Sustainability Science for Food, Forests, and Floods: Integrating Climate Adaptation and Pro-Poor Resource Management

The challenge ahead

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Sustainable Development

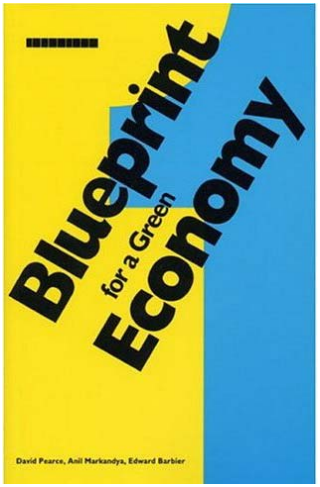
178 images: mostly some variant of the Venn diagram

SD: History of thought

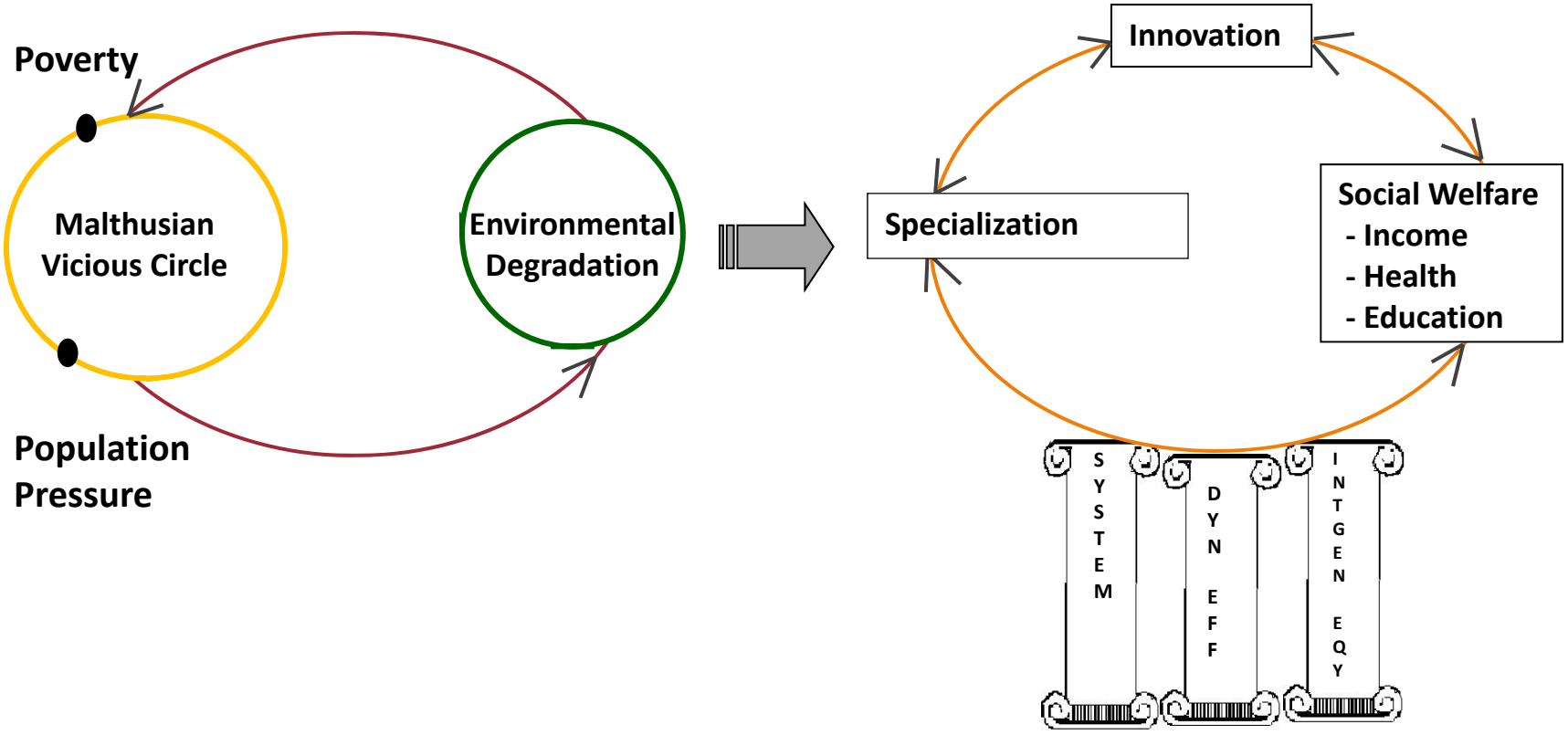
- **1987 – Barbier's Venn diagram of three intersecting circles for biological, economic, and social systems**
- **1987 - *Our Common Future* by the World Commission on Environment and Development**

