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Simulating Global Dynamics with Integrated Assessment Models

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Why models?

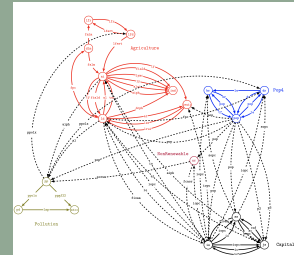
"Every person approaches his problems, wherever they occur on the space-time graph, with the help of models. A model is simply an ordered set of assumptions about a complex system. It is an attempt to understand some aspect of the infinitely varied world by selecting from perceptions and past experience a set of general observations applicable to the problem at hand. ... These mental models are, of necessity, very simple when compared with the reality from which they are abstracted. The human brain, remarkable as it is, can only keep track of a limited number of the complicated, simultaneous interactions that determine the nature of the real world. We, too, have used a model. Ours is a formal, written model of the world. It constitutes a preliminary attempt to improve our mental models of long-term, global problems by combining the large amount of information that is already in human minds and in written records with the new information-processing tools that mankind's increasing knowledge has produced the scientific method, systems analysis, and the modern computer."

The limits to growth, Meadows et al. 1972

Integrated Assessment Models

A numerical model that **estimates** possible scenarios of human society's evolution, for example:

- Capital investment
- Food production
- Natural resources
- Population size
- Pollution



The World Dynamics Project

The World Dynamics project aims to provide a modern Julia framework for **investigating** integrated assessment models of sustainable development, based on current software engineering and scientific machine learning techniques. It allows scientists to **easily use and adapt different world models**, from Meadows et al.'s World3 to recent proposals such as the Earth4All model.

GitHub Organization

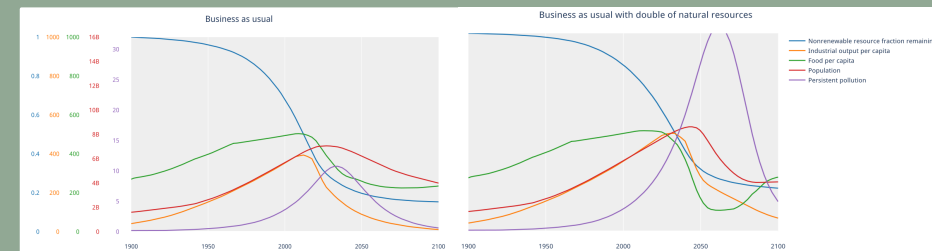
WorldDynamics:

<https://github.com/worlddynamics>



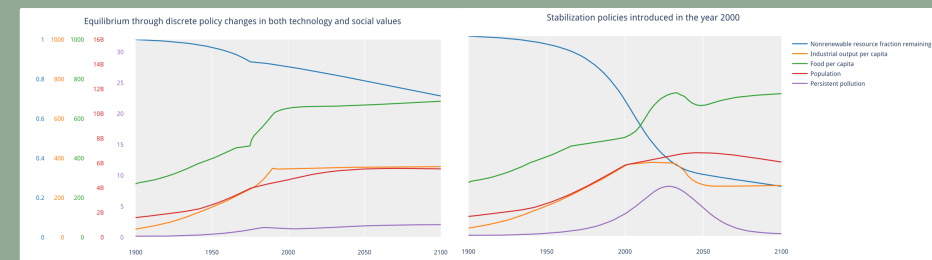
The World3 Model

The World3 model contains 5 sectors: agriculture, population, pollution, non-renewable resources, and capital.



Population and industrial output per capita grow unsustainably, leading to **decline** due to resource depletion.

Non-renewable resources are doubled, sustaining industrialization for a further 15 years until growth is interrupted by resource depletion.

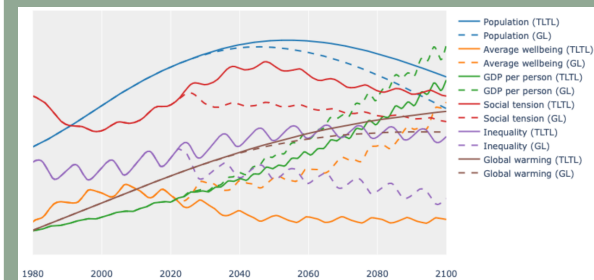


By 2050, population stabilizes at 5 billion, persistent pollution remains low, and resource depletion occurs at a manageable rate, allowing technology and industry to adapt to changes in resource availability.

The adaptive technological and social policies from the previous scenario are **not** implemented until 2000. Continuing growth for another 25 years further reduces the carrying capacity of World3, rendering the **previously effective policies ineffective**.

The Earth4All Model

Comparison of two scenarios generated by the Earth4All model. The **"Too Little Too Late"** (TLTL) scenario assumes a continuation of conventional decision making until 2100, while the **"Giant Leap"** (GL) scenario implements various turnarounds in the areas of poverty, inequality, empowerment, food and energy.



References

- Julia: A fresh approach to numerical computing.* Bezanson et al. (2017)
- Dynamics of growth in a finite world.* Meadows et al. (1974)
- The Earth4All model of human wellbeing on a finite planet towards 2100.* Randers and Collste (2022).

Acknowledgements

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