Green Planning Challenges and Opportunities
A System Dynamics Perspective

Author

13 June 2013

NOTE: This is a presentation made in June 2013 to the Norwegian University of Science and Technology by the author of "DRAFT PAPER TO THE SYSTEM DYNAMICS SOCIETY: OPERATIONALIZING SYSTEMS THINKING AND SYSTEM DYNAMICS PRINCIPLES, METHODS, AND TOOLS IN GOVERNMENT POLICY, DECISION-MAKING, AND MANAGEMENT" -- 18 MARCH 2014. It is representative of the author's work, perspective, etc.

ALL REFERENCES TO THE AUTHOR'S NAME ARE REPLACED BY "AUTHOR"

INTRODUCTION

Purpose: To share a synthesis of the author's recent paper, *Green Planning Challenges and Opportunities: A System Dynamics Perspective*, with emphasis on:

- Defining green planning and systems thinking /system dynamics

- Exploring why and how system dynamics can be applied to green planning and design challenges

- Exposure to the language of systems thinking/system dynamics

- Practical examples of applying the system dynamics language to real-world green planning and design issues

- Conclusions and recommendations resulting from the research

...Followed by Q&A

What is green planning?

Green planning is a methodology to develop "comprehensive management plans that have the final goal of achieving environmental and economic sustainability. They are integrated, all-inclusive strategies that replace traditional single-issue policies".

Source: http://en.wikipedia.org/wiki/Green_Plan and www.rri.org/green-plans

What is systems thinking and system dynamics?

Systems thinking and system dynamics, developed at MIT in the late 1950s, is a methodology to explore complexity, interconnectedness, and change over time.

Systems thinking—includes causal loop diagramming and behavior-over-time graphing, unaided by computers.

System dynamics—a key component of systems thinking—employs computer modeling and simulations. Together they are referred to in this presentation as **system dynamics**.

...Examples follow!

Ref: System Dynamics Society: www.systemdynamicssociety.org
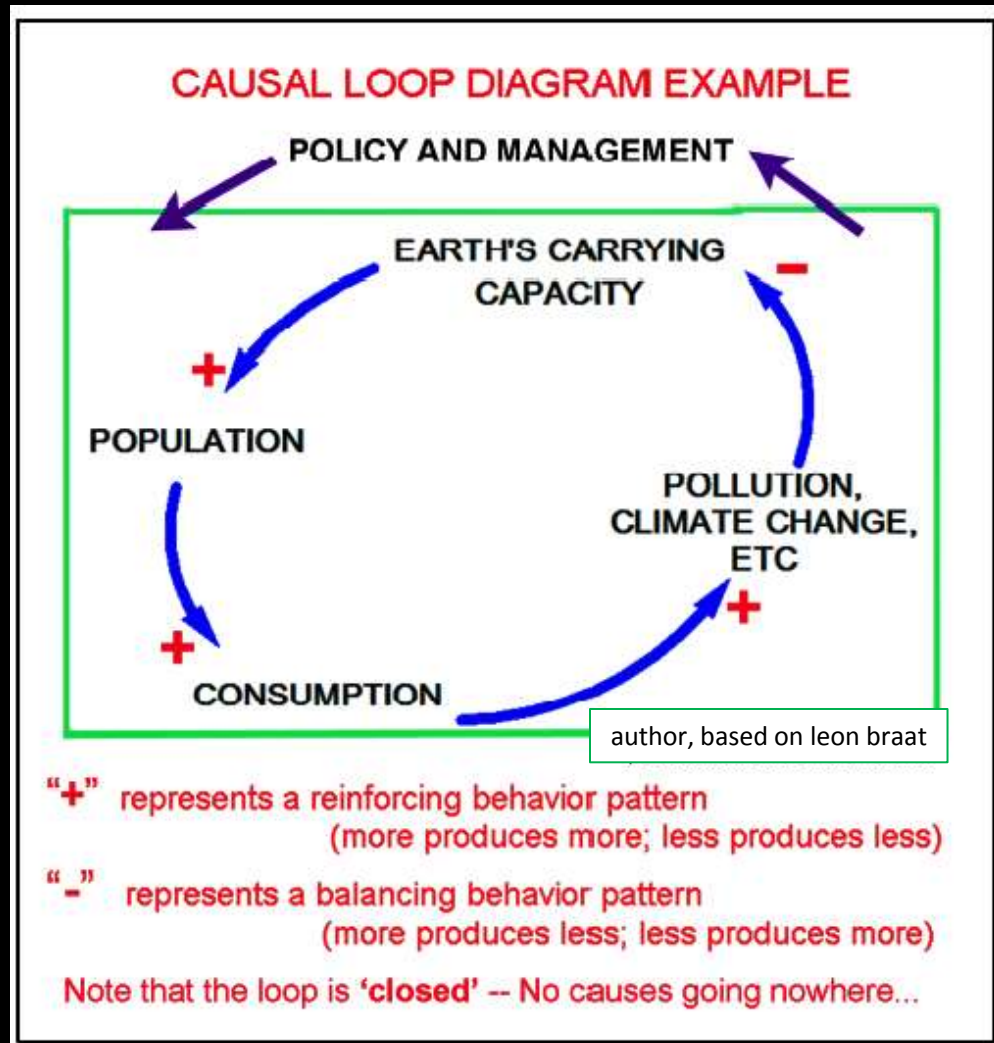
The System Dynamics Language

1. Causal Loop Diagrams

2. Behavior Over Time Graphs

3. Stocks and Flows

1. A Causal Loop Diagram   >>

CAUSAL LOOP DIAGRAM EXAMPLE

POLICY AND MANAGEMENT

EARTH'S CARRYING CAPACITY

−

POPULATION

+

POLLUTION, CLIMATE CHANGE, ETC

+

CONSUMPTION

+

author, based on leon braat

"+" represents a reinforcing behavior pattern
(more produces more; less produces less)

"−" represents a balancing behavior pattern
(more produces less; less produces more)

Note that the loop is 'closed' -- No causes going nowhere...