Barbier et al. abandon Venn

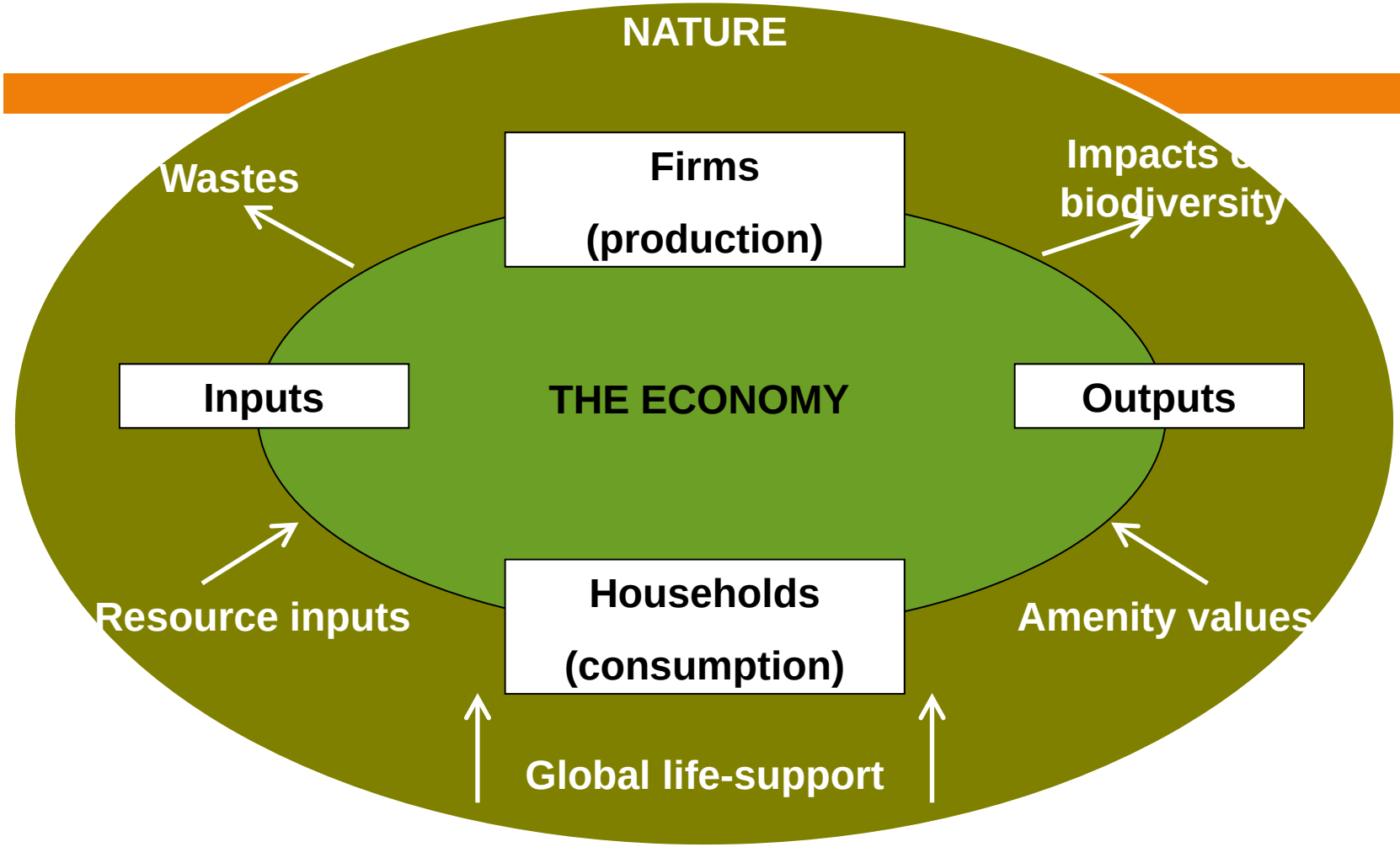
- **1989 – Pearce, Markandya, and Barbier abandoned the Venn approach as conceptually non-operational. Three performance indicators and three constraints!**



Unsustainable and Sustainable Development



Pillar I: the environomy (system)



The maximization of intertemporal welfare incorporates interlinkages within the total economic and environmental system (*environomy*), dynamic efficiency, and intertemporal equity.

