Operationalizing Systems Thinking and System Dynamics Principles, Methods, and Tools in Government Policy and Management

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ABSTRACT
This paper addresses the 32nd International Conference of the System Dynamics Society theme of Good Governance in a Complex World—from global to village to K-12 school levels—with examples and lessons learned through the author's application of systems thinking and system dynamics principles, methods, and tools in different settings. Five 'vignettes' are presented: (1) Strategic Planning in Honduras; (2) Sustainability Planning in Hawaii, (3) Development Project Evaluating in Guatemala, (4) Rio+20 Global Sustainability Planning; and (5) A First Carrying Capacity Exercise for 6th Graders and Teachers. The paper includes basic causal loop diagrams and stock and flow maps. A premise of this document is that both in spite of—and because of—the many relative advances in knowledge, communications, technology, and so on, during especially the past several hundred years, globally we are increasingly in a Titanic-after-it-has-struck-the-iceberg situation. It is argued that even when system dynamics has been successfully employed to help explain complex sustainability issues, such as limits to growth and causes and effects (causes) of climate change, and as an aid in identifying potential solution leverage points—the net result has generally been too little, too late relative to the increasing (magnitude and velocity of) global environmental unsustainability trends. Why? What to do? Read on…

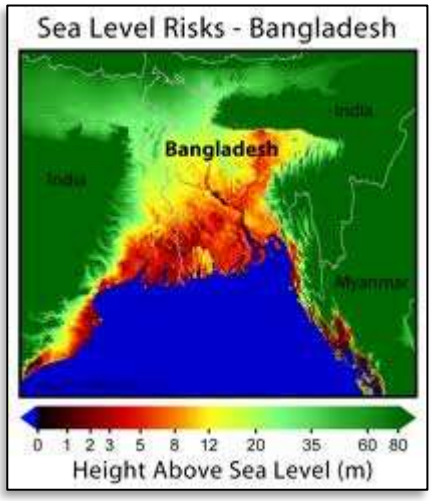
KEY WORDS: un-sustainability, de-growth, climate-change, governance, policy-making, equity, systems thinking/dynamics, positive feedback

1 INTRODUCTION

The author has realized in the course of putting this paper together that a title truer to its evolved meaning would be: *Too Little, Too Late? Global Environmental Sustainability Lessons (Not) Learned, Including in the Systems Thinking and System Dynamics Professions.* As the author believes the reader will agree, this title better represents the author's core systems thinking and system dynamics (ST/SD) experiences and his syntheses of lessons learned over the past four decades—through to mid-2014—many of which are presented in this paper.

The original title, which could not be changed before the paper's presentation in the July 2014 System Dynamics Conference in Delft, the Netherlands, nevertheless remains valid to the extent that all of the systems thinking and system dynamics lessons not learned covered in this paper are intimately connected in positive and negative feedback fashion to—and from—failure to operationalize systems thinking and system dynamics principles, methods, and tools in fundamental government policy and management

processes. This realization, along with recommendations for addressing the associated challenges—is discussed in the *Conclusions* section.



In conjunction with the theme of this conference—*decision-making to solve real world problems using system dynamics principles, tools, and methods*—a central premise of this paper is that the global social-economic-environmental *system* has overshot Earth's carrying capacity and is proceeding to well-documented collapse,[1] in spite—and because—of the many advancements in knowledge, communications, technology, etc., during the past several hundred years. A further premise is that systems thinking principles, methods, and tools—and, importantly, social-ecological-economic, policy-maker, 'sustainability,' education (K-12 and university), and other ST/SD practitioners—have not contributed meaningfully enough to the need for a dramatic slowing of the world's growing unsustainability and inequity challenges, as for example discussed in *A Prosperous Way Down* (Odum & Odum, 2001) and others.

Since the 1970s, the best-known system-dynamics-based attempt to explain the global unsustainability trends and to warn the common citizen, educator, entrepreneur, policy maker, and so on—has been *The Limits to Growth* studies (Meadows, Meadows, & Randers, 2004). However these—as well as non-system dynamics-based initiatives, including *Our Common Future* (World Commission on Environment and Development, 1987) and sequels, and *Agenda 21* (United Nations, 1993)—(with important minor exceptions)[2] have not been translated into sustained, proportionally effective mainstream policy-making at any level.[3]

This paper argues that we—'the Planet'—are in a Titanic-*after*-it-has-struck-the-iceberg situation (1912),[4] or if the reader prefers, a US Airways crash-landing-in-the-Hudson-River (NY, USA) situation (2009),[5] or more recently (2014), the Governor of California's (USA) (population 37+ million, in 2013)[6] declaration of drought emergency (2014),[7] or—projected—Bangladesh sea-level rise displacing over 20 million people by 2050.[8]

One of several systems thinking vignettes (*Rio+20 Global Sustainability Planning*) that make up this paper maintains that even when system dynamics has been successfully employed to help explain -and illustrate- the moving dynamics of complex phenomenon such as limits to growth and causes and effects (causes) of climate change, and as an aid in identifying potential solution leverage points—disappointingly, the net result has been **far too little, too late** relative to the well-documented, accelerating global unsustainability trends (The Worldwatch Institute, 2013), (Hamilton, 2010), (Kunstler, 2005), (Meadows, Meadows, & Randers, 2004), (Odum & Odum, 2001), etc.

Although small numbers of academics, intellectuals, planners, environmental consultants, and others enthused by the system dynamics approach and related research,

lead or participate in organizations promoting sustainability,[9] as well-meaning as they/we may be, even these dedicated professionals might question their continued promotion of a global sustainability paradigm on a sinking ship, particularly given that the outcome in the simplest to the most complex 'sustainability' system dynamics models since 1972 has been *overshoot and collapse*—a phase we have been moving *not toward*, but *deeper into* for over a century. (See previous references and Section 2.5: *A First Carrying Capacity Exercise for 6th Graders and Teachers*, on page 17).

The material in this paper is thus meant to stimulate debate, further reflection, and especially *action* to radically improve the dissemination and use of systems thinking/system dynamics principles, methods, and tools in participatory global sustainability/carrying capacity problem analysis and planning, and in policy formulation and education—action that is pertinent to the growing momentum of unsustainability and inequity trends, and that takes into account that we are aiming at an accelerating target.

2 SYSTEMS THINKING VIGNETTES

The author's fascination with—and respect for—systems thinking and system dynamics (ST/SD) began with his in-depth exposure to the original *Limits to Growth* study (Meadows, Meadows, & Randers, 1972), which was based on the first dynamic computer model of interrelated social, economic, and environmental challenges (causes) affecting Earth and humanity over time. The author has used systems thinking principles, methods, and tools—including system dynamics modeling at a basic level in his international development work since approximately 1990, as well as in relief and development consulting, and in K-12 to university level education since 2000.

Five short stories—*vignettes*—follow. These represent practical situations in which the author has employed systems thinking and system dynamics (ST/SD) principles, methods, and tools to help others and himself better understand what lay behind complex problems, why these problems were often so difficult to resolve, and to identify possible solution leverage points—all facilitated by the visual, participatory approach of causal loop diagramming, behavior-over-time graphing, and stock and flow mapping promulgated by especially Jay Forrester, Barry Richmond, and Peter Senge.

Each vignette concludes with a list of lessons learned. The *Conclusion and Recommendations* section (page 23), following the last of the five vignettes, addresses the operationalization of ST/SD lessons unfortunately not learned.

2.1 CARE-HONDURAS STRATEGIC PLAN

While serving as Assistant Country Director for Programs in CARE-Honduras in 1990, the author contacted Barry Richmond, founder of High Performance Systems (now isee systems)—who produce STELLA and iThink modeling software—about a proposed approach the author had for using the systems thinking paradigm and related problem analysis methods to better understand development issues and their causes (or 'causes of causes,' as Barry Richmond would rightly say)—and to prioritize possible solutions in

that systems thinking visual, participatory ‘way’—in the Central American country of Honduras.

We discussed the idea and the state of the world at the time, and the author asked Barry if HPS would be willing to co-facilitate a pilot strategic problem analysis workshop sponsored by the Government of Honduras, CARE, Save the Children-UK, and Catholic Relief Services—in Tegucigalpa, the capitol of Honduras. He agreed, and—on a pro-bono basis—provided several HPS experts to train over 50 people—mostly Hondurans—in systems thinking basics, with the trainees using the systems approach to explore Honduras's intertwined social, economic, and environmental trends.

The result was a workshop with a heterogeneous group of participants (women, men, community leaders, regional and urban planners, etc. It was everyone’s first exposure to systems thinking and system dynamics...and all were enthusiastic about the stocks-flows, feedback, delays method of problem solving, compared to the 'laundry list' (Richmond) approach they were accustomed to.

The workshop produced maps of key interrelated Honduran population growth, education, deforestation, water per capita, and other trends, and where the trends might ‘go,’ given different assumptions and policy scenarios. Leverage points were also identified for special attention in terms of prioritizing potential long-term interventions.

A similar participatory systems thinking workshop—but using causal loop diagramming methodology exclusively—was conducted four years later that focused on Tegucigalpa, following a devastating hurricane. It was co-facilitated by representatives of Strategic Clarity (www.instituteforstrategicclarity.org)—experts in collaborative causal loop diagramming (diagrams in which the causes were logically weighted) and renowned urban planner, John Fregonese (www.frego.com)—all on a pro-bono basis. It too, was a success.

2.1.1 LESSONS

The Honduras planning exercise lessons were:

1. Systems thinking and system dynamics principles, methods, and tools can and should be made available to “the people”, including those with limited formal education, as an aide to analyzing development problems and identifying potential solutions.
2. When properly facilitated, systems thinking principles, methods, and tools can serve as an effective “equalizer” between people of different socio-economic backgrounds, genders, ages, political parties, and so on—as they analyze complex sustainability and livelihood security issues, including water and sanitation, food, shelter, income, physical safety, education, etc., in a visual, participatory (e.g., small groups/teams followed by plenary presentations and Q&A) manner.
3. The basic systems thinking methods—particularly causal loop diagramming, behavior-over-time graphing, and stock and flow mapping—contribute to better and more rapid understanding of changing development problems and opportunities over time, given different assumptions and scenarios—compared with the usual brainstorming/laundry-list approach.