2. Generic Behavior Over Time Graphs

Green Planning: A System Dynamics Perspective
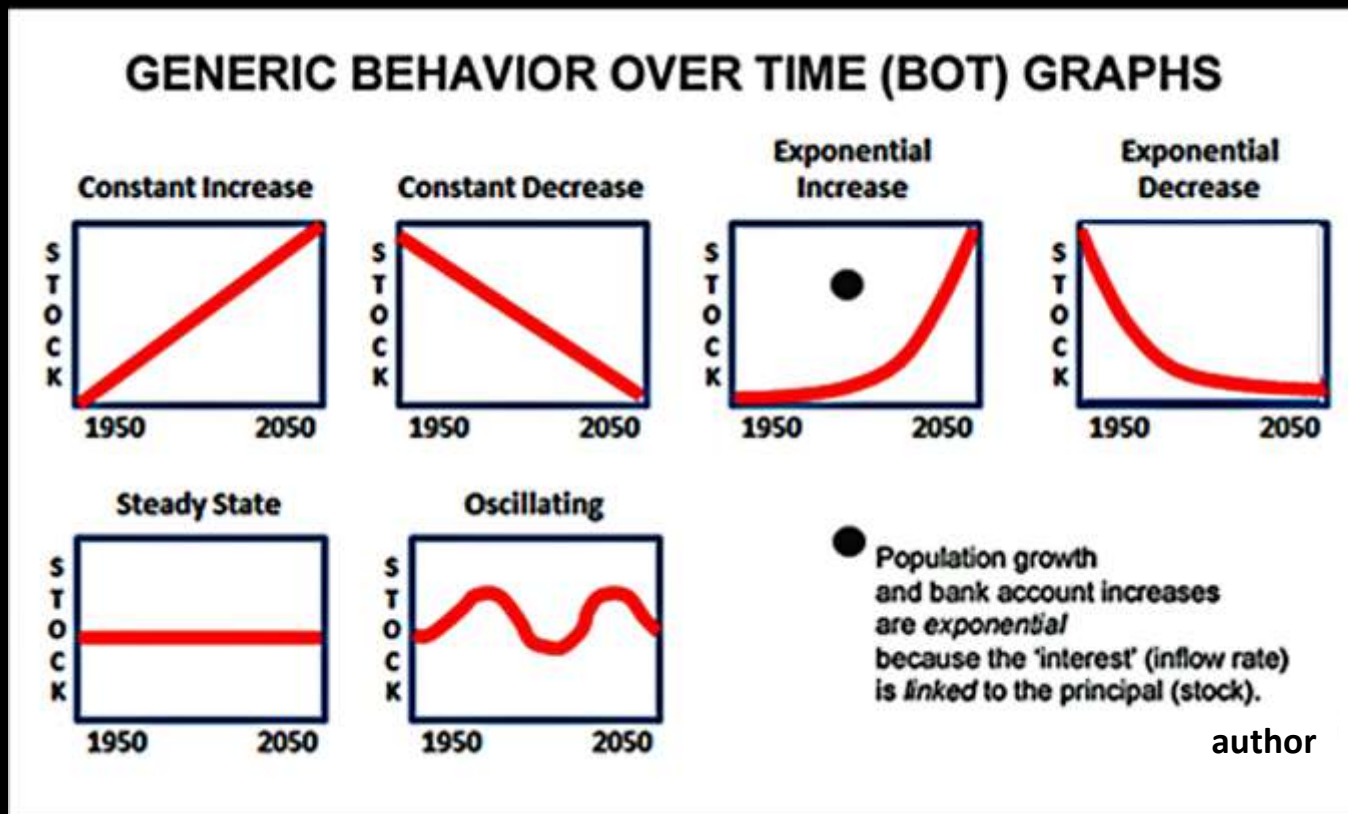
3. Basic Stock and Flow Logic (computer-aided simulation)

2...with a faucet

1. A typical 'bathtub'...

Water **In**flow

water 'Stock'

The only way to change the amount of *Stock* (water, people, money, CO_2, green cities, etc.), is by changing the *Inflow* and/or the *Outflow*.

3...and with a drain

water **Out**flow
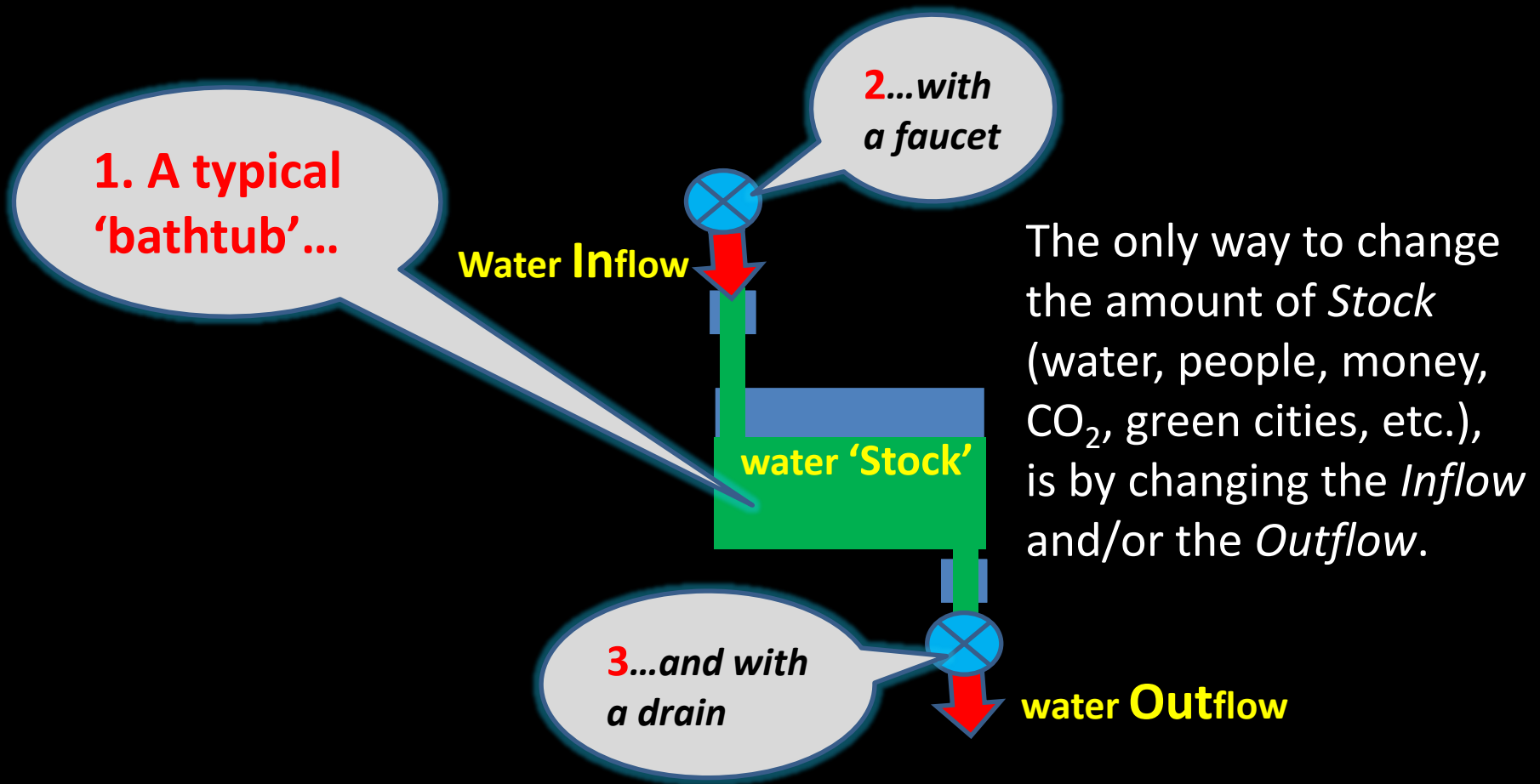
- **Children from age 5** have learned to use causal loop diagramming and behavior over time graphing.

- **Children from age 9** have learned to use causal loop diagramming and behavior over time graphing, as well as basic computer modeling involving interactions between different stocks and flows (e.g., population and non-renewable resources, etc.).

References:

- The Creative Learning Exchange (clexchange.org)

- The Waters Foundation (watersfoundation.org)

- The System Dynamics Society (systemdynamics.org)

- isee systems (iseesystems.com)

CONTEXT

About the Author

- MA: Social Ecology

- 20 years: CARE-International in Latin America, Asia and Africa

- 10 years: International Development Projects Consultant

- 7 years: PhD Candidate Supervisor. Thesis: *Policy Formulation in Sub-Saharan Africa in the Context of Sustainable Development Programs: What Could a Systems Approach Contribute?* (PhD granted to candidate 12-2011)

- 20 years: Applying system dynamics principles and methods to sustainability challenges. Examples:
  - CARE-Honduras Strategic Plan
  - Hawaii 2050 Draft Sustainability Plan Review
  - International NGO project evaluation – Guatemala
  - International NGO project feasibility study – Ghana
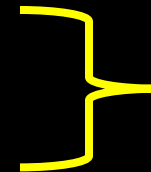
More on these two examples follows.