Max intertemporal welfare

Incorporates:

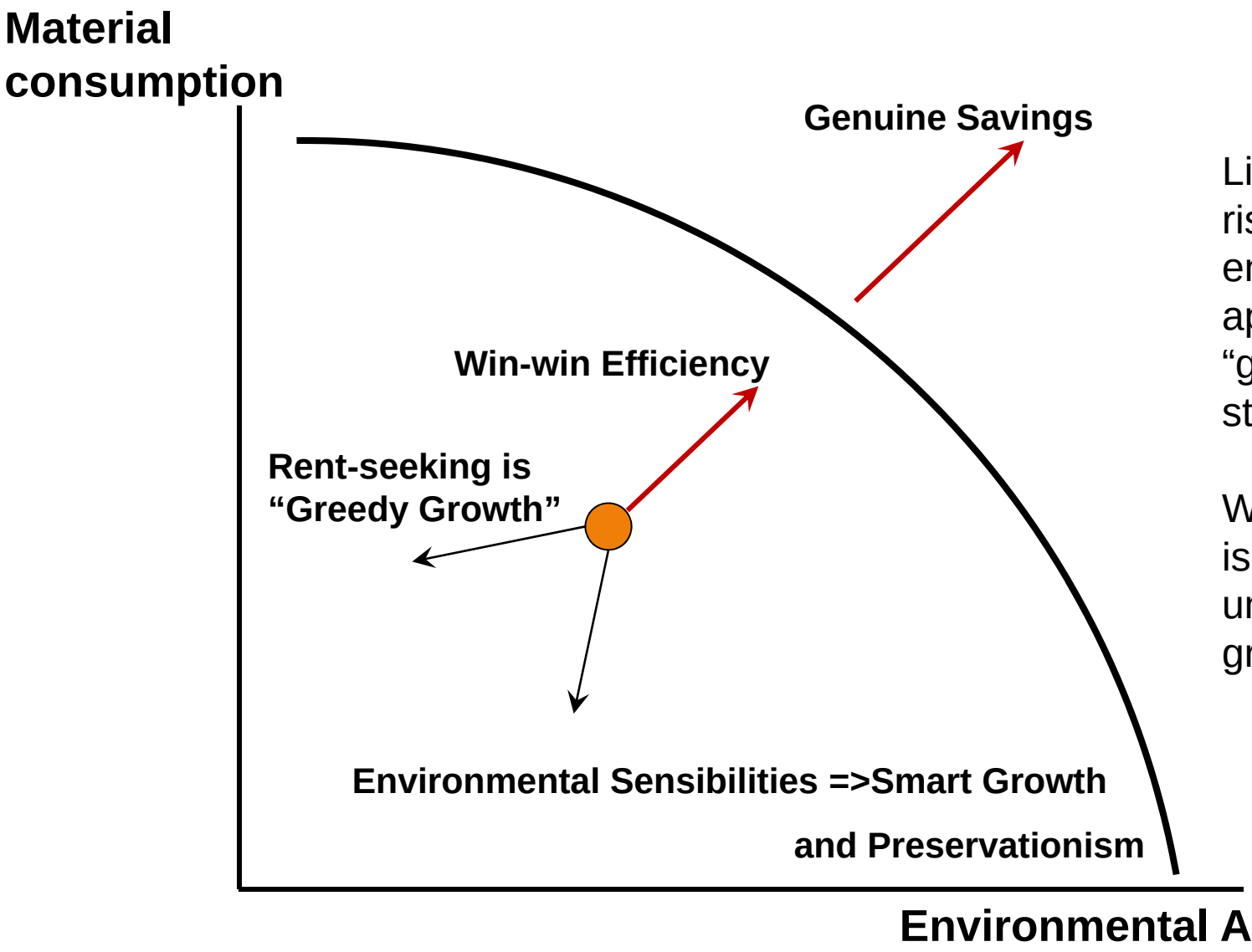
1) interlinkages, especially between natural resource systems, the environment and the economy;

2) dynamic efficiency paths of consumption, investment, and natural capital accumulation/depletion (Pearce equation)

3) intertemporal equity, which is increasingly represented (e.g. in the Stern Review) as intertemporal neutrality (embedded in Ramsey equation).

