Chapter 21

Analysis of the Environmental Proper Coupling Subproblem

"Living poor is like being sentenced to exist in a stormy sea in a battered canoe, requiring all your strength simply to keep afloat; there is never any question of reaching a destination. True poverty is a perpetual state of crisis, and one wave just a little bigger or coming from an unexpected direction can and usually does wreck things," wrote Moritz Thomsen in *Living Poor: A Peace Corps Chronicle* in 1969, p173.

The world's economic sustainability problem, even in highly industrialized countries, is in a perpetual state of crisis after crisis. The latest began in 2008 and shows little sign of resolution. Economic overshoot was so unsustainably large that at first economists feared a downturn as large as the Great Depression was possible. That did not occur, but the crisis is far from over. Even if it's solved there will be more.

The world's environmental sustainability problem is also in perpetual crisis. News about old problems, new problems, the growing suffering due to environmental degradation, and how many nations simply cannot afford to address their environmental problems (even if they wanted to) appears with alarming frequency. Add to this the growing perpetual political crisis confronting too many nations due to mass political deception and you have a perfect storm. The battered canoe of civilization is being wrecked by slightly bigger waves coming from all directions.

Thomsen continues: "In South America the poor man is an ignorant man, unaware of the forces that shape his destiny. The shattering truth—that he is kept poor [and in perpetual crisis] as the principal and unspoken component of national policy—escapes him."

This chapter attempts to uncover the shattering truth about why civilization has been locked in a state of perpetual crisis, as the result of national policies that, once understood, are easily corrected. If, of course, change resistance can be overcome.

The Malthusian Trap

The continual crisis of poverty is in fact the historic norm. Why it occurs was discovered two centuries ago by Thomas Malthus. His surprisingly simple explanation has come to be known as the Malthusian Trap.

The trap occurs because of the IPAT equation. As described on page 71, $I = P \times A \times T$. Once the I in the equation, environmental impact, reaches the maximum an ecological niche can support the PAT factors have reached their limits. Population

(P) cannot go up unless consumption per person (A) or impact per unit of consumption (T) goes down. Maximum population is thus trapped by whatever a society's I, A, and T factors are.

Unless the laws of physics change, the trap is inescapable. Typically what happens is a new technology comes along, such as an improvement in agriculture. This reduces T, because there is less environmental impact per unit of consumption. This in turn raises A, affluence or consumption per person. Because people have more to eat population goes up. Population then rises until P times A times T equals I.

At this point the insidious nature of the trap takes hold. Due to replication and competition for survival of the fittest, P continues to grow *and A starts to fall*, because P times A times T cannot be greater than I except for cases of temporary overshoot. A continues to fall until consumption per person reaches starvation level. That puts the brakes on further growth of P. The end result is A is back where it started. P has grown some, but the same mass misery and poverty a society started out in before invention of the new technology has returned.

Also called "The Iron Law of Population," the trap was first described by Thomas Malthus in 1798 in his highly influential *An Essay on the Principle of Population*. Gregory Clark, writing so persuasively in *A Farewell to Alms*, 2007, covers the trap at length. As he describes it: (p1-2, italics are his)

> …the *Malthusian Trap* ensured that short term gains in income through technological advances were inevitably lost through population growth.
>
> Thus the average person in the world of 1800 was no better off than the average person of 100,000 BC. Indeed in 1800 the bulk of the world's population was poorer than their remote ancestors. The lucky denizens of wealthy societies such as eighteenth-century England or the Netherlands managed a material lifestyle equivalent to that of the Stone Age. But the vast swath of humanity in East and South Asia, particularly in China and Japan, eked out a living under conditions probably significantly poorer than those of cavemen.
>
> The quality of life also failed to improve on any other observable dimension. Life expectancy was no higher in 1800 than for hunter-gatherers: thirty to thirty-five years. Stature, a measure both of the quality of diet and of children's exposure to disease, was higher in the Stone Age than in 1800. And while foragers satisfy their material wants with small amounts of work, the modest comforts of the English in 1800 were purchased only through a life of unrelenting drudgery. Nor did the variety of material consumption improve. The average forager had a diet, and a work life, much more varied that the typical English worker of 1800, even though the English table by then included such exotics as tea, pepper, and sugar.

> And hunter-gatherer societies are egalitarian. Material consumption varies little across the members. In contrast, inequality was pervasive in the agrarian economies that dominated the world in 1800. The riches of a few dwarfed the pinched allocations of the masses. Jane Austin may have written about refined conversations over tea served in china cups. But for the majority of the English as late as 1813 conditions were no better than for their naked ancestors of the African savannah. The Darcys were few, the poor plentiful.
>
> So, even according to the broadest measures of material life, average welfare, if anything, declined from the Stone Age to 1800.