4. Systems organizations such as High Performance Systems ('isee systems' today)[10] can play a critical role in international development at all levels—global to village—merely by sharing their expertise in systems thinking and system dynamics with development organizations and their partners.
5. There is a critical need for many more people engaged in policy making, management, development organization (NGO) leadership, etc., to be even minimally aware of what systems thinking and system dynamics is and how it can contribute to solving development problems.
6. Even following successful, practical strategic planning initiatives involving systems thinking principles, methods, and tools—as in Honduras—it is difficult to institutionalize systems thinking in a meaningful way, whether by an NGO, its government partners, donors, or—especially—the development program (e.g., water and sanitation, small enterprise, agroforestry, livelihood security, etc.) participants. This is largely because systems thinking/system dynamics was not –and still is not– nearly as ubiquitous as it needs to be.

2.2 HAWAII 2050 SUSTAINABILITY PLAN

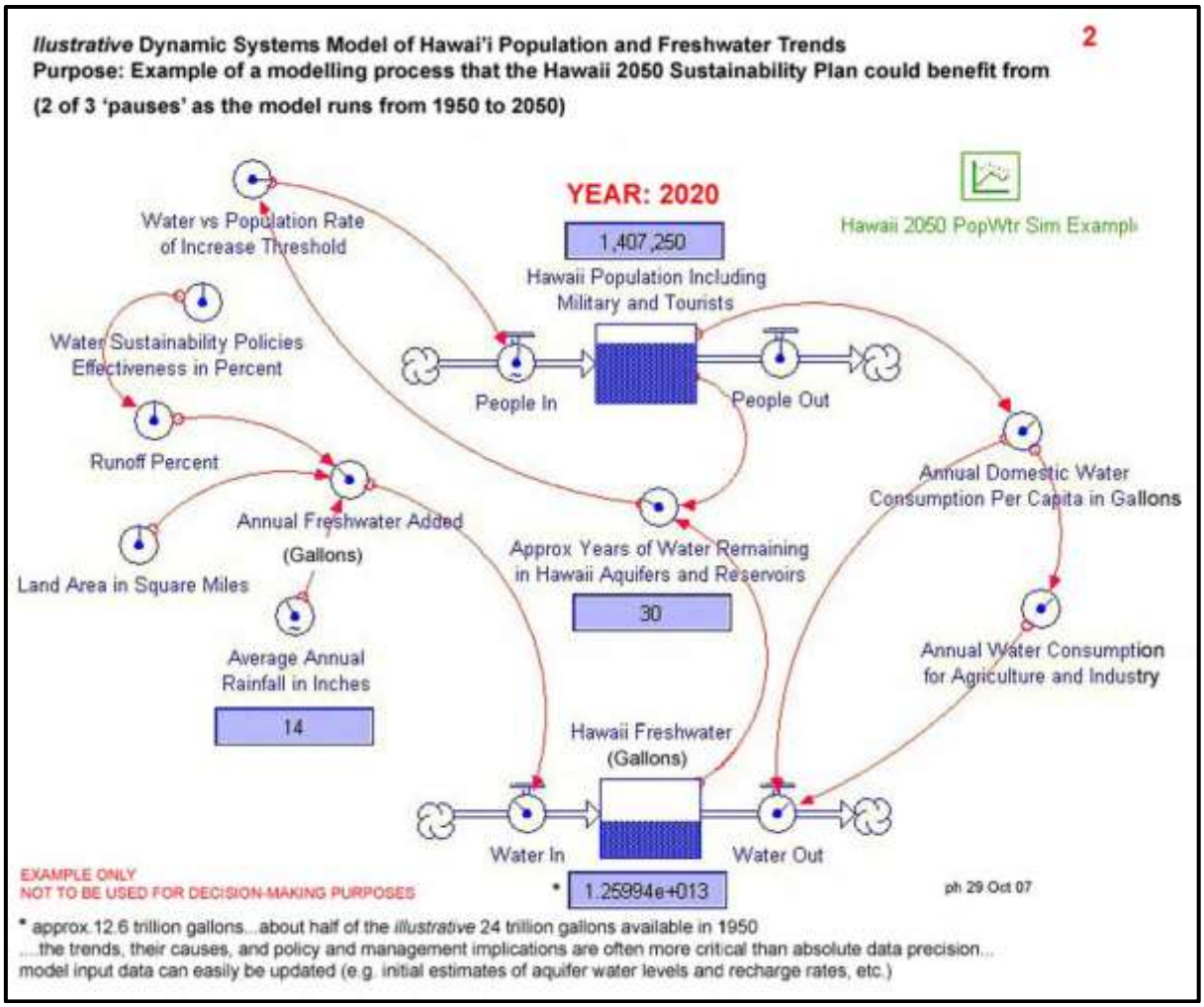
In 2007, the author voluntarily reviewed the State of Hawaii *Draft 2050 Sustainability Plan* and submitted his findings to the Hawaii 2050 Sustainability Task Force, various state and county-level planners, and as public testimony to the Hawaii State Legislature. The author made extensive use of ST/SD principles, methods, and tools in testing the tentative analyses, conclusions, and recommendations of the *Draft 2050 Sustainability Plan* authors, who had not employed any ST/SD principles, methods, and tools in this critically important project.

> The author's report—*Recommendations: Hawaii 2050 Sustainability Plan, Including the Legislative Review and Startup Phases*—is available upon request.

Aided by a simple STELLA model using publicly available rainfall and aquifer data, water consumption estimates, population projections, and other data—one of the author's key findings was that Hawaii could run out of potable water by 2050. The author included the model and projections in his report, emphasizing that the findings were meant to be illustrative only and that the point the author was attempting to make was that system dynamics expertise, principles, methods, and tools such as the ones the author was demonstrating—ought to be employed in developing a more robust *Hawaii 2050 Sustainability Plan*.

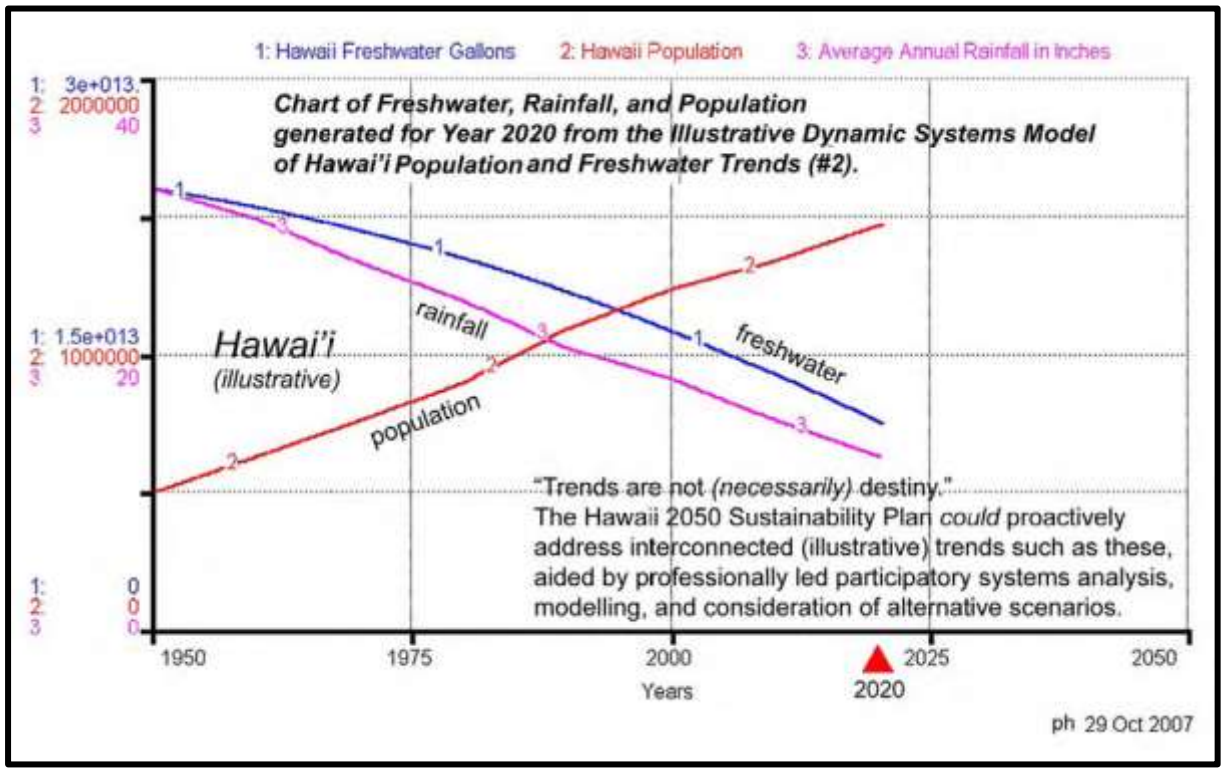
> One suggestion the author made was: *Given the nature of their proposed responsibilities in moving Hawaii 2050 forward, it is recommended that the Hawaii 2050 Coordination (or core) teams should have or develop basic systems thinking capabilities.* (PH)

Following is the second of three screenshots included in the author's findings regarding freshwater trends in Hawaii:



…and these projections resulting from the preceding model:

Hawaii Water and Population Trends (Illustrative)



2.2.1 LESSONS

The lessons from the author's critique of the *Draft Hawaii 2050 Sustainability Plan* were:

1. The absence of ST/SD expertise, principles, methods, and tools contributed to a flawed plan, with the exclusion of potential freshwater shortages being but one example.
2. Had ST/SD principles, methods, and tools—combined with a logical sustainability systems model/template, such as Leon Braat's *A Systems Ecological Model of Global Development* (Braat, 1995)—also included in the author's report—been used in the planning process, the planning team would likely have discovered early on that the initial long-term strategy was not remotely 'sustainable.' This realization would have enabled the planners to identify potential leverage points to address the key integrated **un**sustainability issues over time, resulting in a more reliable roadmap through inevitable difficult times facing the State of Hawaii.
3. Even the visual, transparent "logic" of a Hawaii water-focused system dynamics model with several stocks and flows -using publicly available data- wasn't enough to move the Hawaii 2050 Sustainability Plan team nor its political and other sponsors—to question important plan conclusions, much less the need for professionally facilitated cross-disciplinary, multi-stakeholder ST/SD analysis. An irony (and sign of incompetence/delinquency on some level) of the 'plan' as conceived—was that, being an official 'State Plan', it simultaneously perpetuated

the status quo and a sustainability myth for the Hawaiian Islands, thereby materially contributing to tragic overshoot and collapse[11] probably well before 2050.