Green Planning: A System Dynamics Perspective

SYSTEM DYNAMICS EXAMPLES

- ❖ Hawaii 2050 Sustainability Plan
- ❖ Guatemala Project Evaluation
- ❖ The Planet: Limits to Growth
- ❖ Climate Change
- ❖ Generic Sustainability Model
- ❖ Trondheim, Norway

Hawaii 2050 Sustainability Plan

Green Planning: A System Dynamics Perspective

Source: http://blog.fergystravel.com/hawaii-news/native-hawaiian-population-bouncing-back/

Green Planning: A System Dynamics Perspective

Source: http://blogs.newzealand.usembassy.gov/ambassador/images/waikiki.jpg

Green Planning: A System Dynamics Perspective

Source: Hawaii hopes to say 'aloha' to Gulf tourists: http://www.arabianbusiness.com/hawaii-hopes-say-aloha--gulf-tourists-451688.html

Because of
the shortage
of time,

please look at
the following
system diagrams
as 'abstract art',
with only brief
explanations .

You are
encouraged to
go over them later,
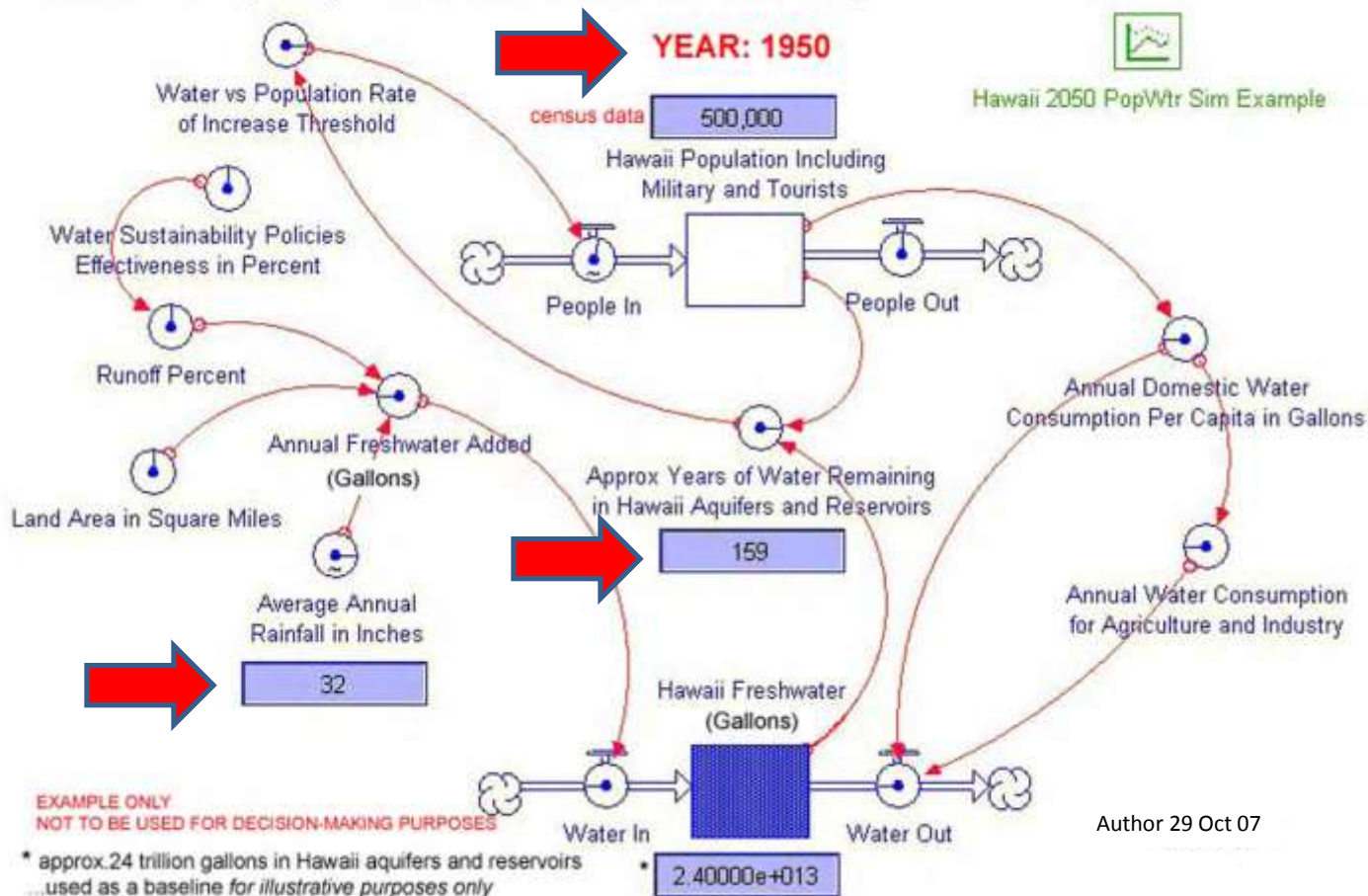at your leisure.

Green Planning: A System Dynamics Perspective

Ilustrative Dynamic Systems Model of Hawai'i Population and Freshwater Trends
Purpose: Example of a modelling process that the Hawaii 2050 Sustainability Plan could benefit from

3 of 3 'pauses' as the model runs from 1950 to 2050

3

YEAR: 2050

1,692,288

Hawaii 2050 PopWtr Sim Example

Water vs Population Rate of Increase Threshold

Water Sustainability Policies Effectiveness in Percent

Runoff Percent

Annual Freshwater Added (Gallons)

Land Area in Square Miles

Average Annual Rainfall in Inches

5

Hawaii Population Including Military and Tourists

People In

People Out

Annual Domestic Water Consumption Per Capita in Gallons

Approx Years of Water Remaining in Hawaii Aquifers and Reservoirs

6

Annual Water Consumption for Agriculture and Industry

Hawaii Freshwater (Gallons)

Water In

Water Out

2.88253e+012

EXAMPLE ONLY
NOT TO BE USED FOR DECISION-MAKING PURPOSES

Author 29 Oct 07

* approx 2.9 trillion gallons of water...about one-third of the water available 30 years earlier (2020) *(Illustrative only)*

1: Hawaii Freshwater Gallons   2: Hawaii Population   3: Average Annual Rainfall in Inches

Chart of Freshwater, Rainfall, and Population generated for Year 2020 from the *Illustrative Dynamic Systems Model* of Hawai'i Population and Freshwater Trends (#2).

Hawai'i (illustrative)

rainfall

freshwater

population

"Trends are not *(necessarily)* destiny."
The Hawaii 2050 Sustainability Plan *could* proactively address interconnected (illustrative) trends such as these, aided by professionally led participatory systems analysis, modelling, and consideration of alternative scenarios.

Author 29 Oct 07

Hawaii Model Tentative Results

- The *Sustainable Hawaii* planners apparently did not employ best practice, integrated green planning/sustainability system dynamics methods in their analysis of long-term trends and policies in Hawaii.

- The illustrative potable water model indicates water for Hawaii residential (including tourist and military), agriculture, and industrial uses—has already reached a critical threshold, and could be grossly inadequate by 2050.