- **Contrivance of a sustainability constraint is unnecessary.**

Positive Sustainable Development



Living standards, rise as the environomy approaches a "golden-rule" steady state.

Win-win efficiency is achieved, and unsustainable growth is avoided .

The Promise

- **One of the greatest dilemmas facing today's educators is how to engage sustainability. Many college students are passionate about the environment and the use of natural resources. The challenge is how to nurture the passion without enabling the self-righteous blame-game that often goes with it. Sustainability science offers the potential to combine the passion with evidence and reason -- the lifeblood of universities and the best hope for civil discourse.**

Sustainability Science

- *Sustainability Science:* **Transdisciplinary organization of environmental and resource management questions**
- **What are you *solving* for?**
  - **Efficient water use, including optimal drawdown/build-up of aquifer; watershed conservation**
  - **Optimal composition/spatial configuration of biological diversity, including appropriate reduction of invasive species**
  - **Atmospheric carbon**
- **What are the policy instruments?**

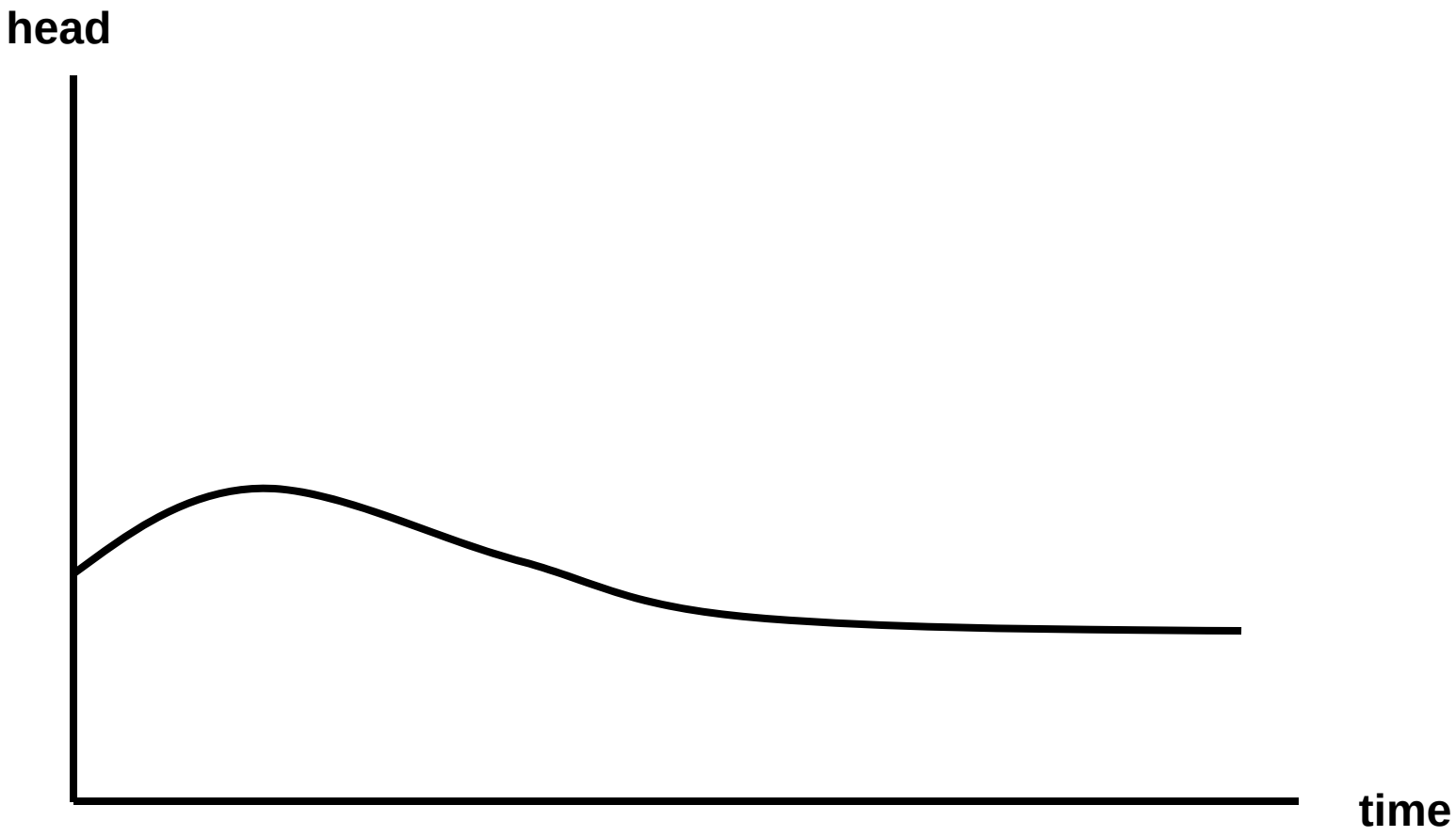
An early prototype

- **William Nordhaus**
  - **Embedded Steve's Sneider's 4 equation model into an intertemporal model of welfare**
  - **Solve for the path of carbon taxes that maximizes welfare.**