2.3 NGO PROJECT MID-TERM EVALUATION/GUATEMALA

From 2000 to 2012+ the author was engaged as an international development consultant in Asia, Africa, and Latin America. The author used systems thinking principles and methods to good effect in all of his overseas consulting work. In 2010 the author was team leader for an integrated food security project mid-term evaluation in Guatemala. The project was managed by a distinguished international NGO.

Photo Credit: Mauro Tartaglia, Save the Children

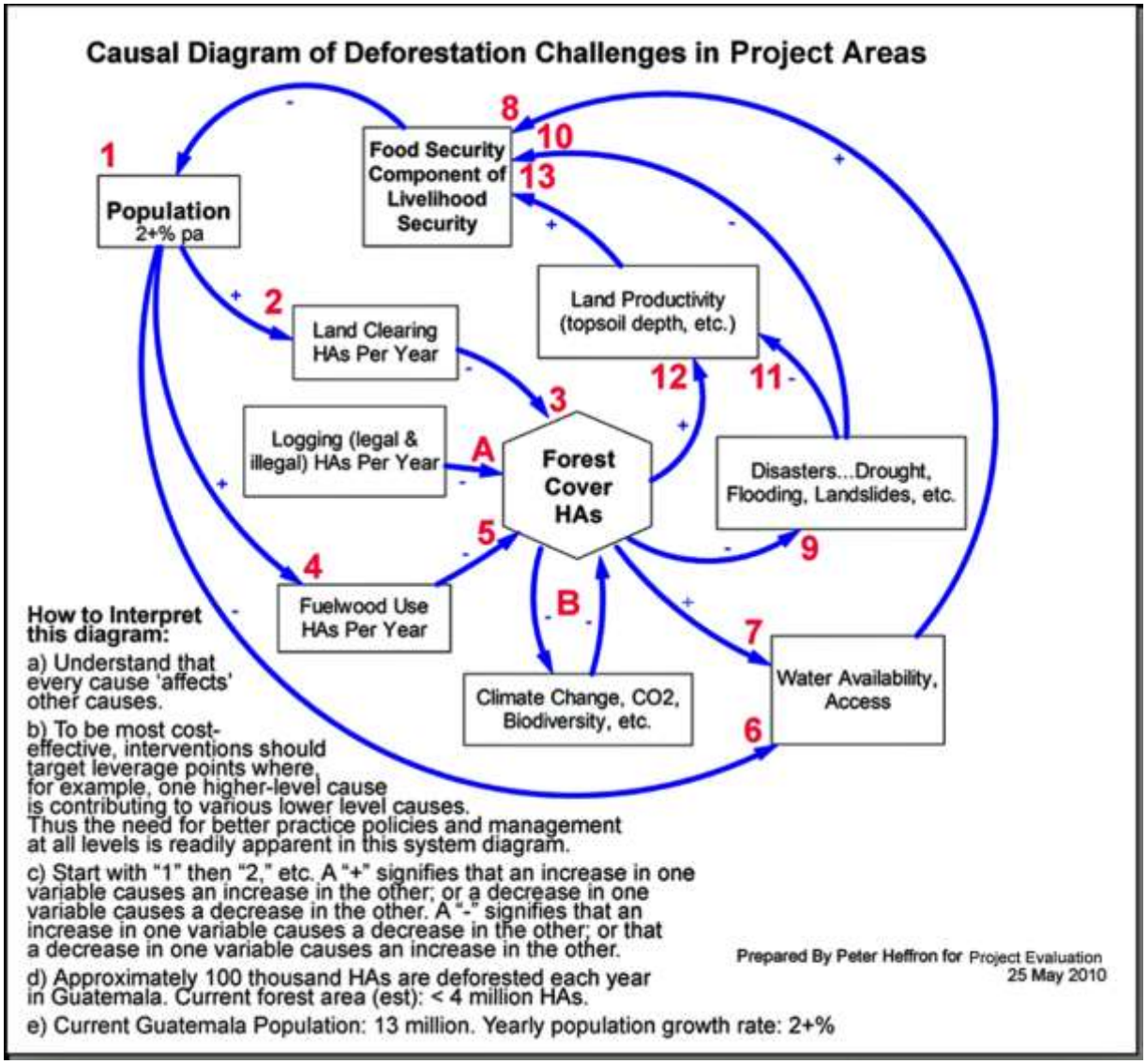
One of the evaluation findings was that indigenous rural communities as well as municipal towns in the project area in rural Guatemala were facing increasingly serious water shortages, adversely affecting health, agriculture, and more. Use of systems thinking principles, methods, and tools helped our assessment team better understand the interrelated dynamics of commercial water companies buying up water rights, deforestation, erosion, falling water tables, population growth, reduced harvests, migration to cities, and so on.

Once the assessment team was able to see what appeared to be the main causes of causes and their effects over time, we were able to share that analysis in draft form with representatives of the various stakeholders for their further input, validation, and assistance in identifying potential solution leverage points.

Many of the stakeholders were illiterate, as well as mistrusting of the foreigners (including some non-Mayan Guatemalans) in their midst, yet after a brief orientation to the neutral 'language' of systems thinking, they easily engaged in validating and often questioning the causal loop diagram relationships, and suggesting changes and additions; changes which the evaluation team accommodated in their presence—to their unhidden glee. (The evaluation team was assisted by Spanish-local dialect translators).

The evaluation process included a formal presentation of the evaluation findings and recommendations to the NGO responsible for project implementation, the international donor, and Government of Guatemala representatives. The author included in his part of the presentation the illustrative results of a basic deforestation systems model to emphasize the urgency of addressing some of the evaluation findings. Using publicly available, fairly reliable data (ranges were used to take into account data variances and

uncertainties), the illustrative model showed Guatemala having no forest cover and becoming largely semi-arid in just 20 years. See below:



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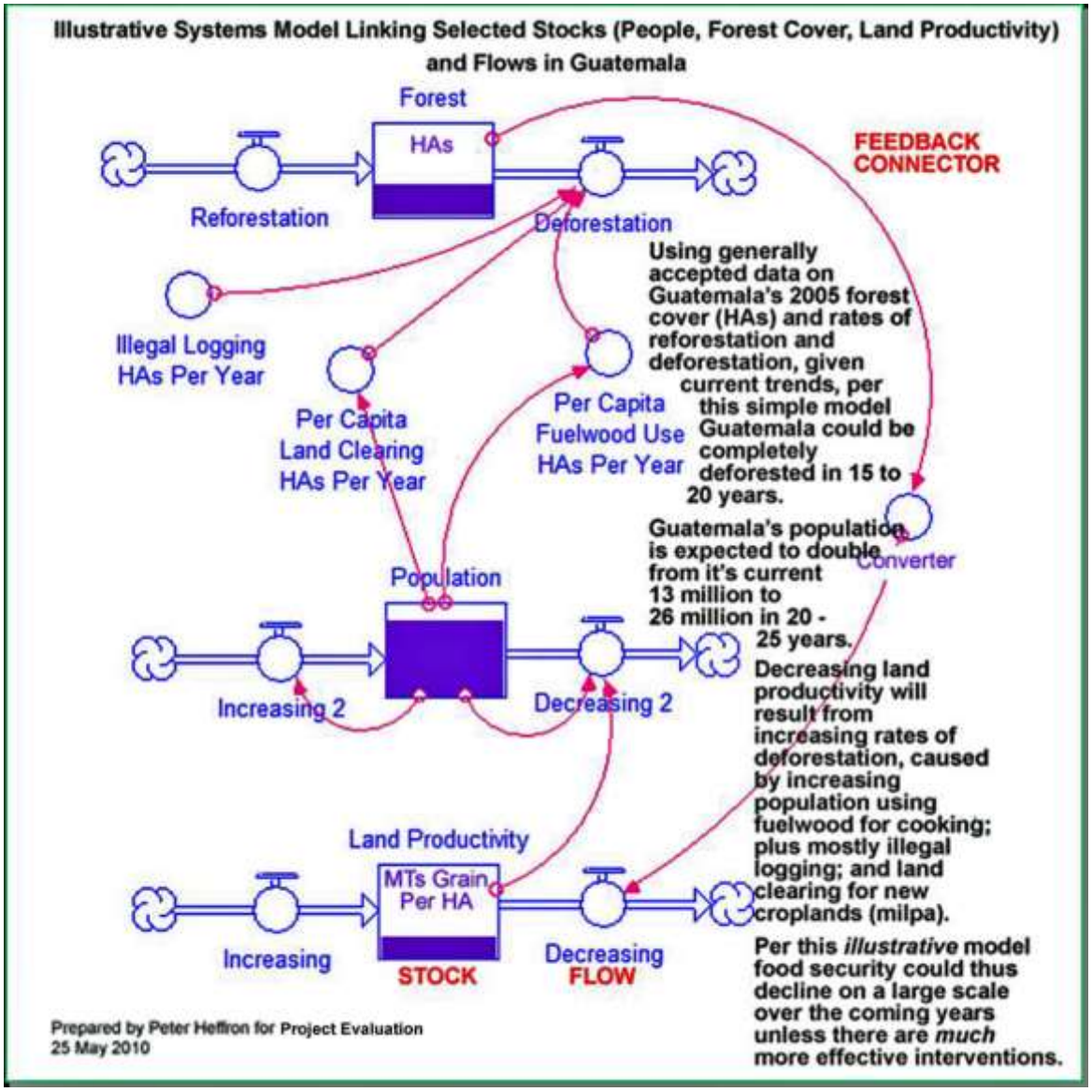
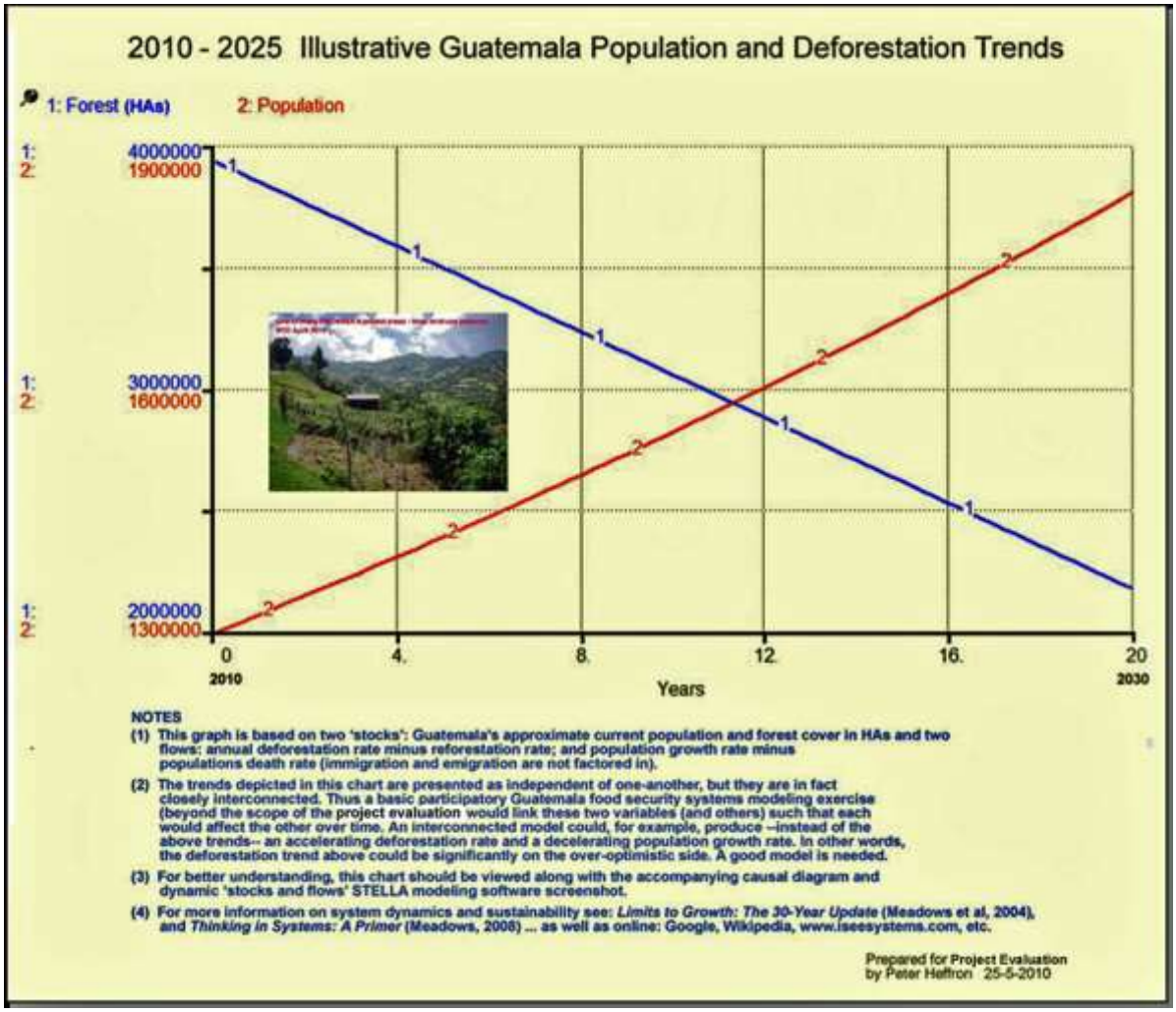

Illustrative Systems Model Linking Selected Stocks (People, Forest Cover, Land Productivity) and Flows in Guatemala
Forest
HAs
Reforestation
Deforestation
FEEDBACK CONNECTOR
Illegal Logging HAs Per Year
Per Capita Land Clearing HAs Per Year
Per Capita Fuelwood Use HAs Per Year
Using generally accepted data on Guatemala's 2005 forest cover (HAs) and rates of reforestation and deforestation, given current trends, per this simple model Guatemala could be completely deforested in 15 to 20 years.
Converter
Guatemala's population is expected to double from it's current 13 million to 26 million in 20 - 25 years.
Population
Increasing 2
Decreasing 2
Decreasing land productivity will result from increasing rates of deforestation, caused by increasing population using fuelwood for cooking; plus mostly illegal logging; and land clearing for new croplands (milpa).
Land Productivity
MTs Grain Per HA
Increasing
STOCK
Decreasing
FLOW
Per this illustrative model food security could thus decline on a large scale over the coming years unless there are much more effective interventions.
Prepared by Peter Heffron for Project Evaluation
25 May 2010

And…



2.3.1 LESSONS

The lessons from the Guatemala Project Evaluation were:

1. Combined with other best practice project evaluation techniques—experiencing first-hand the work/living environments of project staff, partner organizations, and especially project participants—even basic systems thinking/dynamics expertise principles, methods, and tools are invaluable for analysis of social, economic, environmental, and policy trends and interventions over time.
2. Relatively simple system models—and especially model building with heterogeneous stakeholders—permits stakeholders, including villagers, to more easily buy into "what if" problem solution scenarios incorporating explicit assumptions, policy implications, and risk analysis. (One does not need a Ph.D. in system dynamics to operationalize ST/SD principles, methods, and tools. An illiterate Chorti Indian female head-of-household earning one dollar per day 'gets' ST/SD—no worries.)
3. Even if not 'provably' accurate—if presented as "illustrative", with all inputs and outputs easily accessible, basic models can demonstrate development issues changing over time, and thus the need to consider means of addressing longer-

term causes of linked moving targets, rather than the usual practice of focusing on one-off static, short-term manifestations of problems, followed too often, reflexively, by 'fixes that fail'.[12]

2.4 RIO+20: GLOBAL SUSTAINABILITY PLANNING

In February 2013, the author produced a draft paper—*Rio+20 Conference on Sustainable Development Malfunction: If Only We Had Used a Better Approach.* The paper included the following sections—each concentrated on a crucial element absent from the process and/or the results of the Rio+20 Conference:

- *Systems Thinking—Not Employed*
- *Not 'Sustainable' Development and Further Growth—But De-Growth*
- *'Long Emergency'* (Kunstler, 2005) *Planning—Missing*
- *Principles of Physics, Ecology, and Human and Social Behavior—Not Taken Into Account*
- *Risk Analysis—Absent*
- *Not 'Smile-Or-Die'* (Ehrenreich, 2009) *False Optimism—But Reality-Neutral*

Rio+ 20: What Happened?
Sources: www.achama.org
and www.allvoices.com/cartoons

The author incorporated feedback on versions of the draft paper received from fellow members of Linked-In's Systems Thinking World Discussion Group and the Systems Thinking World editors. The draft (still unpublished) paper deliberated on the widely felt post-Rio+20 Conference let-down (Yglesias, 2012), implications for accelerating global unsustainability and inequity, and critical (but likely too late) planning improvements needed for a more successful conference "next time" (Rio+30 in 2022?).

The author's Rio+20 research on this topic resulted in (for the author anyway) a revelation regarding how the human brain is apparently "wired" in such a way as to restrict our ability to analyze and solve complex problems—with or without ST/SD.

The author quotes from his Rio+20 paper:

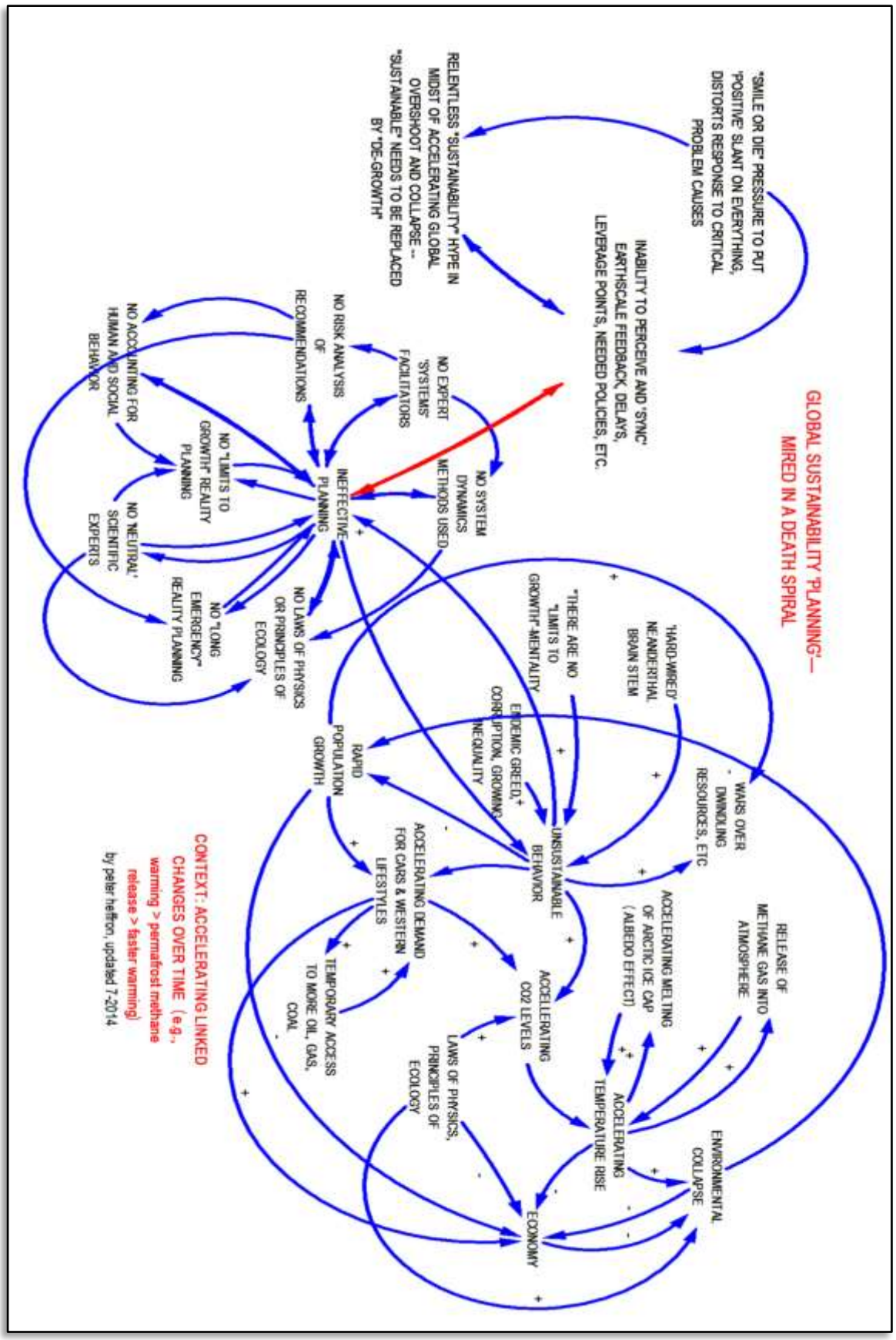
> There is a good deal of evidence explaining why homo sapiens—we humans—regardless of education, social-economic status, etc., simply cannot get our collective act together to slow, much less reverse, our determined slide over the sustainability cliff.* (Heffron, 2013, unpublished)

*Perhaps the strongest compilation of such evidence may be found in William Reese's pivotal paper, *What's blocking sustainability? Human nature, cognition, and denial*. (Rees, 2010), followed by Garrett Hardin's article, *The Tragedy of the Commons* (Hardin, 1968).

The Rio+20 debacle and the papers mentioned above encouraged the author to develop the following causal loop diagram: *Global Sustainability 'Planning' ... Mired in a Death Spiral?*— in an attempt to better understand why, in spite of global overshoot and collapse warnings and recommendations for reducing the causes of overshoot since at least the 1972 systems study, *Limits to Growth* (Meadows, Meadows, & Randers, 1972)—policy makers, planners, United Nations experts, and many others have proven incapable of effective action (e.g., to even reduce the rates of increase of global warming and of inequality).

Global Sustainability 'Planning' ... Mired in a Death Spiral?
CLD following…

Global Sustainability 'Planning' ... Mired in a Death Spiral?

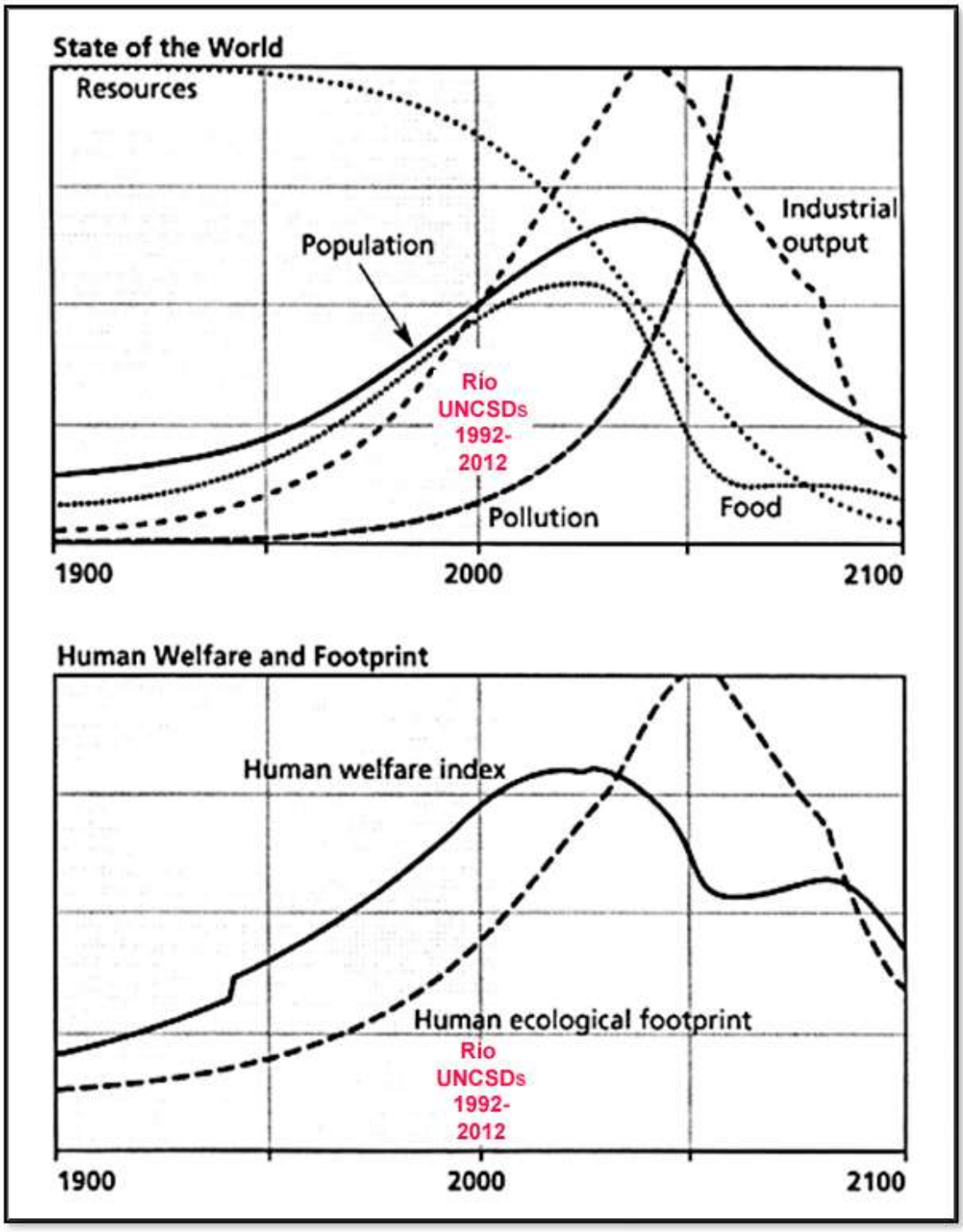


2.4.1 LESSONS

The lessons from the author's draft, unpublished Rio+20 critique were:

1. Systems thinking/system dynamics expertise, principles, methods, and tools are essential ingredients for more effective, participatory sustainability and equity problem-solving by policy makers and managers engaged in global problem-solving exercises. However, in an attempt to overcome—or compensate for—the human-wired brain issues mentioned above, ST/SD needs to be pro-actively complemented by other mindsets, methods, and tools, including:
    a. Since we/Earth have been in overshoot and collapse mode for decades now, the constant growth paradigm needs urgently to give way to a more realistic de-growth paradigm, including a 'long emergency' (Kunstler, 2005) approach to pending events such as an end to affordable (see 'energy return on investment') access to diminishing non-renewable energy supplies (and the terrible CO_2 consequences of utilizing existing and projected non-renewable stocks in any case—even if they were 'free' (Hamilton, 2010), sea-level rise, water shortages, droughts, flooding, possibly even a new ice age in Western Europe and North America (NASA, 2004), soil losses, economic refugees, and so on.
    b. The principles of physics, ecology, energy, human and social behavior, and others—need to be integral parts of problem-solving exercises; meaning that unbiased scientific expertise in these and other basic science areas should be not only available, but actively engaged in assisting planners in determining the feasibility and costs-benefits of different solution scenarios. A specific example would be the participation in a systemic problem-solving exercise of a physicist who would advise planners to take into account the Second Law of Thermodynamics (entropy—which means, for example, that it is impossible to recover –or 'recycle'– energy that has been used).
    c. Risk (or constraints and opportunities) analysis should also be a standard component in global planning, including risks of implementing particular strategies -or not- to resolve or mitigate global unsustainability problems.
    d. The insistent pressure—particularly on policy makers and politicians—to always be -or pretend to be- 'optimistic', needs to be replaced by a 'tell-it-like-it-is' approach (Ehrenreich, 2009). The current overshoot and collapse situation ('the sinking ship') demands greater honesty, transparency, and professionalism than is generally seen—as we witnessed in Rio+20.

2. When addressing most sustainability and equity challenges at all levels—global to village—systems thinking/system dynamics practitioners and their followers in policy-making and governance—are advised to consider basing their problem-solution analysis -at least initially- on the following author-supplemented *Limits to Growth* behavior-over-time graphs and causal loop diagram.



Credit: *The Limits to Growth* (Meadows, Meadows, Randers, 2004
-Rio Conferences added by the author-

The 1900—2100 State of the World and Human Welfare graphs are products of the 2004 update to the *Limits to Growth* study (Meadows, et al) and they

illustrate the overshoot and collapse behavior-over-time pattern increasingly being observed at all Earth scales.

3. It is suggested that development problem analyses by policy makers and managers and their planning teams and other stakeholders need to consider adapting these global BOTGs and CLD to suit appropriately scaled 'global-to-local' social, economic, and environmental sustainability (e.g., de-growth) and equity (e.g., addressing the widening income gap) challenges.