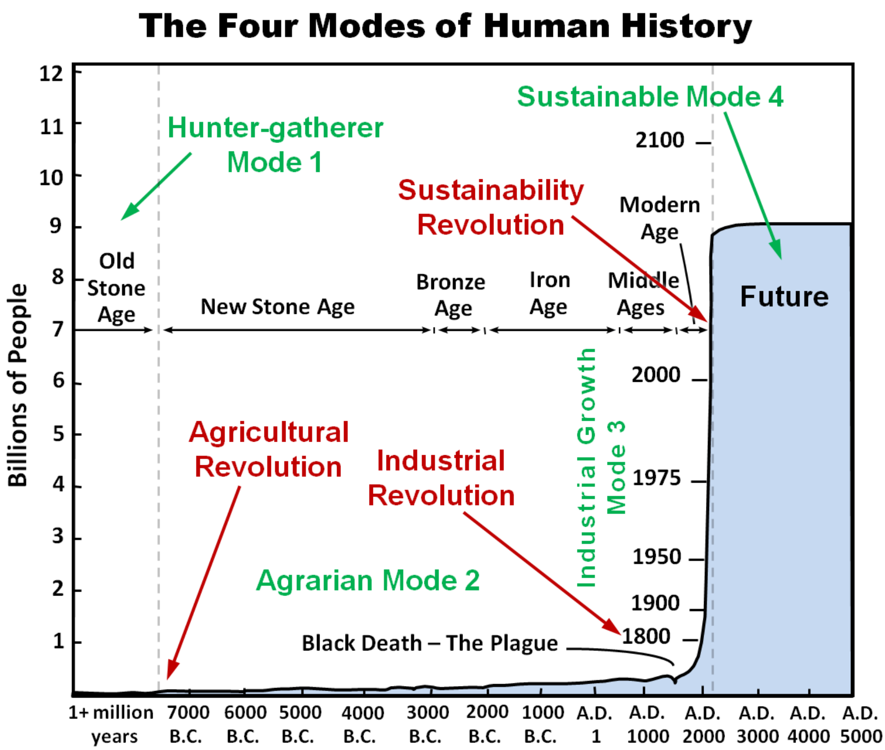
How bad can the trap become? Malthus did extensive research in that area to support his thesis. In book 1 of his *Essay*, chapter 3 presents *On the Checks to Population in the Lowest Stage of Human Society*: [173]

> The wretched inhabitants of Tierra del Fuego have been placed, by the general consent of voyagers, at the bottom of the scale of human beings. … [Their] very appearance indicates them to be half starved, and who, shivering with cold, and half covered with filth and vermin, live in one of the most inhospitable climates in the world….
>
> Next to these, and almost as low in genius and resources, have been placed the natives of Van Diemen's land; but some late accounts have represented the islands of Andaman in the East as inhabited by a race of savages still lower in wretchedness even than these. Every thing that voyagers have related of savage life is said to fall short of the barbarism of this people. Their whole time is spent in search of food: and as their woods yield them few or no supplies of animals, and but little vegetable diet, their principal occupation is that of climbing the rocks, or roving along the margin of the sea, in search of a precarious meal of fish, which, during the tempestuous season, they often seek for in vain. Their stature seldom exceeds five feet; their bellies are protuberant, with high shoulders, large heads, and limbs disproportionably slender. Their countenances exhibit the extreme of wretchedness, a horrid mixture of famine and ferocity; and their extenuated and diseased figures plainly indicate the want of wholesome nourishment. Some of these unhappy beings have been found on the shores in the last stage of famine.

The point is every one of these human beings *wanted* to do better. But they could not. They and their societies were trapped in a life of endless misery, no matter what their level of technology or where they lived. Most did much better than those in the passage above. But as Collier found, as technology increased the average person became *worse* off, not better.

The need for a mode oriented model

The suffocating grip of the Malthusian Trap was broken seemingly forever by the beginning of the Industrial Revolution. As The Four Modes of Human History graph below shows, population exploded around 1800. Why did this happen? How can we apply the brakes in time to prevent return of the trap? Answering those questions requires a mode oriented model. It must be able to explain the four modes and three revolutions shown on the graph.



Graph source: Pop. Reference Bureau and UN, *World Pop. Projections to 2100* (1998). Modified by Thwink.org to show modes, revolutions, and pop. leveling out at 9B not 11B.

A **system mode** occurs when a system becomes locked into an overall pattern of behavior for awhile. Small impacts on the system will not knock it out of that mode, due to the presence of strong balancing feedback loops. Only large impacts like invention of the radical new technology of agriculture can do that. Mode lock-in is usually good because it provides stability to a system. *However, once a system slips into an undesirable mode it can be surprisingly difficult to snap the system into a desirable mode.*

One example of undesirable mode lock-in is how long Western Europe remained stuck in the Dark Ages: 1,000 years, from the fall of Rome in the fifth century to the beginning of the Renaissance in the fifteenth century. Another is how long North Korea and Cuba have suffered under dictatorships, despite repeated efforts by the rest of the world to change that mode. Still another example is the 58 nations (according to Paul Collier in *The Bottom Billion*, 2007, p7) that are locked into a poverty/undeveloped mode, despite numerous attempts to help these countries escape that mode. In Collier's words, of the world's population, "a total of five billion people are already prosperous, or at least are on track to be so, and *one billion are stuck at the bottom*." (p3, italics added)

A four mode model differs from what conventional wisdom is analyzing. Conventional research has voted unanimously that recent growth, overshoot, and collapse are the symptoms to model. This is a confining, low level view of the problem, however. To get to the root of the problem we need to examine the full sweep of human history, starting with where *Homo sapiens* was about 200,000 years ago, when our species branched off from the rest of the genus *Homo*. Since that time *Homo sapiens* has progressed through a number of distinct phases, notably hunter-gatherer, then agrarian, and finally industrial. What triggered these mode changes? Why is the current mode so unsustainable? These questions should lead us to our quarry of root causes, high leverage points, and solution elements that work. *Thus we need a mode oriented model.* It must explain why modes 2, 3, and 4 occurred or could occur:

	Mode	Precipitated By
1	Hunter-gatherer	Appearance of *Homo sapiens* about 200,000 BC
2	Agrarian	Agricultural Revolution about 10,000 BC
3	Industrial	Industrial Revolution about 1800 AD
4	Sustainable	Sustainability Revolution, hopefully soon

Mode 3 is currently in overshoot and headed toward collapse, so the problem to solve is how to cause an immediate change to mode 4. The graph itself is the beginning of a model, so let's first describe it. The graph is a little old so future population is high. Present UN projections estimate world population is most likely to level off at about 9 billion in 2050.

Mode 1 – Let's begin with the first mode. For a long time, the human system was stuck in the Hunter-gatherer Mode, on the left side of the graph. That ended around 10,000 BC with the Agriculture Revolution. Agriculture is widely considered mankind's greatest invention because it caused the first major mode change. This led to all the others.