Guatemala: Project Evaluation

Source: http://discover-centralamerica.blogspot.no/2011_11_01_archive.html

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Causal
Loop
Diagram:

Forest Cover

Causal Diagram of Deforestation Challenges in PROMASA II Areas

1 Population 2+% pa

2 Land Clearing HAs Per Year

Logging (legal & illegal) HAs Per Year

3 Forest Cover HAs

Food Security Component of Livelihood Security

Land Productivity (topsoil depth, etc.)

Disasters...Drought, Flooding, Landslides, etc.

4 Fuelwood Use HAs Per Year

Climate Change, CO2, Biodiversity, etc.

Water Availability, Access

How to Interpret this diagram:

a) Understand that every cause 'affects' other causes.

b) To be most cost-effective, interventions should target leverage points where, for example, one higher-level cause is contributing to various lower level causes. Thus the need for better practice policies and management at all levels is readily apparent in this system diagram.

c) Start with "1" then "2," etc. A "+" signifies that an increase in one variable causes an increase in the other; or a decrease in one variable causes a decrease in the other. A "-" signifies that an increase in one variable causes a decrease in the other; or that a decrease in one variable causes an increase in the other.

d) Approximately 100 thousand HAs are deforested each year in Guatemala. Current forest area (est): < 4 million HAs.

e) Current Guatemala Population: 13 million. Yearly population growth rate: 2+%

Prepared B Author
25 May 2010

Stocks
and
Flows
Model

Forest Cover

Illustrative Systems Model Linking Selected Stocks (People, Forest Cover, Land Productivity) and Flows in Guatemala
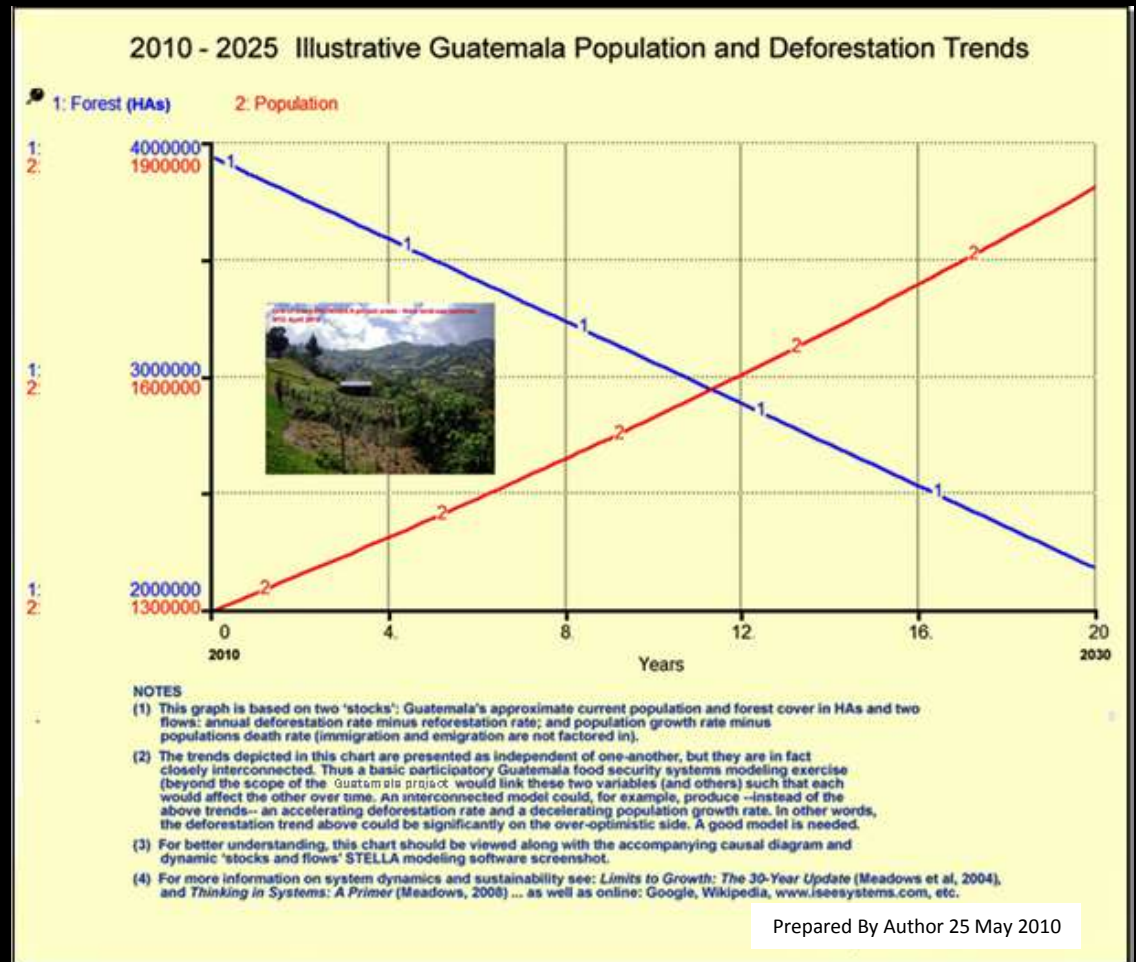
Prepared By Author
25 May 2010
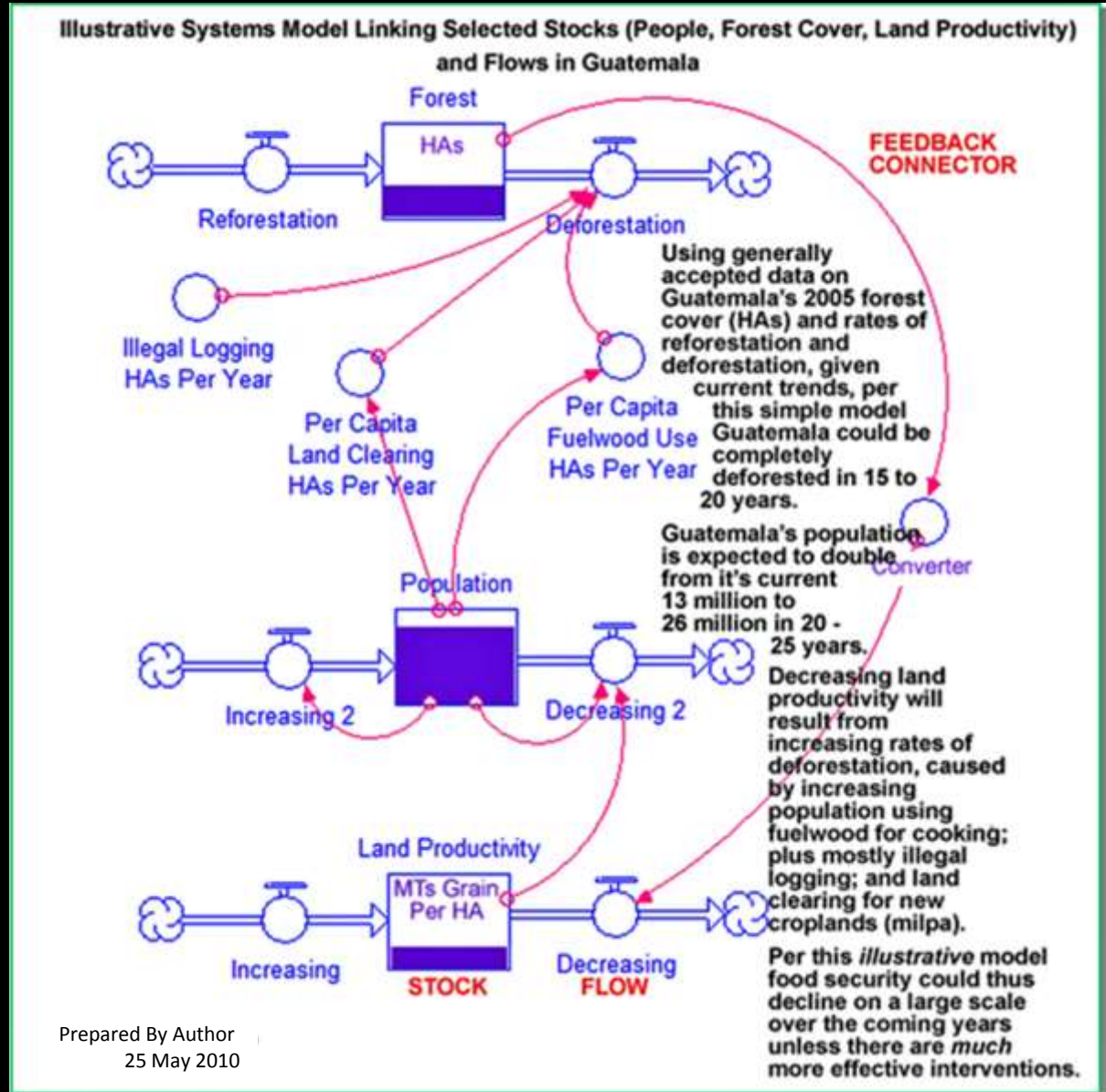
Trends Graph Produced by Model
(previous slide)