   If implemented as a standard best practice for problem analysis and planning, and if competent multi-disciplinary, heterogeneous teams were engaged in the process—it would be more likely that many of the pressing global, regional, urban, and rural unsustainability and social inequity issues would be more adequately addressed than they have been to date.

   Although systems thinking/system dynamics wouldn't be the only principle, method, and tool brought to the fore, it would be, in this opinion, the **key** ingredient ("The Fifth Discipline", unifying all the others—to paraphrase Peter Senge).

4. A further value in policy makers, planners, managers and their teams and other stakeholders familiarizing themselves and working with the preceding BOTG and CLD—is the likelihood that many of them would 'internalize' the core science-based principles (physics, ecology, etc., facts of life) affecting and being affected by 'the system' they are a part of—over time.

Caveat

The demonstrated speed and growing momentum of the global unsustainability and inequity trends relative to homo sapiens' collective (but especially at policy maker and leader level) inability to effectively address the unsustainability trends indicates that the preceding list of lessons is not at all likely to translate into the sort of urgent coordinated action appropriate to the sinking ship situation discussed earlier.

2.5 CARRYING CAPACITY EXERCISE FOR 6TH GRADERS AND TEACHERS

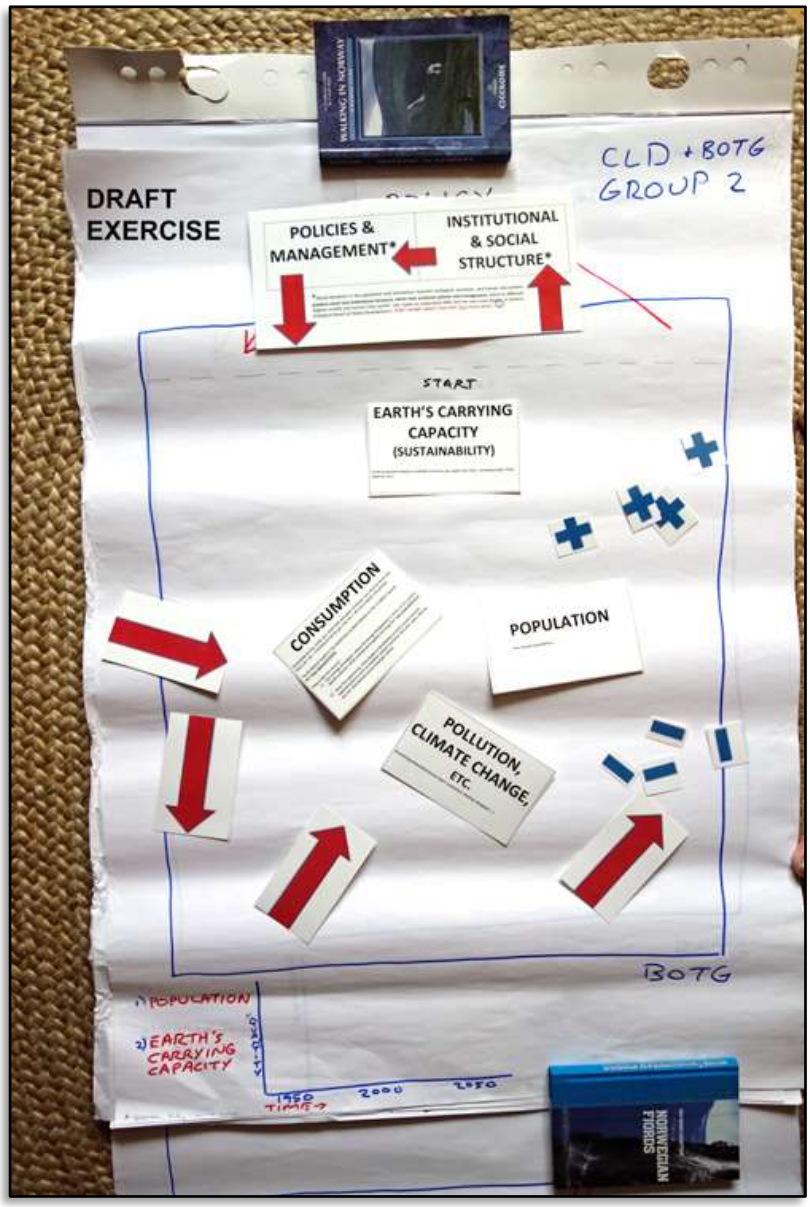
In parallel with his international development consulting work from 2000 to 2012+, the author was engaged as a K-12 substitute teacher in Hawaii and Norway, where the author took (and takes) advantage of every opportunity he could/can to introduce students, teachers, and school administrators to systems thinking principles and methods. The author has discovered that most students were (and are) enthusiastic about using causal loop diagramming, behavior-over-time graphing, and stock and flow mapping to achieve deeper understanding of topics they were already studying, and in some cases (e.g., limits to growth, carrying capacity, unsustainability, de-growth, etc.)—probably *should* be studying.

Near the end of the 2013-2014 school year, the author was given the go-ahead by two K-12 international school teachers, to conduct a systems thinking exercise with and for their 40 Year-6 students (11-12 year-olds).

The author used—with very little modification—the *Introduction to Systems Thinking in K-12 Schools* presentation and exercise he had made to Nordic Network of English-Speaking K-12 Schools (www.nordicnetwork.net) administrators and teachers several months earlier, to the Year-6 classes.

The purpose of the class was:

1. To expose the students and their teachers to the basic systems thinking methods and tools in a manner that would encourage them to continue experimenting with the methods/tool, which were: causal loop diagramming and behavior-over-time graphing, with dynamic model construction/re-construction—to follow in the coming school year.



5. Expose the students and their teachers to basic ecological concepts as applied to the state of the Earth/humankind over time, particularly: carrying capacity, sustainability, and overshoot and collapse, including better understanding of time and delays in the system as a major limiting factor, the 'bi-focal' (Richmond) realization that given the Earth's accelerating unsustainability and overshoot (and income/pollution gaps) situation, there is likely a need to concentrate on the structural, management, and policy issues at all levels more-or-less in 'emergency mode,' etc.

Based on previous systems thinking classroom work, the author learned that—in the absence of a dedicated systems thinking/system dynamics slot in the school curriculum—only sporadic, brief bits of time for systems thinking work could be expected with teachers and their students. This forced the author to develop a 'fast food' (quality fast food) systems thinking methodology. The methodology consisted of:

a) Ensuring the availability of two 'props': An hourglass and a large clear jar full of water (ideally with a few fish). As the sand slowly flows through the hourglass, teachers and students are reminded that all system causes happen over time and that all systems are affected by the Law of Entropy, in which systems 'wind down' over time. The jar of water helps keep the participants aware of the Earth as a closed system in which everything affects everything else.

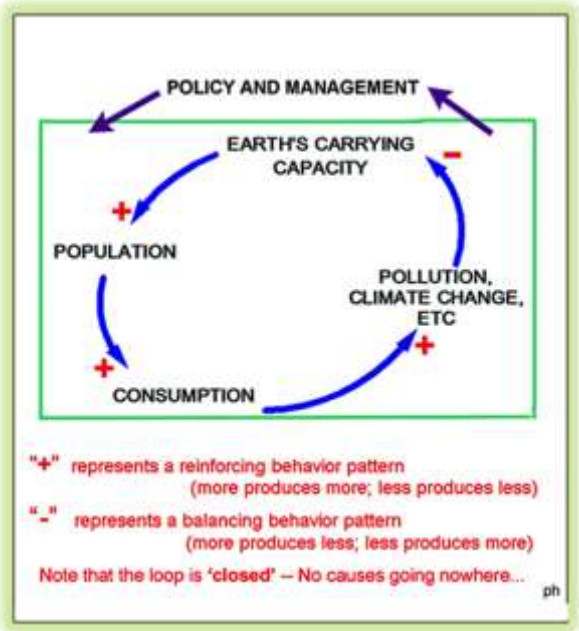
b) Preparing sets of 3x5 cards representing the following stocks: *carrying capacity/sustainability, population, consumption, pollution/climate change/etc., carrying capacity/sustainability, and management/policy*—with the overall concept distilled from Leon Braat's *Systems Ecological Model for Sustainable Development Analysis* (Braat, 1995) discussed earlier.

c) Preparing cut-out arrows -to connect the preceding stocks- and "+" and "-" signs to use as Reinforcing or Balancing effects at the ends of the arrows.

d) Pre-locating the *Policy and Management* 'stock' and the *Carrying Capacity/Sustainability* stock on one flipchart page per team.

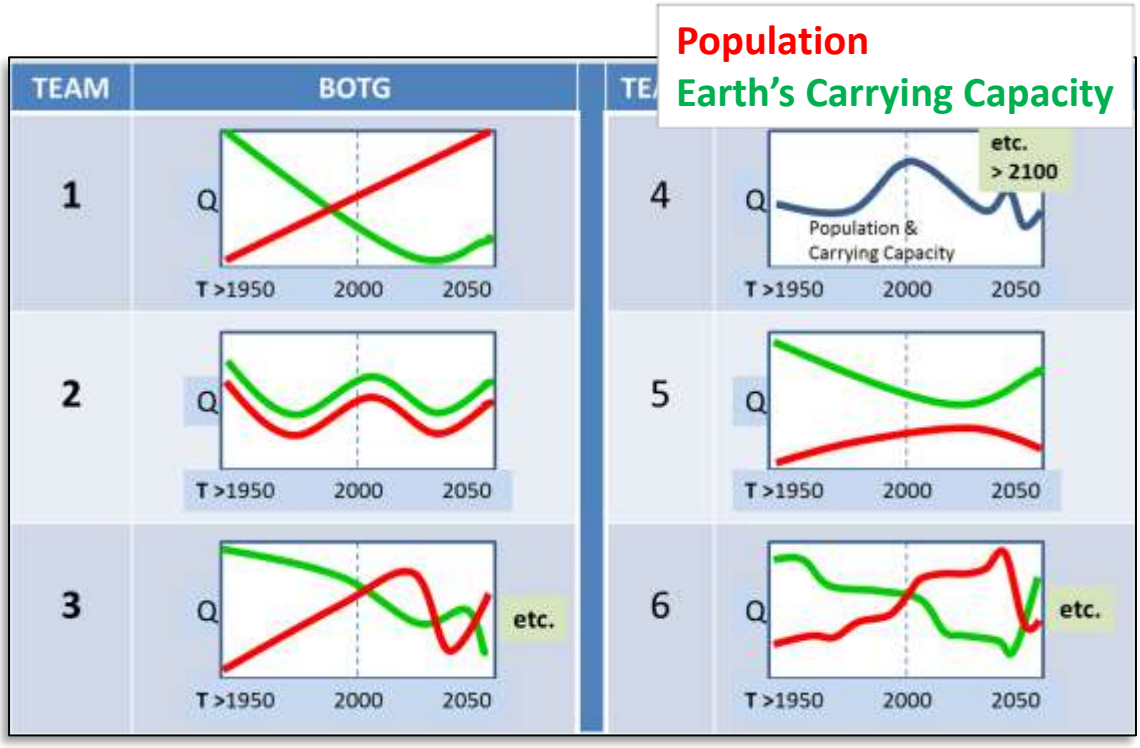
e) Drawing a behavior over time graph frame at the bottom of the flipchart page, with instructions for each team—based on the results of the CLD exercise—to prepare the BOTG using the team's perception of *Population* and *Carrying Capacity* for the period 1900-2000-2100.