Mode 2 – Next the system entered the Agrarian Mode. Population went up a little but hit the same ceiling as in the previous mode: the Malthusian Population

Trap. The Agrarian Mode came to an end around 1800 when the Industrial Revolution caused population to shoot up like a rocket.

Mode 3 – Now we're stuck in the Industrial Growth Mode. We've got to get out of this mode because it's unsustainable.

Mode 4 – A global Sustainability Revolution hasn't happened yet. It needs to happen soon, right about now. After that we'll be in the Sustainable Mode.

More than these four modes could be included. But they are so fundamental to the history of our species that if we can fathom why the first two revolutions occurred at the root cause level, we should be able to determine the root causes of why the third revolution has not yet occurred and how to trigger it by pushing on the right high leverage points.

This we have done. The conclusions are listed in the *Summary of Analysis Results* on page 202 in column D. First we will describe the model used in the analysis and how it explains the mode changes. Then the analysis for column D is described.

The environmental proper coupling subproblem

Proper coupling occurs when the behavior of one system affects the behavior of other systems in a desirable manner, using the appropriate feedback loops, so the systems work together in harmony in accordance with design objectives. **Economic improper coupling** occurs when an economic system is improperly coupled to another system, such as the legal system or the human system. In the environmental sustainability problem the world's economic system is improperly coupled to the greater system it lives within: the environment.

This is a powerful abstraction because it tells us that to solve an improper coupling problem, we must strengthen and/or introduce the correct feedback loops. That's exactly what SIP was designed to do.

The Property Management System model

Execution of the analysis step of SIP requires construction of a physical model of understanding. The purpose of the model is to provide the deep insights needed to solve the problem. That's all. There is no need, for example, for the model to be able to simulate the present or future behavior of the system. That can be useful but is not required, as is the case here.

The reason this chapter doesn't use a simulation model is that simulation is not required to demonstrate model correctness. That's already been done by history.

The Property Management System model is a causal flow model. The happy result is it's a hundred times easier to understand than a simulation model. Fewer than 1% of the population has simulation model training, while nearly everyone can understand a one page diagram. Ours is so simple that its four main subsystems and four feedback loops could be drawn on a napkin in a minute. The result is a model activists can understand and therefore apply. If we'd used a simulation model instead it would have been of the complexity of *The Limits to Growth's* World3 model, which runs into ten pages and 290 variables, and took a second 637 page book, *Dynamics of Growth in a Finite World,* to describe in detail.

On the next page is the analysis model. It approximates the evolution and essential structure of the world's two property management systems using four subsystems. These are connected by causal flow arrows, some of which form feedback loops. These four subsystems and four feedback loops explain the important behavior of the total system.

The system on the right, Common Property Rights (CPR), is the candidate solution. It already partially exists. Everything else fully exists and is working well, so there's no need to simulate it. The CPR system closely mimics the private property rights (PPR) system. The only difference is each system manages a different type of property. Once all necessary CPR components exist the CPR system should work just as well as the PPR system. Thus there is little needed for simulation. Instead of putting our energies into the intricate details of simulation they are better directed to the higher level of systems thinking the diagram allows.

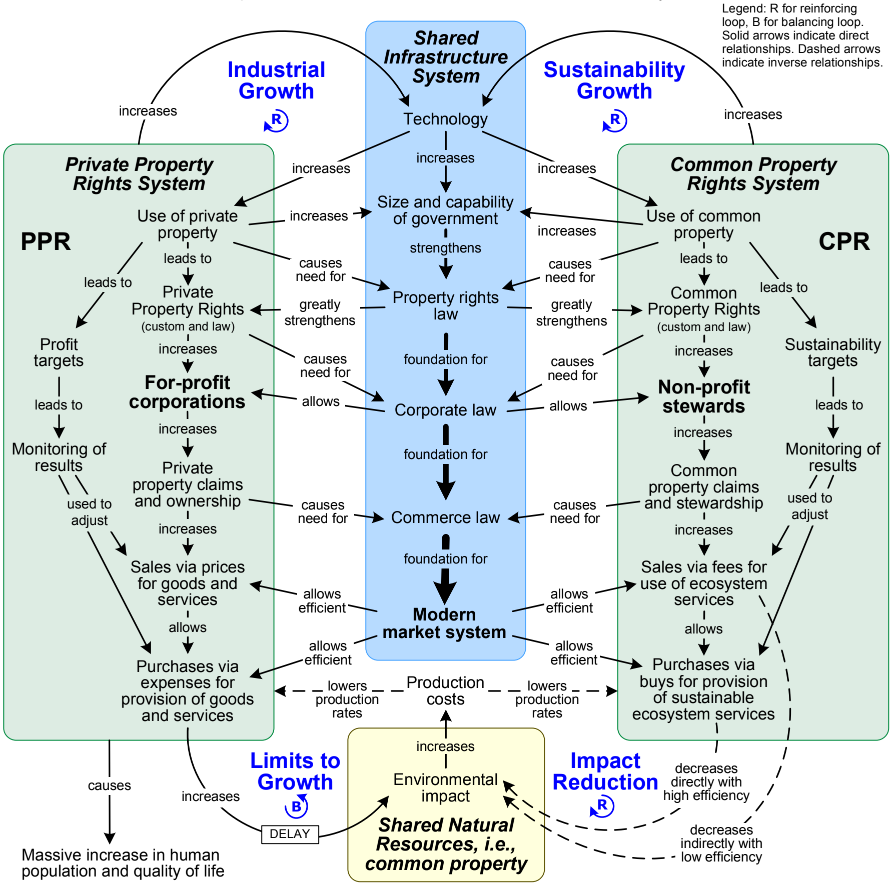
Candidate solution design is based on the undeniable fact that the world's existing PPR system has very high efficiency. By viewing private and common property in terms of their management needs rather than their physical forms, the planet's property management system can be conceptually divided into two symmetrical halves sharing a central backbone. The existing PPR management system, once extracted from the larger amount of the system that can be shared, forms a template for creating the proposed CPR system. Each is the mirror image of the other because of ultra high reuse of existing infrastructure. The CPR system thus designs itself. Its essential components pop out of thin air as those components that form the PPR system are identified.