Forest Cover

Guatemala's Population Growth and Deforestation Trends ...Relative To Development Project Impacts...

Too Little, Too Late?

Guatemala Project Evaluation: Deforestation Model

2010 - 2025 Illustrative Guatemala Population and Deforestation Trends

1: Forest (HAs)   2: Population

1: 4000000
2: 1900000

1: 3000000
2: 1600000

1: 2000000
2: 1300000

Years

0   4.   8   12   16.   20
2010   2030

NOTES

(1) This graph is based on two 'stocks': Guatemala's approximate current population and forest cover in HAs and two flows: annual deforestation rate minus reforestation rate; and population growth rate minus populations death rate (immigration and emigration are not factored in).

(2) The trends depicted in this chart are presented as independent of one-another, but they are in fact closely interconnected. Thus a basic participatory Guatemala food security systems modeling exercise (beyond the scope of the Guatemala project would link these two variables (and others) such that each would affect the other over time. An interconnected model could, for example, produce --instead of the above trends-- an accelerating deforestation rate and a decelerating population growth rate. In other words, the deforestation trend above could be significantly on the over-optimistic side. A good model is needed.

(3) For better understanding, this chart should be viewed along with the accompanying causal diagram and dynamic 'stocks and flows' STELLA modeling software screenshot.

(4) For more information on system dynamics and sustainability see: *Limits to Growth: The 30-Year Update* (Meadows et al, 2004), and *Thinking in Systems: A Primer* (Meadows, 2008) ... as well as online: Google, Wikipedia, www.iseesystems.com, etc.

Prepared By Author 25 May 2010

Guatemala Deforestation Model Tentative Results

- The Guatemala development project planners and implementers did not employ best practice, integrated green planning/sustainability system dynamics methods in their analysis of long-term trends and policies affecting Guatemala's low-income target population.

- The illustrative deforestation model indicates deforestation has already reached a critical level, and if the trends continue, Guatemala could be nearly completely deforested by 2020—2025.

- Many development projects in Guatemala could be having impacts that are "too little, too late" unless intervention leverage points are soon identified and addressed, aided by participatory, transparent system dynamics methods and tools.

The Planet: Limits to Growth

Global trends relative to UN Conferences on Sustainable Development

Credit: Meadows, Meadows, Randers.*
Limits to Growth: The 30-Year Update
Google Images: www.mnforsustain.org
(*Rio UNCSDs 1992—2012* added by author).
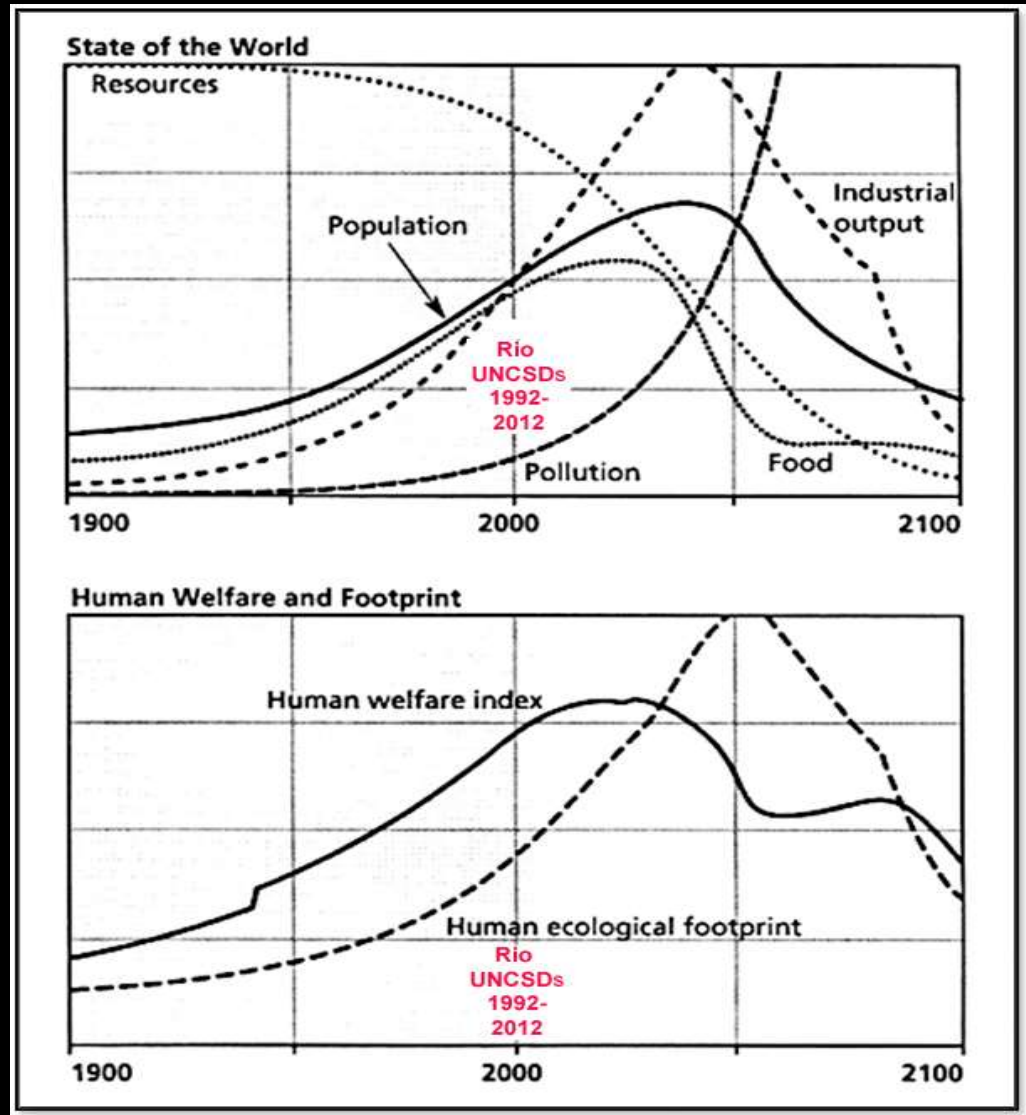
Climate Change