Water Management

- **Demand-management tools (e.g. block-pricing)**
- **Supply-side investments (groundwater development, water recycling, desalination)**
- **Watershed conservation: how different habitats affect balance between**
  - **Recharge / runoff / evapotranspiration**

Rules of thumb such as MSY are likely wasteful. Intertemporal efficiency ...



SS in Forest Management

Need an integrated policy analysis

1. **Sequestration should be combined with reducing forest emissions.**
2. **Reducing net forest emissions should be part of more comprehensive forest policies that account for the full marginal opportunity cost of deforestation.**
3. **Forest policy should be broadened to include adaptation to increased water scarcity, soil erosion, sedimentation, food insecurity, and other consequences of climate change.**
4. **Programs should be combined with conventional mitigation proposals rather than advanced separately.**

Questions

- **Designing incentives**
  - **Ecosystem payments**
  - **Proposal contests**
  - **Organizing restoration**
    - **Public-private partnerships**
- **Organizing research**
  - **Science into social science, or other way around?**

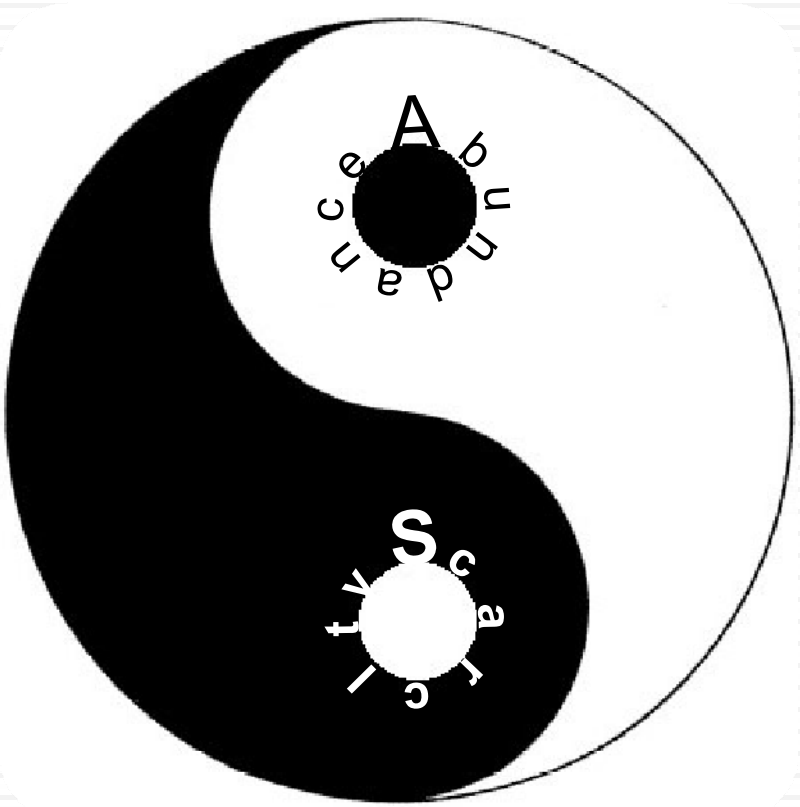
Bad *environomic* policy worsens environment, increases poverty

- **Good *environomic* policy conserves total capital and promotes welfare-increasing trade within and with other countries:**

  ⇑ human welfare and ⇓ poverty.