The CPR system has already partially appeared. <u>Use of common property</u> (node names are underlined) began long ago. Some <u>sustainability targets</u> have been set. <u>Monitoring of results</u> occurs regularly. Let's trace the total system's evolution:

In *Homo sapiens*' hunter gatherer stage, <u>technology</u> was very low. There was little <u>use of private property</u>, such as crude hunting tools and shelters, and low <u>use of common property</u> in the form of the natural resources used for hunting and gathering. That stage lasted from about 200,000 to 10,000 years ago, when invention of agricultural <u>technology</u> changed evolution of the system abruptly.

The World's Property Management System

With emphasis on the evolution and structure of the twin subsystems



Note the shared infrastructure system. This forms the bulk of the management system and is easily shared with the proposed system on the right. The feedback loops show how the left system is causing the sustainability problem and how the right system can solve it. Because of high reuse of proven mechanisms, the solution on the right should achieve the same high efficiency we have long enjoyed from the solution on the left. We are essentially reusing an old system rather than designing a new one from scratch.

The introduction of agriculture radically increased use of private property, use of common property, and the size and capability of government. More efficient food production allowed a ruling class to specialize in governance. This and greater use of private and common property increased property rights law and ability to enforce those laws. This strengthened private property rights and allowed formal private property claims and ownership. It also strengthened common property rights and allowed some formal common property claims and stewardship, like shared hunting grounds, communal forests, and managed community water sources. But from the beginning the CPR system lagged behind development of the PPR system, due to environmental impact delays and poor understanding of ecosystem behavior.

As technology continued to increase, higher use of private property led beyond personal consumption to opportunities for profit. One could produce goods and services and sell them for considerable amounts of personal gain. This led to profit targets for large farmers, master craftsmen, merchants, money changers, and so on. This in turn led to measurement of results. This information was used to adjust a producer's sales via prices for goods and services and their purchases via expenses for provision of goods and services in order to meet their profit targets.

At this point a complete PPR system existed, with one exception. The **managing agent**, the agent who makes the on-the-spot decisions on what should be sold, what prices should be, where purchases should go, etcetera, was still the individual person. They might have employed others, as in cottage industry, master craftsmen, or farm owners and laborers, but they acted as persons. If they died, moved, or failed to pass the business down, it usually disappeared.

As time passed and technology grew still further this changed. Businesses became larger. They began to be sold. Investors began to fund them. Century by century, what became the modern corporation slowly emerged. The granting of guild and corporate charters, such the one to the infamous East India Trading Company in 1600, marked the beginning of corporate law. This allowed for-profit corporations to appear routinely. Because corporations have much lower transaction costs than individuals and allow more specialization, this led to greatly increased sales and purchases. This caused the need for commerce law to allow conducting market transactions in a more orderly manner. Strong and capable governments, plus the laws they provided and enforced, plus the spread of corporations, caused the modern market system to appear. This was an epic event. Price signals, rather than tradition, personal relationships, and barter, began driving economic system efficiency. This allowed exponentially more efficient sales and purchases. The end result, especially since the Industrial Revolution, was a massive increase in human population and quality of life.

But this came at a hidden cost. The world's PPR system became far more efficient than its CPR system. The **Industrial Growth** loop raced far ahead of the **Sustainability Growth** loop, throwing the total system off balance into a state of ominous unsustainability. The **Limits to Growth** loop was silently, usually after a delay, increasing environmental impact. This increases production costs, which lowers production rates.

This brings us to where we are today. Due to an inefficient CPR system the **Sustainability Growth** and **Impact Reduction** loops are weak. As more and more effects of delayed environmental impact appear, production rates will fall. If business as usual continues, eventual environmental collapse will trigger economic collapse.

This unpleasant scenario can be avoided by pushing on the high leverage point of *allow firms to appear to lower transaction costs for managing common property sustainably*. Once property rights law is updated to allow Common Property Rights, a torrent of non-profit stewards will appear because there are so many unsolved environmental problems, not to mention so many dedicated environmentalists looking for altruistic occupations. Just as corporations file claims for minerals, patents, and copyrights, stewards will file claims for unclaimed common properties (like a polluted river or an overused aquifer) whose wise stewardship would benefit the common good.

Once a claim is accepted, the government (with help from the steward, who has some expertise here) sets the sustainability targets for that common property, such as the ambient standard for a pollutant in a sink or the maximum rate of sustainable harvest of a renewable resource. The targets will follow an achievement schedule of increasingly stricter goals, so as to reach 100% sustainability for a common property in a certain number of years. S curves will probably be used. If targets are not achieved a steward loses its claim.

Once a steward's claim is accepted the steward becomes the managing agent. Government no longer plays that role, thus eliminating command-and-control. If an environmental problem is more efficiently managed by government prescriptive regulations, then government would continue as the managing agent and claims would not be allowed.

Stewards are authorized to charge fees for any activity that excessively degrades the health of their common property. Fees are charged at the most efficient places in the system. The fee type is whatever a steward feels works best: flat fees per unit of resource use, seasonally adjusted fees, tradable permits, permit auctions, etc. Fees must be charged in a non-discriminatory manner. Since the CPR system is so far behind the PPR system, special care will be needed for transition to minimize hardship. Once the health of a steward's common property meets its target, fees fall to a very low level, just enough to pay for the costs of monitoring, administration, minor additional R&D, setting up new customers and closing out old ones, etc. This is the maintenance phase of stewardship.

Psychologically and legally, fees are not a tax. They are the price of an ecosystem service.