Melting Glacier
(contributing to global sea level rise)

Morteratsch Glacier and Piz Bernina,
Canton Graubünden,
1911 (above) and 2005 (below)

www.swissinfo.org/xobix_media/images/
sri/2006... (courtesy of Google Images)

1911

2005

Norwegian glaciers could melt completely

"Climate researchers predict that the approximately 1,600 Norwegian glaciers could melt completely away in the course of the next 100 years. This would mean that only 28 glaciers would remain in the country."

http://phys.org/news63617437.html#jCp

GREEN PLANNING CHALLENGES AND OPPORTUNITIES - A SYSTEM DYNAMICS PERSPECTIVE

Based on *A Systems Ecological Model of Global Development* By Leon Braat (1995)
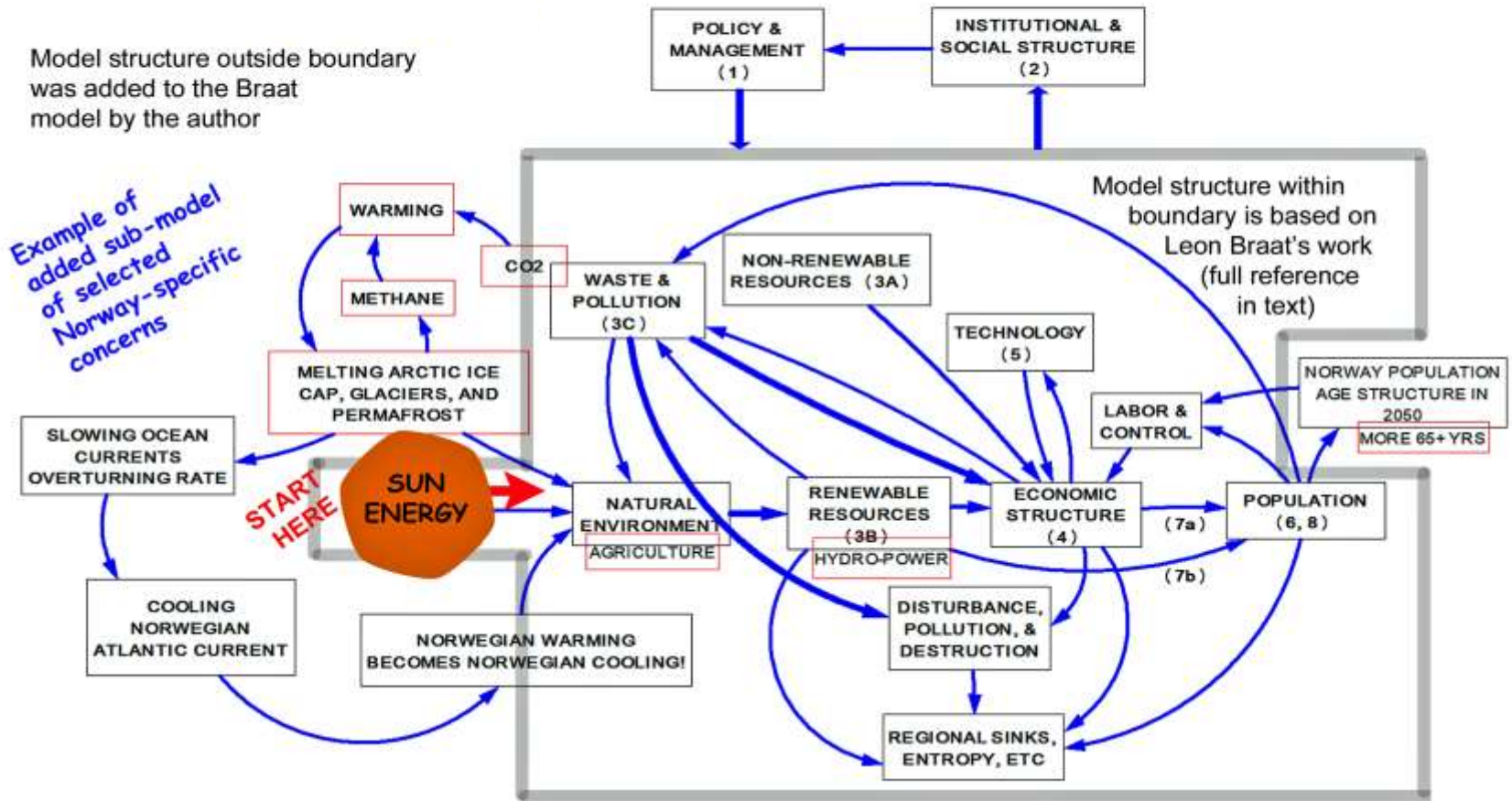
Trondheim Water *Illustrative Model*

TRONDHEIM WATER* — DYNAMIC SYSTEMS MICRO-MODEL
Illustrative example using STELLA software (isee systems)
* WATER FOR DOMESTIC, AGRICULTURE, FISHING, INDUSTRIAL USES
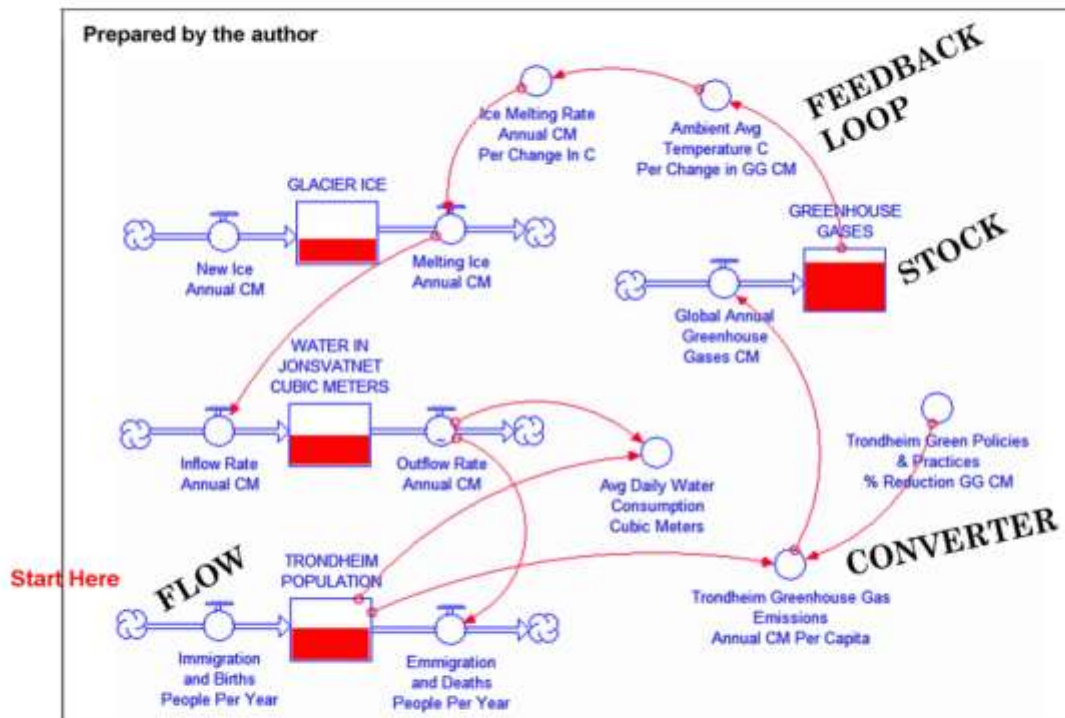
This illustrative mini-model demonstrates the use of *stocks, flows, and feeback* in a closed loop. Each stock affects -and is affected by- another stock over time. Initial values are assigned to the stocks (e.g., 180,000 for Trondheim Population). Basic formulas or values are also assigned to each flow and converter. An illustrative model output with explanation follows below. Purpose: Better understanding of complex interactions and identification of possible leverage points for problem prevention/solving.