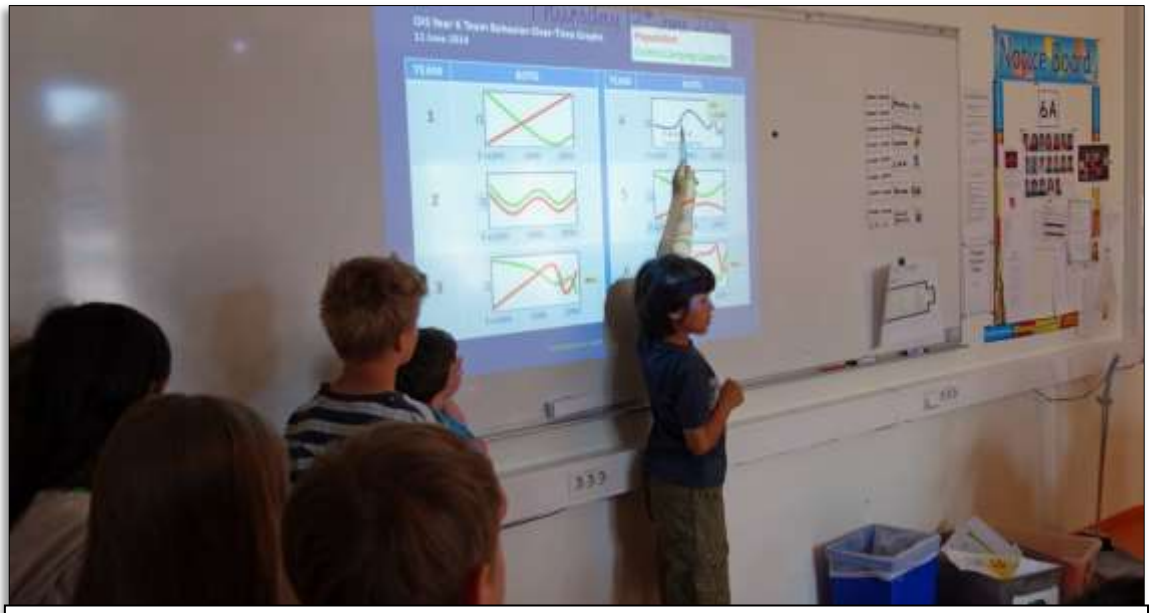
f) Team guidelines and several questions each team was asked to answer related to the exercise—with responses to be presented in plenary.



…Followed by a brief overview of the tools, including examples and Q&A, then a small group/team exercise in which the participants (students) are challenged to place the cards (stocks) in logical order, place the cause arrows, and assign logical polarity (+ or-), prepare the BOTG, answer the exercise questions, and prepare to present to the plenary (fellow students and teachers).

The result of the Year 6 presentation and exercise was that the students all 'got' the desired answer(s) shown below and in the previous section, and were able to explain its behavior, aided by their BOTGs (also shown below.)





The author prepared a synthesis of the six Year-6 team outputs, including copying their BOTGs from flipchart paper using Word's 'Shapes' tool. The author asked one representative from each group —gender balanced overall—to confirm that the team outputs on the flipchart paper were accurately represented in the PowerPoint synthesis. The synthesis was then presented to classmates by the six team representatives for Q&A, discussion, with inputs from the two class teachers as well.

2.5.1 LESSONS

The lessons learned from this exercise -and efforts to introduce systems thinking on a wider scale in the school- were:

1. Surprisingly little modification is required in presenting basic systems thinking and ecological and physics principles, methods, and tools to K-12 students, their parents, teachers, and school administrators.
2. It is possible -and desirable- to introduce basic systems thinking methods and tools and elementary environmental sustainability concepts simultaneously.
3. The lecture-to-hands-on ratio should be approximately 1:3 (e.g., one hour orientation, examples, and Q&A **to** three hours of team (group) problem-solving exercises, including presentations to plenary, Q&A, and synthesis).
4. Close cooperation/coordination with teachers is necessary to ensure that the introduction to systems thinking/system dynamics examples and exercises generally reinforces the curriculum they are covering at the time (e.g., Integrated Primary School Curriculum, International Baccalaureate, etc.).
5. As much as teachers might be interested in exploring systems thinking principles, methods, and tools—as great as these may be!—for themselves and with/for their students—teachers are often severely constrained by lack of time and energy to learn new approaches and then to apply these in the highly competitive/standards-oriented/testing-focused/pre-planned school/classroom environment. This requires the systems facilitator to expend significant time in

preparing ‘fast-food’ ST/SD lessons and exercises to accommodate, for example, a 40-minute classroom period, with another 40-minute session after several weeks.

6. Constrained by the same competitive, academic standards-based environment noted above for teachers, school administration (from board of directors to school director and principals, etc.) tends to be averse to new—even pilot—initiatives such as introducing systems thinking/system dynamics into an already overloaded school curriculum and operating environment. Other contributing factors include usual school politics and limited readiness for taking on new risks (whether potentially positive or negative).

   In the absence of school administration support—primarily: **(a)** a minimal *budget* to support a qualified part-time systems thinking facilitator/trainer—even for a limited ‘pilot’ period of, for example, one academic year; and **(b)** *time* within the existing schedule allocated for teachers and students to learn and apply basic systems thinking principles, methods, and tools linked to the existing curriculum—*promoting systems thinking/system dynamics in a K-12 school is – unfortunately– not a viable proposition.*[13]

7. Organizations promoting and providing resources for introducing systems thinking and system dynamics in K-12 schools include the Creative Learning Exchange, the Waters Foundation, CC Systems—and of course the System Dynamics Society. Companies that produce system dynamics modeling software and that make it possible to share a wide array of models online—all promote systems thinking/system dynamics in K-12 schools. In addition, some schools are held up as examples of what is possible over the past 20 years-or-so, notably in the Catalina Foothills School District of Tucson, Arizona, USA (Morrison, 2008).

   Sadly—*tragically!* in this view—the preceding organizations and their often sustained, well-intentioned efforts over decades—have not been adequate to the challenge of introducing—much less contributing to institutionalizing—sorely needed systems thinking/system dynamics expertise, principles, methods, and tools to the international (or any national) K-12 education system. This deficiency is true relative to numbers of schools, teachers, and students in the world who have never created a causal loop diagram and who have not connected a flow to a stock. This deficiency is also true relative to the accelerating decline in global sustainability/carrying capacity and inequity trends—a complex problem ‘made’ for systems thinking/system dynamics in schools—but absent from almost all of them.

   The lesson—whether learned or not—*appears* to be that a significantly more effective strategy was and is—given accelerating global unsustainability and inequity trends (Meadows, Meadows, & Randers, 2004) (Kunstler, 2005), now, more than ever—needed to promote ST/SD in the global education system (K-university), including having input to international and national standard-setting, curriculum development, teacher training, and so on.

3 CONCLUSIONS AND RECOMMENDATIONS

The author has experienced a number of other systems thinking vignettes, including seven years as supervisor for a PhD candidate whose thesis was *Policy Formulation in Sub-Saharan Africa in the Context of Sustainable Development Programs: What Could a Systems Approach Contribute?* (Amelewonou-Thalmensy & isee-systems, 2012).

These real-world experiences have been complemented by ST/SD and sustainability and equity-related literature reviews, participation in webinars, presentation of peer-reviewed papers, and correspondence with ST/SD and sustainability experts. Aided by a parallel commitment since the 1970s to better understanding deteriorating global sustainability **and** equity challenges (VISTA, Peace Corps, CARE-International, etc.), (United Nations, 1993), (Catton Jr., 1998), (Yglesias, 2012) etc., the author's ST/SD and sustainability/equity real world and theoretical world have thus merged over the years.

Surprisingly—thanks largely to common threads exposed to the author in the process of writing this paper—the author (and it is hoped, the reader) can with some confidence derive a relatively short list of conclusions and recommendations for consideration by the systems thinking/system dynamics community—professionals, amateurs, and the simply-curious, alike. (As always, there are opportunities for further research into these matters—although lack of effective action based on prior research has been the key weak point for some time now.) These conclusions and recommendations follow.

3.1 CONCLUSIONS

The author's conclusions are as follows:

1. The global social-economic-environmental 'system' no longer has the possibility of being or becoming "sustainable," even if 'perfect, logical, and fair' (especially environmental) sustainability policies were put in place tomorrow and implemented the day after. This is because too many limits to growth have been and continue to be exceeded. We are deeply ***in*** overshoot and collapse. Analogies include (a) the Titanic after it struck the iceberg and as it was sinking (1912); and (c) the southern region of Madagascar after suffering years of drought and as its people and livestock were starving (2009).