- **Symbolicly *green* policy may fragment the economy, decreases produced capital more than it increases natural capital:**

  ⇓ welfare and ⇑ poverty.



Mahalo

Sustainability Rule

- **Strong sustainability (category mistake)**
  - **prohibits any level of depletion of natural capital such as trees, water, or fish**

$$p_N \dot{K}_N \geq 0$$

- **Weak sustainability (Arrow, Daily, Erlich et al., 2004)**
  - **requires the summed value of produced and natural capital to remain constant or increase over time**

$$C \geq \text{requires} \qquad p_M \dot{K}_M + p_N \dot{K}_N \geq 0$$

Dasgupta and Mäler (1995, p. 2394) criticize strong sustainability on the grounds that it is a:

category mistake, the mistake being to confuse the determinants of well-being (for example, the means of production) with the constituents of well-being (for example, health, welfare and freedoms)

i.e., by proposing strong sustainability as both a criterion and a constraint, the means are confounded with the ends.

Sustainability criterion

- **Has been shown that the weak sustainability *rule* can indeed be derived from the sustainability *criterion* (Arrow et al., 2004).**

- **Sustainability *criterion* – the mandate that the total welfare of all future generations not be diminished (Arrow et al., 2004).**
  - **the weak sustainability rule is a necessary and sufficient condition to achieve the sustainability criterion.**

Sustainability criterion: the empirics

- **Genuine investment is the increase in the stock of capital assets – manufactured, human, and natural.**

- **Indicator of SC (Arrow et al., 2004, Dasgupta 2007, Hamilton and Clemens, 1999). ➔ SC is met if GI ≥ 0**
  - **Sub-Saharan Africa, are unsustainable even though net investment and increases in human capital (education expenditure) are positive.**
  - **China's GI is high, even amidst claims of heavy pollution and natural capital depletion, because of extremely high domestic net investment and human capital accumulation.**

SC ≅ Negative Sustainability

- **The statistic provides a useful signal to examine the components more closely and to formulate possible strategies to combat unsustainability.**