3-2013

Scandinavia<>Norway <> Trondheim <> etc.

Human Development Index: Trends 1980 - present

World
2012: **0.694**
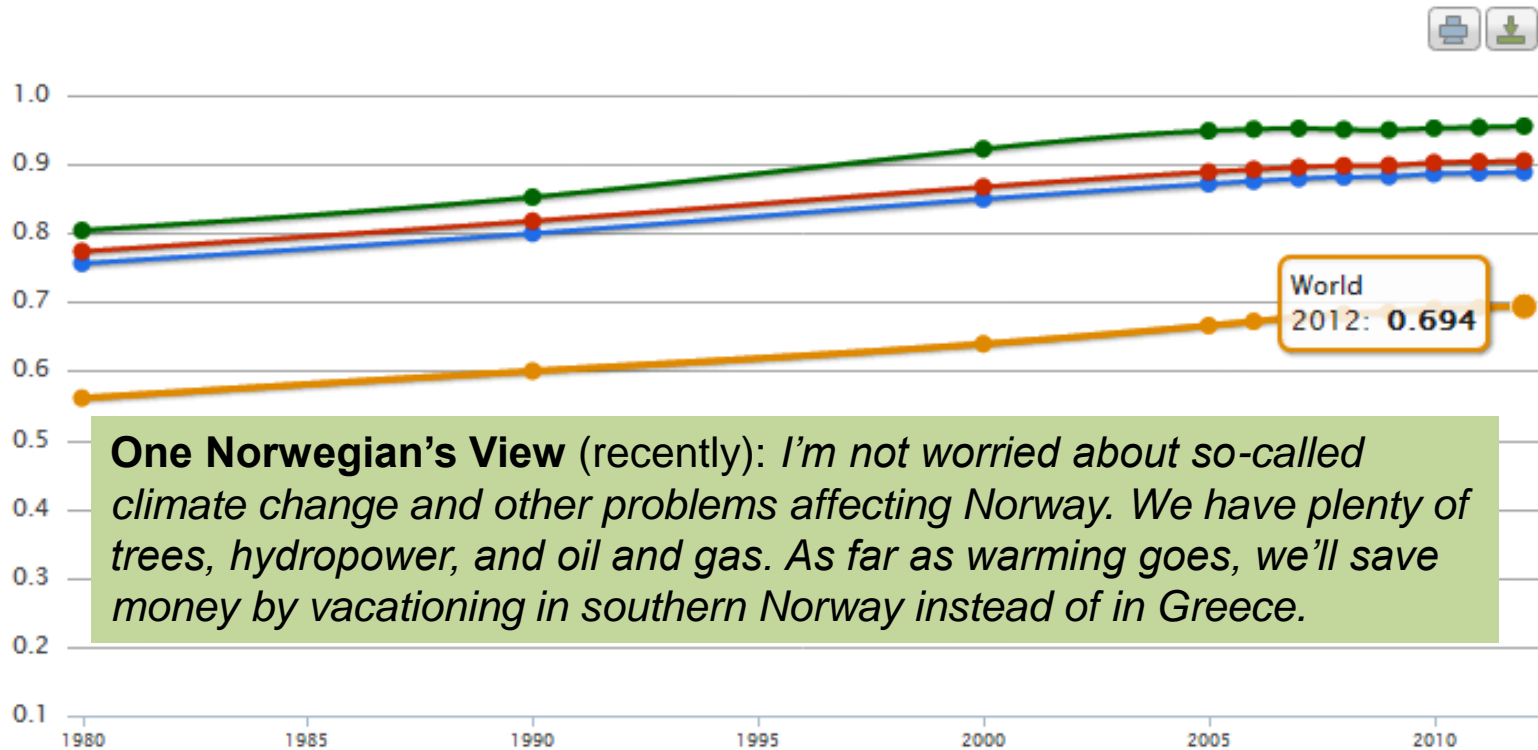
One Norwegian's View (recently): *I'm not worried about so-called climate change and other problems affecting Norway. We have plenty of trees, hydropower, and oil and gas. As far as warming goes, we'll save money by vacationing in southern Norway instead of in Greece.*

- OECD
- Very high human development
- World
- Norway

Graphic Ref: *Human Development Indicators*:
http://hdrstats.undp.org/en/countries/profiles/NOR.html
Quote: Author conversation.

It's complicated...

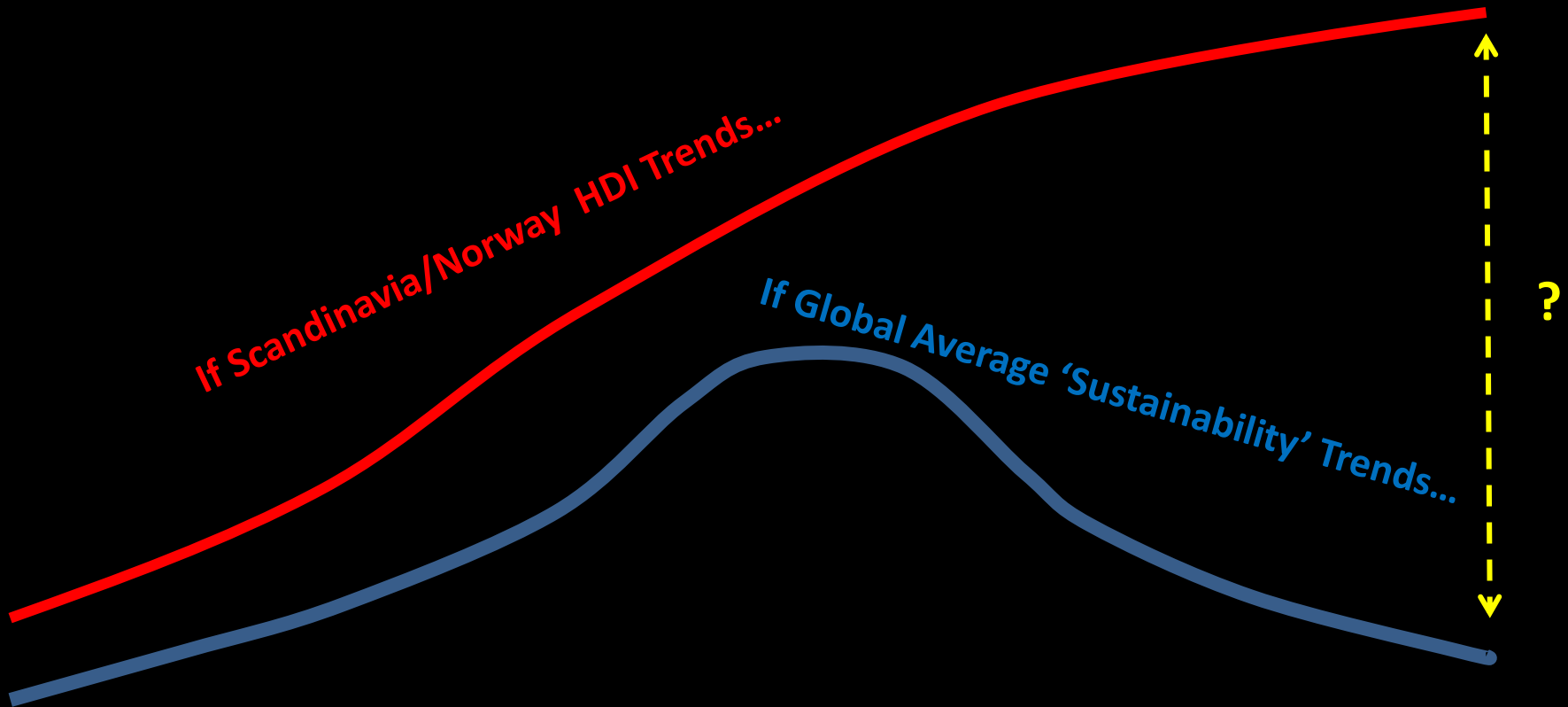If Norway were your home instead of Bangladesh you would...