Authority to charge fees leads to sales via fees for use of ecosystem services. Fee income goes to purchases via buys for provision of sustainable ecosystem services. Buys go to buying anything that will move the health of a common property into its targeted safe zone in time. Examples of buys are administrative overhead, monitoring of ecosystem health, measurement of ecosystem service use rates for charging fees, R&D for new or improved best practices, cost/share for implementation, education, and awareness campaigns. Stewards will frequently pool their buys for greater efficiency, such as joint R&D or transfer of technology to developing nations.

Like prices and expenses, fees and buys are a powerful combination. Fees discourage harmful behavior. Buys buy things that will reduce future fees. By monitoring of results stewards can adjust the level of fees and where their buys go to the approximate optimum required to meet their sustainability targets, just as corporations do with prices and expenses to meet profit targets. A well run stewardship will, in the long run, lower fees to the lowest level humanly possible—just as price curves for new technologies start out high and fall low, usually by one or more orders of magnitude. The net effect will be high **Sustainability Growth** and large amounts of **Impact Reduction**.

Once the CPR system is mature and all necessary claims are well managed, the economic system will be properly coupled to the environment.

How the model explains the mode changes

The first mode change was the Agriculture Revolution. The property management model shows that increases in technology cause increases in use of private property and use of common property. Invention of agriculture caused a huge leap in technology, which caused use of private and common property to soar. Agriculture was such a profound invention it caused the entire property system to start growing, which was impossible before.

The second mode change was the Industrial Revolution. This could not occur until the private property rights system was sufficiently mature. Once it was, the **Industrial Growth** loop could grow much faster than ever before. That's exactly what happened starting around 1800 in England and later in different nations and regions of the world. However, growth of the private property rights system has a side effect: increased environmental impact, which causes the environmental sustainability problem.

The third mode change needs to be the Sustainability Revolution. That will occur when the Common Property Rights system is sufficiently mature. After that the **Sustainability Growth** and **Impact Reduction** loops will grow and the sustainability problem will be solved.

The analysis step

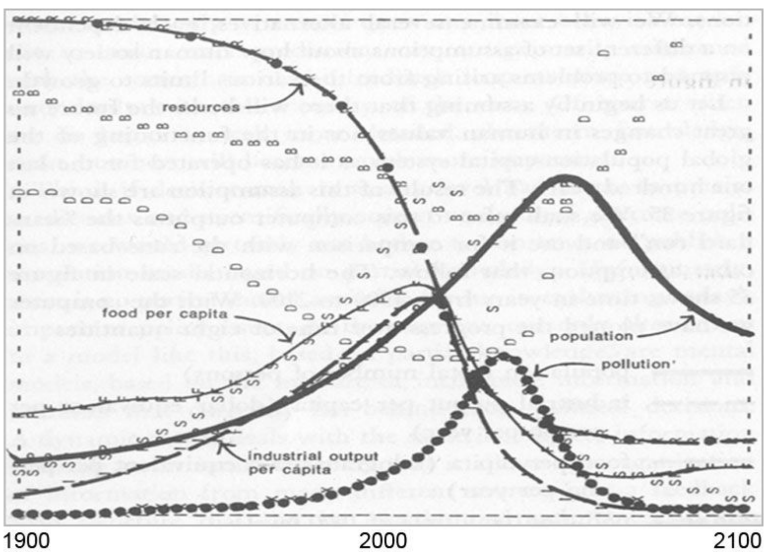
The Property Management System model didn't intuitively appear in a flash of insight. It slowly (and to be honest, painfully) grew out of the analysis step of SIP. First a more traditional IPAT based causal flow diagram appeared in 2007 in a chapter in the *Analytical Activism* book on Common Property Rights. Then in early 2010 a simulation model was built to better understand the analysis. While it exhibited fascinating graphical behavior, the model was weak due to oversimplification and too many exogenous factors (constants) that were estimated rather than measured.

Worse yet, the simulation model didn't provide any new insights. It only confirmed old ones, and not that well because it would have taken a huge calibrated model to do that. For example, it took 17 MIT researchers two years to build the 1972 World3 model. In late 2010, as a paper was being written on resolving the economic root cause with CPR, the diagram appeared. It's been lifted intact from that paper and placed in this chapter, which allowed the chapter to be completed.

The beauty of the diagram lies in how simply and persuasively it supports the analysis step of column D, How to Achieve Environmental Proper Coupling. In column D the world's economic system is improperly coupled to the environment. The subproblem symptoms are that the economic system is causing unsustainable environmental impact. Here are the analysis substeps:

Substep A. Find the immediate cause of subproblem symptoms in terms of the system's dominant feedback loops.

The symptoms and their immediate cause in terms of feedback loops were definitively described by the World3 model of *The Limits to Growth* in 1972. The book went on to become the best selling environmental book of all time, with some 30 million copies sold. The closest runner up is *Silent Spring* with 9 million copies. The reason is *The Limits to Growth* performed substep A so well the world woke up. It had a new mega-problem to solve, as convincingly shown by this graph:



The graph predicted a bleak scenario of the future if business as usual continued. The graph's caption said: (p124)

> The "standard" world model run assumes no major change in the physical, economic, or social relationships that have historically governed the devel-

> opment of the world system. All variables plotted here follow historical values from 1900 to 1970. Food, industrial output, and population grow exponentially until the rapidly diminishing resource base forces a slowdown in industrial growth. Because of natural delays in the system, both population and pollution continue to increase for some time after the peak of industrialization. Population growth is finally halted by a rise in the death rate due to decreased food and medical services.

As striking and sound as the book's message was, something went wrong. The planet is still on track to play the above scenario out because no significant solution to the *complete* sustainability problem is in sight. Why? From the viewpoint of the System Improvement Process there's a simple reason: The process doesn't fit the problem. The predictable results are below:

1. Problem Definition		Done by *The Limits to Growth* in 1972	Actual progress on the global environmental sustainability problem due to using Classic Activism		
			A. Change Resistance	**B. Proper Coupling**	**C. Model Drift**
2. Analysis Spend about 80% of your time here. The problem solving battle is won or lost in this step, so take the time to get the analysis right.	A		?	Dominant loops causing symptoms found by World3 model	?
	B		?	?	?
	C		?	?	?
	D		?	?	?
	E		?	?	?
3. Solution Convergence			?	?	?
4. Implementation			?	?	?

