, three events occur simultaneously: a) the collective intelligence approach fails to be profitable, b) individuals start to act selfishly ('Selfish behaviour in the figure) and c) the resource declines abruptly towards a complete crash past which no income is possible: once again the tragedy of the commons has been reached. Transitions of this kind are typical in the dynamics of distributed renewable resources.

The abrupt resource decline defines a sharp boundary between two different regimes which deserves further analysis: why is accounting for an action's impact rather than acting selfishly profitable before the boundary? And why does this approach fail to succeed past the boundary?

When the resource is relatively abundant, the collective intelligence prevents resource waste, this leads to the community increasing its total income by spreading its effort proportionally to the available resource and as a result the average income of an individual also increases. By accounting for his role within the community an individual indirectly provides a benefit to the overall community as well as to himself: his strategy is not selfish, but nevertheless competitive and optimal.

Things change abruptly when the available resource falls below a certain threshold. When resource is scarce, all available resource is exploited by the community and the individuals have to share the little resource available. Whatever choice an individual takes, whether effective or not, will not change the overall community income, since all remaining resource will be exploited anyway by his competitors; in other words his action can not have any impact on the overall community income. In this setting, following the collective intelligence is equivalent to acting randomly since no information is available on how to influence the community outcome. All an individual can do is to act for his own interest disregarding global outcomes; the result is the tragedy of the commons (Boschetti and Brede 2008).

The threshold of abrupt decline is also very important for centralised management as we discuss in detail in (Boschetti and Brede 2008). First, incentives based on an individual's impact on the community can work only when such impact can occur; as we have seen, under considerable hardship this is not possible. Under more fortunate conditions a management body may need to ensure that the proper initiatives are in place to make impact achievable in practise or else this potentially useful approach will not succeed. Second individuals need to be able to evaluate such impact; in very large organisations this may not be possible and extra effort should be placed in providing such information to individuals. Finally, if the management was able to monitor the number of individuals who successfully account for their impact and the ones who merely act selfish, it could in principle obtain some feedback on the resource status: the more the successful individuals who follows a collective intelligence approach, the more healthy and abundant the resource is likely to be. For more details about these conclusions we refer the reader to (Boschetti and Brede 2008), where the effect of centralised versus decentralised management is also discussed.

Discussion and conclusions

Resource depletion by selfish individuals (tragedy of the commons), wasted opportunity due to over protective players (tragedy of the anticommons), crowd following (majority wins) and competition for niches (minority wins) are settings we commonly encounter in our social, professional and business life. The economics and game theoretical community have studied these scenarios carefully but most often in isolation. Our contribution is to show that they all can be seen as extremes of a continuous resource exploitation problem; as so often occurs in complexity science, the most interesting, challenging and counter-intuitive results are found at the transition between 'pure' scenarios.

We summarise our results graphically with the help of Figure 3. To keep the figure simple we limit ourselves to 3 dimensions which are represented by axis X, resource distribution (single or multiple locations), Y, amount of available resource and Z, amount of regulation (here intended both as centralised and de-centralised).

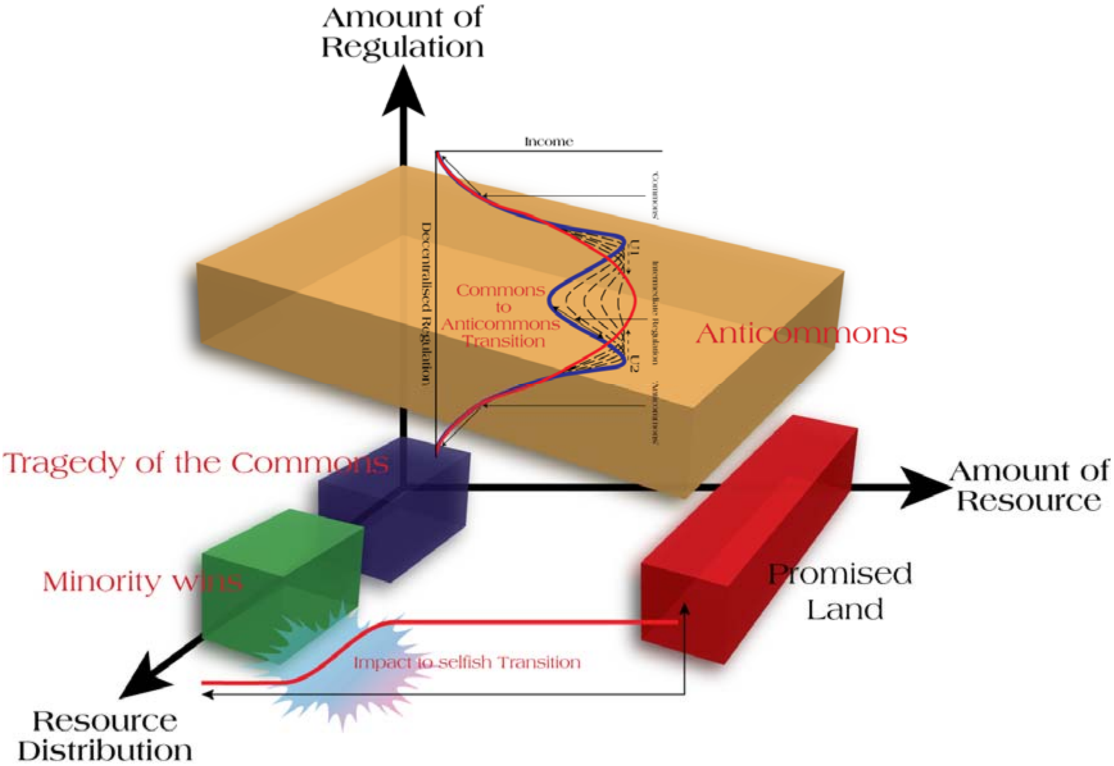

Figure 3. Summary of the scenarios discussed and their transitions as a function of resource distribution, resource amount and amount of regulation.

The blue box (low values of the X and Y axis) represents a scarce homogenous resource; in this scenario very little can be done if individuals do not have an external incentive not to exploit the resource, in which case the ‘tragedy of the commons’ may be unavoidable[2]. For high values of the Y axis, the red box of plentiful resource depicts the ‘Promised Land’ scenario in which nothing can go wrong. The yellow box of maximum regulation represents the ‘tragedy on the anticommons’. Parallel to the Z axis (that is for change of regulation and fixed amount and distribution of resource) we overlaid the plot from Figure 1which represents the transition from tragedy of the commons to anticommons. For distributed resources (X axis >1) the green box represents the ‘minority wins’ scenario and the plot taken from Figure 2 shows the transition for a collective intelligence dominated strategy to a selfish one.

The role of the centralised management (not plotted in the image) lies in recognising in what scenario the system is. In certain cases, this may be obvious. In others, some monitoring may be devised, for example by measuring the ratio between collective intelligence and selfish agents as suggested in the previous section. Intervention may be possible in the distributed resource settings by favouring impact seeking individuals and providing for the information necessary to detect such impact or in the de-centralised regulation setting, by providing incentive to avoid economic optimisation which may decrease system sustainability as discussed in section “From Commons to Anticommons – amount of regulation”. In other scenarios (‘tragedy of

[2] Several authors suggest that social factors usual come into place to prevent the full extent of a tragedy of the commons to occur in real situations. The historical analysis of whether these claims apply are beyond the scope of our discussion, which is based on the relatively simple individual behaviour discussed above.

the commons') intervention may be futile unless it allows to increase the size of the system, for example by providing additional income from external sources which may induce individuals not to overexploit and resource close to exhaustion.

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Biography

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