use **203.6 times more** electricity

consume **78.3 times more** oil

and produce **38 times more CO$_2$** than the average Bangladeshi

Sources: http://www.ifitweremyhome.com/compare/BD/NO
http://www.nationmaster.com/compare/Bangladesh/Norway/Environment

How are these related?

If Scandinavia/Norway HDI Trends…

If Global Average 'Sustainability' Trends…

?

Green Planning: A System Dynamics Perspective

"It's complicated"

Which is why much more and significantly better green planning aided by system dynamics principles, methods, and tools— is urgently needed at global, regional, country, and urban levels.

CONCLUSIONS

Conclusions

In Scandinavia/Norway, much <u>excellent</u> planning, design, project management, etc.

However

1. Inadequate long-term planning to address interrelated unsustainability scenarios and trends at all levels, including in green planning

2. Inadequate policy and management of 'the system' at all levels relative to the trends (see causal loop diagram and Braat Model)

3. Lack of sense of urgency

4. Non-use of system dynamics principles and methods (related to all of the above)

An Opportunity For

1. More cross-disciplinary studies and collaboration (planners, architects, engineers, project managers, etc.), aided by system dynamics principles and methods

2. Better-targeted/more relevant/cost-effective assistance to developing countries

3. NTNU to encourage <u>all</u> students to use the language of systems thinking and system dynamics: *causal loop diagrams, behavior over time graphs, and stocks and flows*
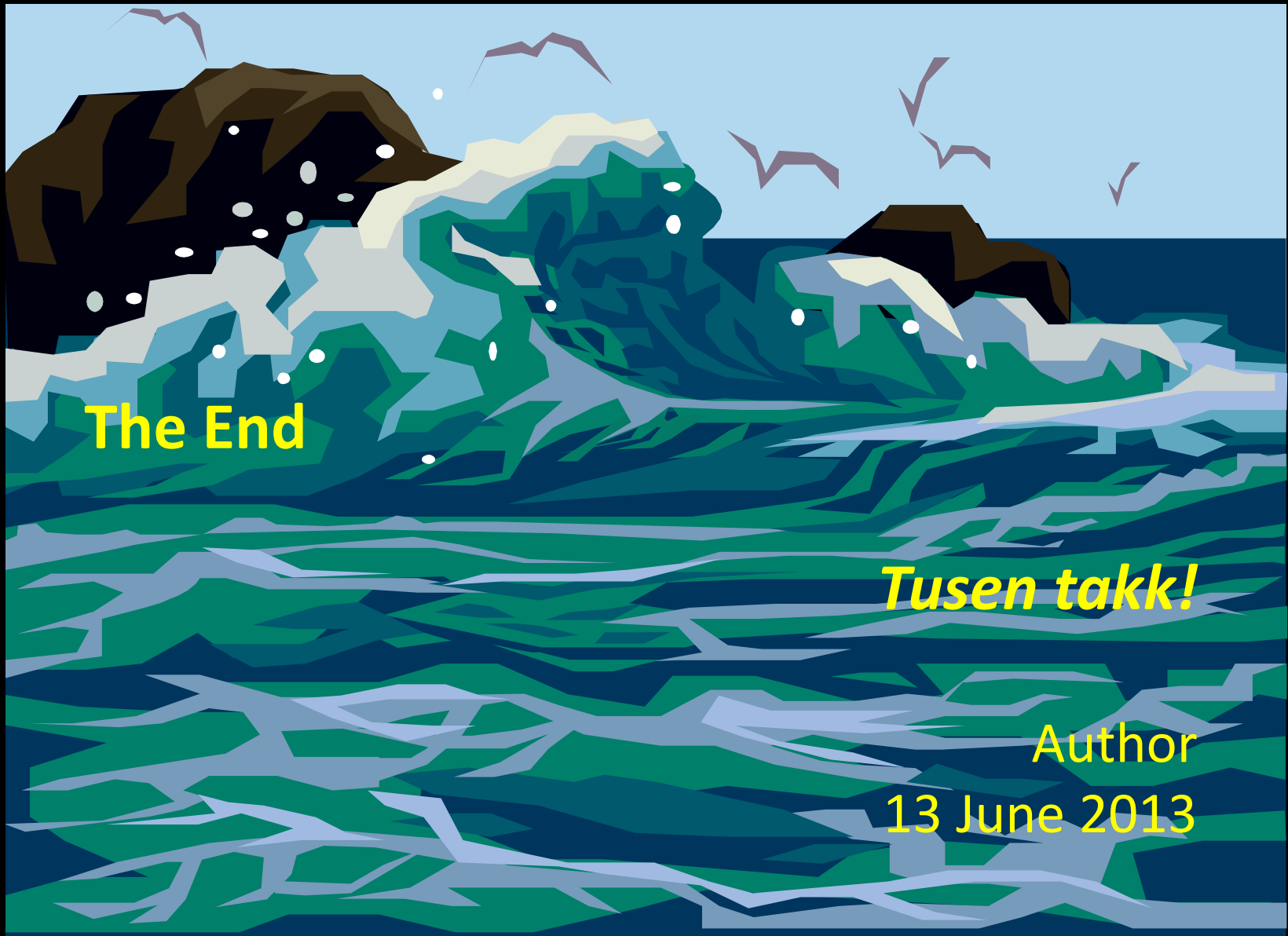
The End

Tusen takk!

Author
13 June 2013

Green Planning: A System Dynamics Perspective

Selected Resources

- **Local Governments for Sustainability: ICLEI Europe** (http://www.iclei-europe.org)

- **Resources Renewal Institute** (www.rri.org/index.php)

- **Modeling Earth's Climate System with STELLA** (www3.geosc.psu.edu/~dmb53/DaveSTELLA/climate/climate_modeling_1.htm)

- **World 3 Again (**http://rs6.risingnet.net/~ddcc/wbi/World3Again.html)

- **Meadows, Dana. *Thinking in Systems*** (book)

- **The Creative Learning Exchange** (clexchange.org)

- **The Waters Foundation** (watersfoundation.org)

- **The System Dynamics Society** (systemdynamics.org)

- **isee systems** (iseesystems.com)

Q&A