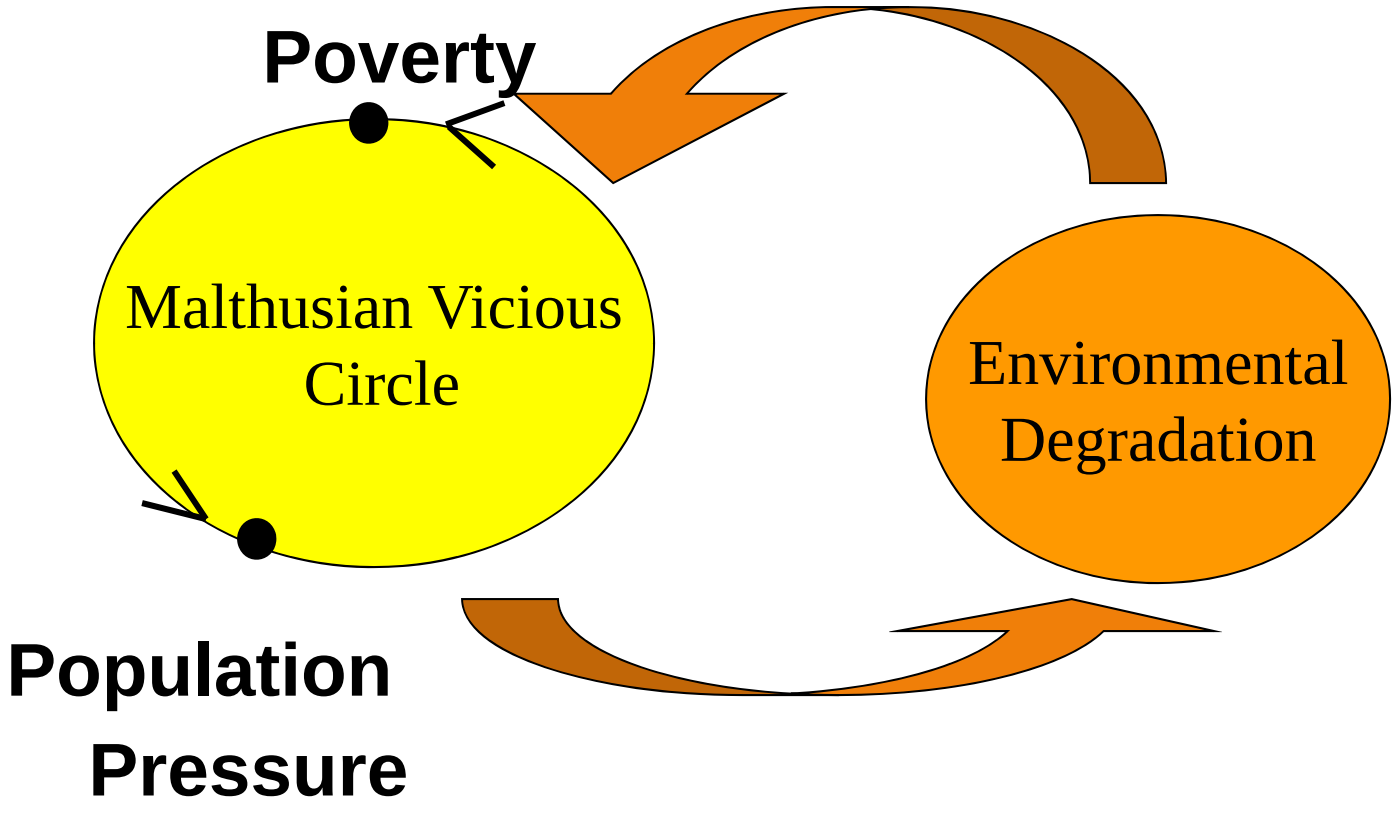
- **Does not provide clear guidance regarding how much genuine investment should be increased nor how much its components should be changed.**
  - **Thus, SC can be classified as *negative sustainability* – it only tells us what not to do.**

Sustainable growth

Attention was shifted away from development to the question of sustainable growth.

- **Negative Sustainability**
- **Positive Sustainability**

Brundtland Vicious Circle



How to do Sustainability Science?

- **Groundtruthing (basic monitoring)**
  - **What is the state of Manoa watershed?**
  - **How much is it degraded?**
  - **Pig population?**
  - **Stream quality/quantity?**
  - **How impacted by humans?**
- **Feed scientific data into integrated resource/ecological management models that balance tradeoffs over time and space.**
- **Policy/resource management recommendations**

Modeling the ecosystem

- **Stability**
- **Resilience**
- **Irreversibilities**
- **Non-linearities**
- **Non-convexities**
- **Complex interaction**
- **Multiple equilibria**
- **No equilibrium**

SS in watershed

- **Begins with questions regarding the targets and instruments of watershed management.**
  - **Include forest and watershed conservation, ground and surface water management, flood risk reduction, and food system management**
- **Bad management of one part of the system reduces welfare-enhancing opportunities in others.**
  - **forest degradation and deforestation accelerate soil erosion, runoff, sediment transport, flooding, biodiversity loss, and carbon emissions**
  - **Productivity of forest, agriculture and fishery sectors are negatively impacted**
    - **Driving populations to seek their livings on marginal hillsides and other fragile ecosystems**

Water balance modeling

- Rainfall = interception + through-fall
- Through-fall = ET + runoff + recharge

- Determinants: slope, elevation, soil type, radiation, *habitat*

Challenges

- **Monitoring capability improved**
  - **From digital to kitchenware**
- **Statistical / modeling challenges**
  - **Cross-section / time series**
  - **Seasonal and other cycles**
  - **Adjustments following environmental shocks**

Challenges cont.

- **Indicators, patterns, explanations**
  - **Water balance (ET, recharge, runoff)**
  - **Sedimentation**
  - **Habitat**
  - **Interpolation / inference across habitats**