As SIP sees it, problem solvers have completed only 2 out of 22 of the steps in the grid. Both were admirably done by *Limits to Growth* in 1972. But what have the super sleuth's of the world been doing since then? Where are the results for the rest of the process or one something like it? I've searched for years, but they are nowhere to be found. Instead, what we find are the artifacts of Classic Activism, like what *should* be done and *why* we have to do it and *please* let's do it now, because if we don't….

Still, Jay Forrester, the Club of Rome, Dennis and Donella Meadows, Jorgen Randers, and the rest of the 17 person Limits to Growth team pulled off a precocious miracle. They spotted a problem few had noticed and wrestled it into a form that allowed them to complete the first two steps.

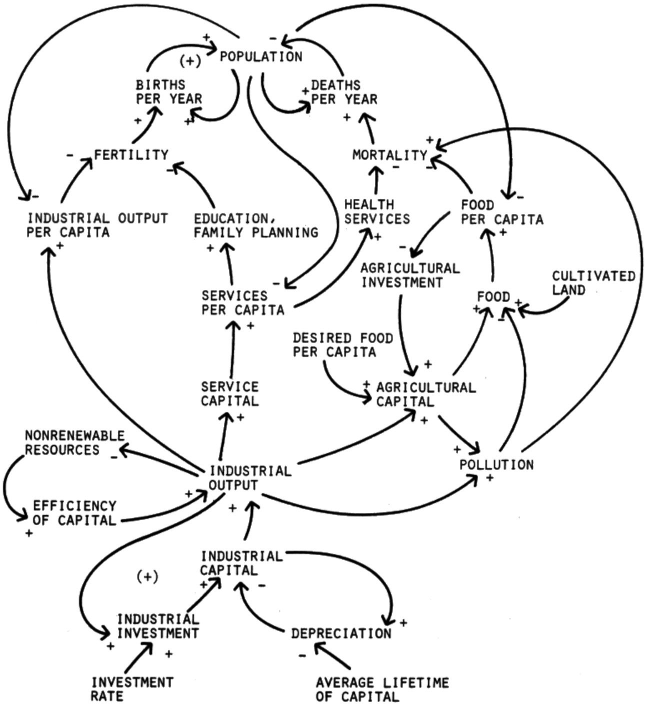


Figure 1-3 Causal-loop diagram of several important feedback loops in World3

Let's see if it's possible to take up where *Limits to Growth* left off.

The World3 model used the forces of the IPAT equation to explain behavior. P is population growth. A is affluence or consumption per capita. T is environmental impact per unit of consumption. World3 modeled these three forces and their resultant impact with basic five sectors: population, capital, resources, agriculture, and pollution. How these work together is roughly shown below: [174]

These feedback loops are the immediate cause of the symptoms of unsustainability. The World3 model and its standard run produces growth, overshoot, and collapse. But what causes these tendencies? What causes industrial output to grow so ravenously? Why is the human system so locked into growth, regardless of future consequences? What is the rock bottom root cause of these loops?

The World3 model provides no clues whatsoever to these questions. That's because it's trying to solve one big problem instead of four little subproblems. The questions cannot be answered by extending the World3 model, unless you prefer an awkward gigantic complex model that no one but its builders can understand. That's why this book uses multiple (and much simpler) models for the different subproblems.

Our model for the environmental proper coupling subproblem is the Property Management System model. It uses a mere two loops to summarize how the economic system impacts the environment. These are the **Industrial Growth** and **Limits to Growth** loops. Now when we ask the questions asked above, all the clues we need to answer them are right there on the model. That's why a process that fits the problem is so productive.

Substep B. Find the intermediate cause, low leverage points, and symptomatic solutions.

The universal consensus among economists is that the environmental sustainability problem is a classic case of market failure. **Market failure** occurs when a market fails to allocate resources efficiently. The consensus is reflected in this statement in *The Stern Review on the Economics of Climate Change* of 2007 by Howard Stern: "Climate change presents a unique challenge for economics: it is the greatest and widest-ranging market failure ever seen."

If the problem is market failure, what's the cause? In a classic statement of market failure theory, in 1958 Francis Bator wrote *The Anatomy of Market Failure.* This paper classified market failure into five types or modes. Bator then turned to causes: "If, however, one looks for an organizing principle not to modes of failure but to causes, there appear to be three polar types: (1) Ownership Externalities, (2) Technical Externalities, and (3) Public Good Externalities." These were examined at length. Works like this established the foundational consensus that externalized costs are the cause of environmental problems.

Today, fifty years later, little has changed. *The Stern Review* contains a section on "Understanding the market failures that lead to climate change" that says:

> In common with many other environmental problems, human-induced climate change *is at its most basic level an externality*. Those who produce greenhouse-gas emissions are bringing about climate change, thereby imposing costs on the world and future generations, but they do not face directly, neither via markets nor in other ways, the full consequences of the cost of their actions. (Stern, 2007, p27, italics added)

But externalized costs are not the root cause. They are the *intermediate cause* because one can legitimately ask what is the cause of externalized costs. Economists, governments, and activists of all types have not done that. Instead, they stopped as the first plausible cause and assumed that was the root cause.

The *low leverage point* for resolving the intermediate cause was obvious. It was to internalize the costs.

Now then, how have classic activists, including economists, gone about doing that? At the system level, solutions to the environmental sustainability problem fall into two main groups: prescriptive regulation and market-based solutions like pollution taxes and cap and trade. But these are *symptomatic solutions* because they don't resolve the root cause. They only resolve the intermediate cause.

Substep C. Find the root causes of the intermediate causes.