The Titanic Sinking
http://en.wikipedia.org/wiki/RMS_Titanic#mediaviewer/File:St%C3%B6wer_Titanic.jpg

In systems and ecological terms, Earth's carrying capacity stock is being drawn down and damaged faster than it can replenish and repair itself. This is caused primarily by the *Population x Consumption Per Capita* syndrome, resulting in growing and in some cases self-generating destruction, pollution, global warming (after Braat), generally reinforced by technology—affecting carrying capacity, which in turn affects all/everything dependent on carrying capacity.

2. Inadequate long-term planning to address interrelated unsustainability scenarios and trends at all levels, including in green planning
3. Inadequate policy and management of 'the system' at all levels relative to the unsustainability trends (see *Limits to Growth*, 'Carrying Capacity' causal loop diagram, Braat Model, etc.)
4. Disconnect with feedback delays, macro-scales, time needed for stocks to empty and fill, lead time for planning-to-implementation, etc.
5. Lack of sense of urgency
6. Non-use of system dynamics expertise, principles and methods (related to all of the above)

The above conclusions synthesis is mirrored in the author's CLD, *Global Sustainability 'Planning … Mired in a Death Spiral?* on page 14

3.2 RECOMMENDATIONS

The purpose of these systems thinking vignettes is to address the 32nd International Conference of the System Dynamics Society theme of Good Governance in a Complex World—from global to village levels—with examples and lessons learned through the author's application of systems thinking (including system dynamics) principles, methods, and tools in various settings. It is apparent that the system dynamics profession needs to re-assess its relevance and identify alternative approaches to contributing to the ability of policy makers, planners, managers, and other stakeholders to analyze, prioritize (leverage points), and address mounting interrelated global unsustainability and inequity challenges.

"But it's complicated"...
…Which is why much more and significantly better, coordinated, collaborative, green **de-growth** policies, planning, and implementation—aided by systems thinking and system dynamics expertise, principles, methods, and tools—is **urgently** needed at global, regional, country, and urban levels.

A rapid paradigm shift is needed from:
"Sustainability" and "growth"—to equitable **de-growth**

Increasing income gaps—to much more equitable income distribution—between and within job classifications, regions, and countries

‘Smile or die’ pressures and -alternatively- denial and depression—to greater neutral, frank assessment

Pangloss used now and then to say to Candide, “There is a concatenation of all events in the best of possible worlds; for, in short, had you not been kicked out of a fine castle for the love of Miss Cunegund; had you not been put into the Inquisition; had you not travelled over America on foot; had you not run the baron through the body; and had you not lost all your sheep, which you brought from the good country of El Dorado, you would not have been here to eat preserved citrons and pistachio nuts.”

“Excellently observed,” answered Candide; “but let us take care of our garden.”

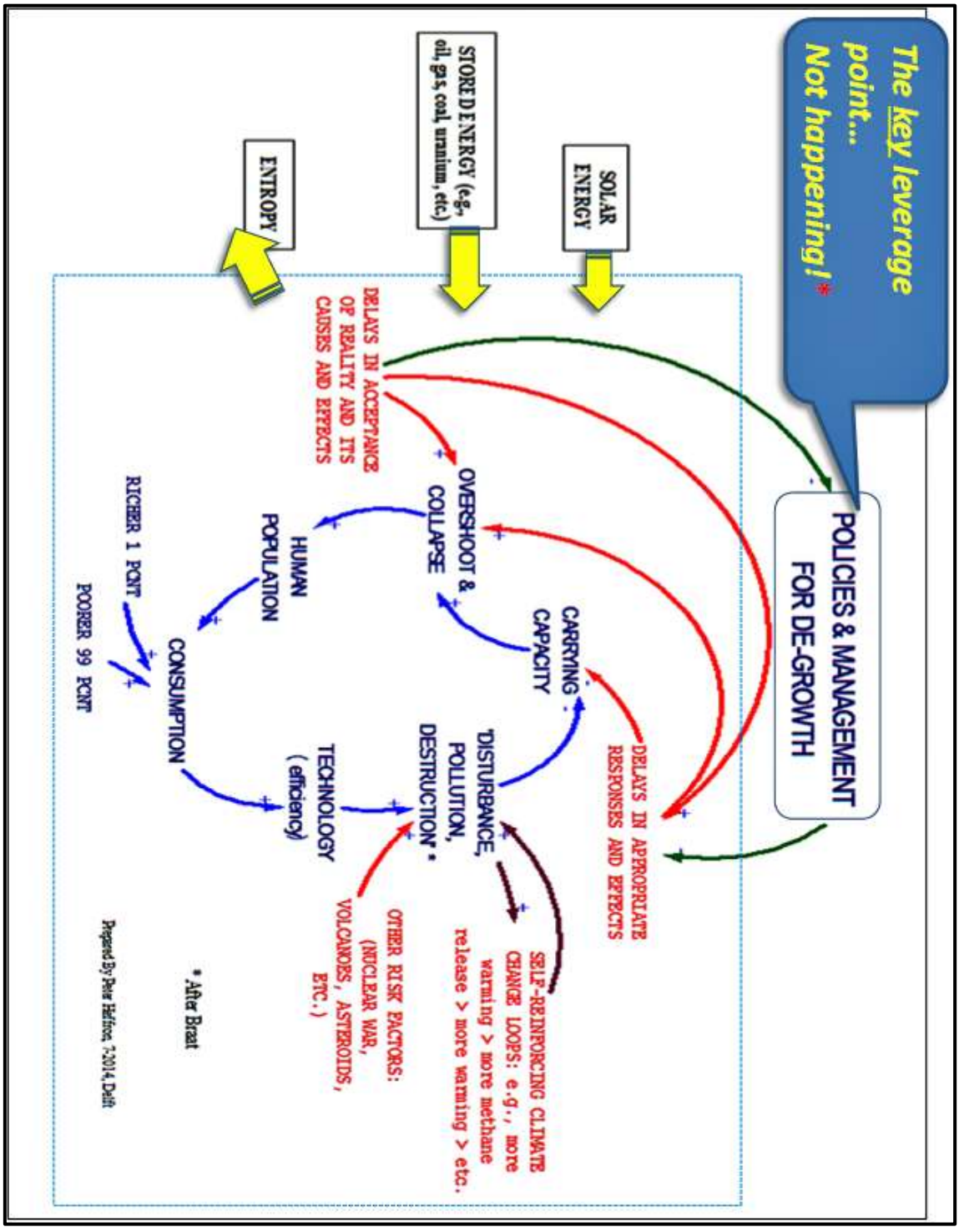
Ref: *Candide, ou l'Optimisme,* by Voltaire January 1759

Peter Heffron
15 August 2014

Guatemala Project Participants, Peter Heffron, 2010

4 APPENDIX

Example of a systems analysis that national and local planners, policy makers, managers and other stakeholders could use as a problem analysis, prevention, and mitigation aid.



END APPENDIX

REFERENCES

1 Beginning with *The Limits to Growth*, 1972—the first analysis of global sustainability trends and scenarios using system dynamics methods. Also as explained in *Humanity's Footprint* (Dodds, 2008).

[2] There are various global, regional, and national sustainability initiatives to translate the critical recommendations in the cited studies—into long-term sustainability strategies and policies backed with coordinated and funded, programs, and projects. For example see: Canada's Federal Sustainable Development Act and Federal Sustainable Development Strategy (www.ec.gc.ca/dd-sd). There have also been various local initiatives to address unsustainability challenges, including, for example: The Green Belt Movement (www.greenbeltmovement.org), However sustainability-related indicators, including global CO_2 and temperature increases, fresh water per capita decreases, and so on—demonstrate that as well-meaning as they may be, these initiatives have been far 'too little, too late.'

[3] The author is prepared to be corrected on this point. If the reader is aware of an example -or examples- of successful sustainability or de-growth plans at global, regional, national, watershed, city, etc.-levels, please inform the author, including references to information sources at: peter.heffron@gmail.com the author will then amend this paper accordingly, and recognize, if s/he so-desires, the person contributing said information.

4 The Titanic: http://en.wikipedia.org/wiki/RMS_Titanic

5 15 Jan 2009: http://en.wikipedia.org/wiki/US_Airways_Flight_1549

6 http://suburbanstats.org/population/how-many-people-live-in-california

7 http://gov.ca.gov/news.php?id=18368

8 http://newsworld365.com/2014/03/11/bangladesh-needs-billions-of-dollars-to-adapt-to-climate-change; and *Perfect Storm? Population Pressures, Natural Resource Constraints, and Climate Change in Bangladesh:* http://goo.gl/TRLdgs

9 Sustainability organizations: http://en.wikipedia.org/wiki/Sustainability_organizations

10 The author mentions HPS/isee systems only because they were the company that assisted us (CARE and partner organizations and individuals) at the time. However the author is aware that there are other systems organizations—most notably the System Dynamics Society—and companies (e.g., Ventana Systems, and others) that have done -and continue to do- a lot to promote ST/SD and its use in helping to understand and resolve global sustainability and equity challenges.

[11] *Overshoot and collapse* is a term used in ecology to describe what happens when for a time, a population exceeds the carrying capacity of its habitat. Also see the *Limits to Growth* 1950-2050 trends and projections.

[12] One of a number of system archetypes. See Senge, Peter M., The Fifth Discipline (1990).

[13] The author acknowledges that the same K-12 school that rejected his proposals over two years to support a pilot Introduction to Systems Thinking initiative—permitted him to make *Systems Thinking in K-12 Schools* presentations/exercises in two Nordic Network Conferences (2013, 2014), and is supporting his participation in the July 2014 System Dynamics Conference in Delft, The Netherlands (on condition that a user-friendly STELLA model of student year-to-year cycling/turnover be produced by the author). Thus there is some incongruence/inconsistency regarding school support.

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