Substep A found that dominance of the **Industrial Growth** and **Limits to Growth** loops is the immediate cause. Substep B found the intermediate cause of this is too many *externalized costs of environmental impact*. What's the root cause of that?

Let's begin by studying our model. Why are the **Industrial Growth** and **Limits to Growth** loops so dominant? Dominance is relative. What's weak is the **Sustainability Growth** and **Impact Reduction** loops. Why are they weak?

The answer to that question has been sitting in plain sight for over seventy years. In 1937 Ronald Coase published *The Nature of the Firm*. In it he posed a question no one had seriously asked before: Why do firms appear? In theory the price mechanism should work equally well for organizations or individuals. But Coase asked:

> …why is such organization necessary? Why are there these "islands of power"? Outside the firm, price movements direct production, which is coordinated through a series of exchange transactions on the market. Within a firm these market transactions are eliminated, and in place of the complicated market structure with exchange transactions is substituted the entrepreneur-coordinator, who directs production.

Coase showed that firms appear because "Within a firm these market transactions are eliminated." This increases economic efficiency, which allows a firm to sell its output at a lower price and still be profitable. This opportunity attracts entrepreneurs and investors. From this arises the principle that *firms appear when there is a profitable opportunity to lower transaction costs*.

But firms have not appeared to manage unsustainably managed common-pool resources. Why? Because transaction cost are so sky high they cannot enter the market. We have therefore found the economic root cause. It's *high transaction costs for managing common property sustainably*.

According to Coase **transaction costs** are "the cost of using the price mechanism" or "the cost of carrying out a transaction by means of an exchange on the open market." There are two types of costs in a firm: transformation costs and transaction costs. **Transformation costs** are the costs of converting inputs into outputs. This is the actual cost of making a product or service. Transaction costs are the costs of using market transactions to sell your output or buy someone else's. Examples of transaction costs are the cost of finding out where to get it, the cost of determining the quality of the product, the cost of bargaining, the cost of contracting, and the cost of payment. Added up, these can be substantial.

Let's define **technology** as any practice that will reduce the PAT factors in the IPAT equation. "New technology" means more sustainable technology. For the sustainability problem transactions costs occur in areas like these:

1. Searching for the most cost effective existing technology.
2. Contracting and managing creation of needed new technology.
3. Education on the implementation of new technology.
4. Cost/share programs for new technology introduction.
5. Transfer programs to developing countries for use of new technology.
6. Monitoring a source's amount of environmental impact.
7. Enforcement of contracts, regulations, permits, etc.
8. Design, lobbying, drafting, negotiation, etc. of related new legislation.
9. Research to identify and organize common property problems.
10. Research to set sustainability targets for common property problems.

Presently these costs are high because they can't be conducted inside a firm. Instead, to solve an environmental problem the above transactions have to be conducted by the many individual parties involved: politicians, government agencies, local authorities, the sources causing environmental impact, NGOs, individuals interested in solving the problem, and so on. It's a transactional mess.

Another way to see why transaction costs for managing common property are high is to study the Common Property Rights system in the Property Management System model. In the CPR box there are seven nodes. The top one, <u>use of common property</u>, is what needs managing within a firm. But due to lack of legal Common Property Rights firms can't appear to perform the other six nodes. Instead, these are awkwardly and expensively performed in the manner described above by many different social agents.

The five requirements for a root cause (plus other material on column D not included in this chapter) are covered in a paper in progress titled *Resolving the Economic Root Cause of the Environmental Sustainability Problem with Common Property Rights.*

Substep D. Find the feedback loops that should be dominant to resolve the root causes.

These are easily found by examination of the Property Management System model. To counteract the dominance of the two loops on the left, the two loops on the right need to be the dominant loops in the system. They need to be stronger than the loops on the left or the system as a whole will continue to operate unsustainably.

The loops that should be dominant are thus **Sustainability Growth** and **Impact Reduction**.

Substep E. Find the high leverage points to make those loops go dominant.

The root cause is high transaction costs for managing common property sustainably. How can those costs be lowered? Ronald Coase has the answer. *The Nature of* *the Firm* discovered the principle that firms appear when there is a profitable opportunity to lower transaction costs. The right kind of firm will lower those costs. Therefore the high leverage point is to *allow firms to appear to lower transaction costs*. It's that simple.

Note how easily the five analysis substeps were performed. None seemed hard at all. Why? Because we had the right model of the problem. Why was that? Perhaps because we're following a process that fits the problem.

The work of Hernando de Soto

In mid 2010 while writing this book I discovered the work of Hernando de Soto. De Soto is a Peruvian economist who's been working on the same problem Moritz Thomsen was working on in *Living Poor*: the world's poverty problem. What stunned me is de Soto found the same root cause I did: high transaction costs. In the sustainability problem the economic root cause is high transaction costs for *common* property. According to de Soto, in the poverty problem the general root cause is high transaction costs for *private* property. Why? Because in undeveloped nations there is no workable private property system for the poor.

De Soto summarized his work in 2000 in *The Mystery of Capital: Why Capitalism Triumphs in the West and Fails Everywhere Else*. The back cover states his central conclusion:

> Why do some countries succeed at capitalism while others fail? In strong opposition to the popular view that success is determined by cultural differences, de Soto finds that what creates capital in the West is a process buried deep in the legal structure of its property systems. Every developed nation in the world at one time went through the transformation from predominately extralegal property arrangements, such as squatting on large estates, to a formal unified legal property system. In the West we never realized that capital is a dormant value hidden in the assets and talents we own and which legal property bring to life.

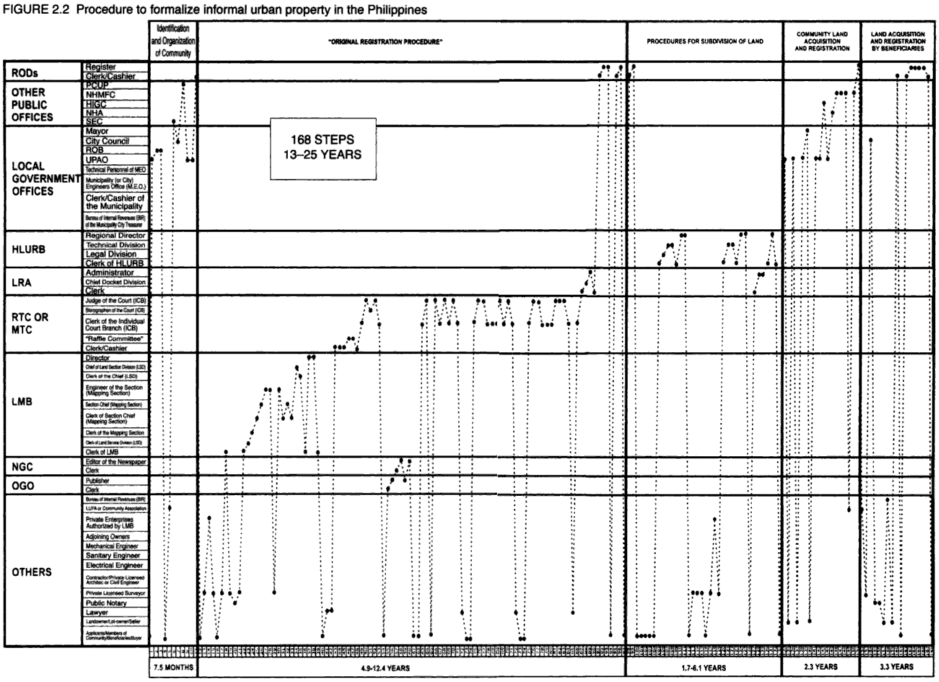
Late in his book de Soto explores why property rights are needed. This leads to his root cause of why "capitalism triumphs in the West and fails everywhere else." His conclusion is the same as mine: (p219)

> A good legal property system is a medium that allows us to understand each other, make connections, and synthesize knowledge about our assets to enhance our productivity. … By representing economic aspects of the things we own and assembling them into categories that our minds can quickly grasp, property documents reduce the costs of dealing with assets and increase their value commensurately. This notion, that the value of things can be increased by reducing the costs of knowing them and transacting with

others, is one of Nobel laureate Ronald Coase's major contributions. In his treatise *The Nature of the Firm,* Coase established that the costs of carrying out transactions can be substantially reduced within the controlled and co-ordinated context of a firm. In this sense, property systems are like Coase's firm—controlled environments to reduce transaction costs.

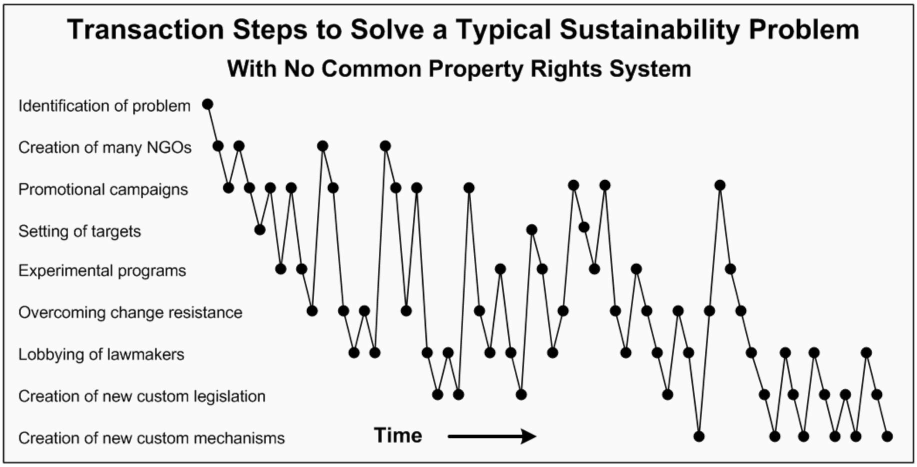
The Mystery of Capitalism contains several graphs of the transaction costs for carrying out a private property transaction. For the poor living outside the legal system, the way inside is to gain formal legal rights to private property. On pages 22 and 23 is the graph below:

FIGURE 2.2 Procedure to formalize informal urban property in the Philippines



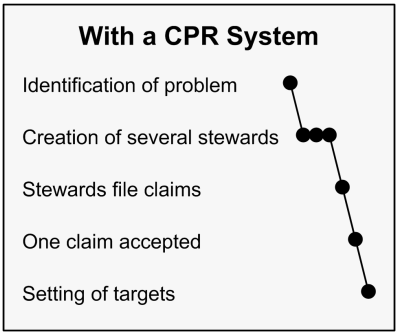
Each dot on the graph is a transaction cost. It takes 168 steps and 13 to 25 years to formalize informal urban property in the Philippines. Total costs are so high and take so long the process is rarely performed. The result, in de Soto's words, is an insurmountable "paper wall" preventing the poor from beginning solution of their poverty problem. *The Times* of London agreed, calling the book "The blueprint for a new Industrial Revolution."

What struck me about de Soto's graphs was the same pattern occurs in the sustainability problem. There the issue is common rather than private property. Currently environmental activists face the same paper wall the world's extralegal poor do. They can't help anyone gain legal management of common property in order to manage it sustainably and efficiently. If we graphed that paper wall it would look about like this:



These steps are so long and expensive that most sustainability problems are never solved. Activists give up long before the end of the above process.

But that could change if we pushed on the high leverage point of *allow firms to appear to lower transaction costs* for managing common property. This can be done with Common Property Rights. Then the graph would look more like this smaller one:



What a difference. Transaction costs are an order of magnitude lower. After the last dot on the graph the remaining transactions occur inside a firm. Stewards then play the same role as corporations. That role works, which is why a sufficiently mature Common Property Rights system will lead to the Sustainability Revolution.