HS 232

Lecture 13 6th February 2025

Feedback Loop, IPAT and EKC

Recap

- Market failure – under production / over production
- Policy options to correct the marker failure
- Carbon Tax
- Cap and Trade
- Elastic and inelastic demand
- Case of India
- Consumption and production based emissions
- Lecture 11 (documentary) and lecture 12 (Climate Models)

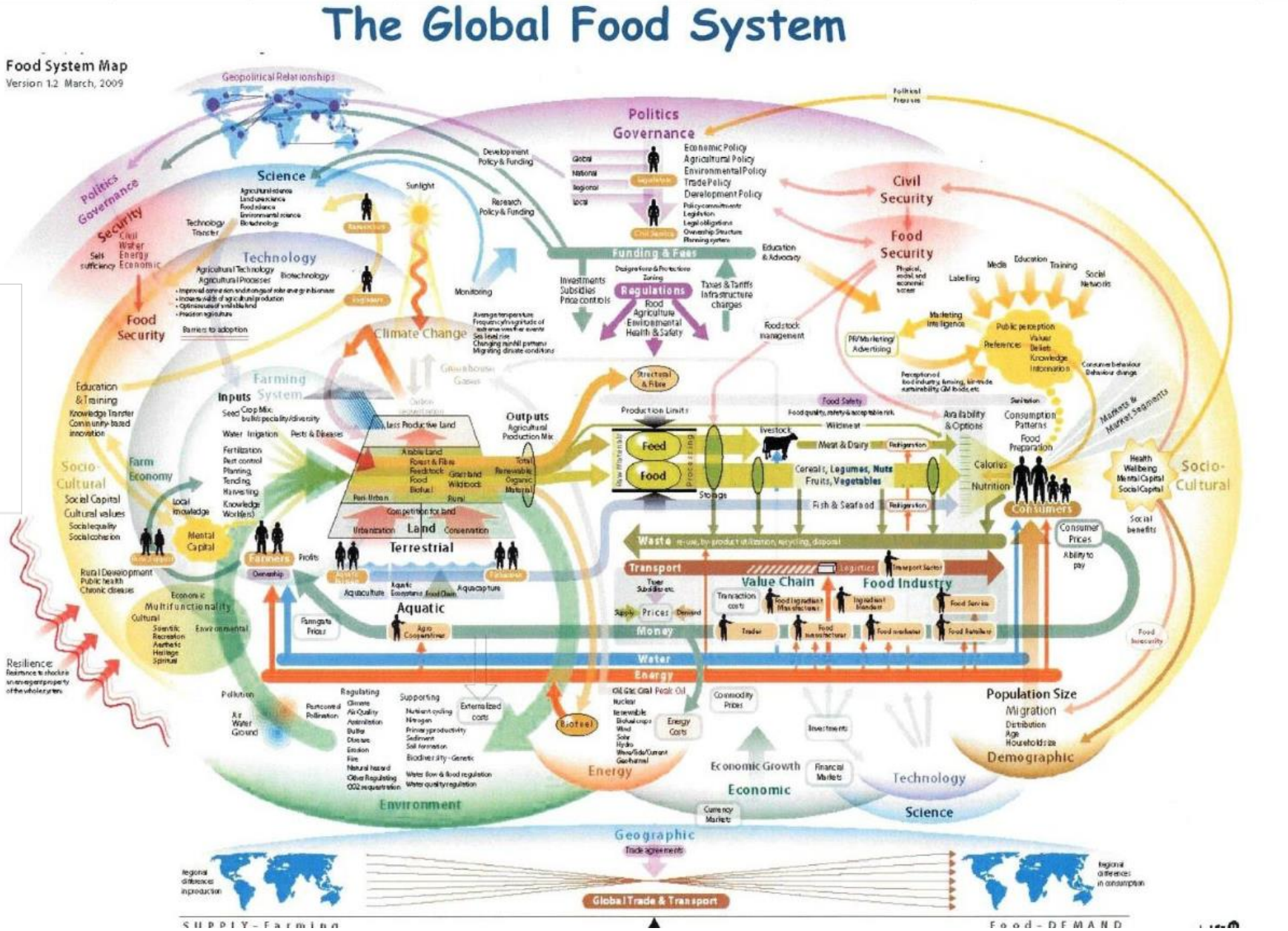
Coupled Human-Environment Systems

- Humans impact the environment, and the environment impacts humans.
- These impacts happen in many different ways. In other words, there are very many interactions between humans and the environment. In order to help us keep track of all these interactions, and to learn from them, it is very useful to use a ***systems perspective***.
- This means treating humans and the environment as systems: the human system and the environmental system. We could even treat them as one combined human-environment system.

What is a system?

- A system is a collection of components that interact with each other to form some aggregated whole.
- For example, this course is a system. It has many components, including the classes, the course assignments, the instructor, and the students. These components all interact with each other to form the course.
- The components can also be thought of as systems. For example, this class has slides, some supplemental readings, and say a learning activity at the end. Each of these module components can be thought of as a system, too.

Simple to complex system



Feedback Loop

- This phenomenon of system components both impacting each other creates a ***feedback loop***.
- Feedback is an impact to a system component that is a consequence of an action performed by that component. For example, suppose you take the action of writing an email to the instructor, asking a question about the course. The email you get back is a feedback

Positive and Negative Feedback Loops

- There are two basic types of feedback: positive and negative.
- A ***positive feedback loop*** is a circumstance in which performing an action causes more performances of the action.
- For example, suppose that every time you emailed the instructor with a question about the course, the instructor wrote back with an email so confusing that you had even more questions about the course, which cause you to write two emails back for more clarification. This would be a positive feedback loop.

- A ***negative feedback loop*** is a circumstance in which performing an action causes fewer performances of the action.
- For example, suppose that every time you emailed the instructor with a question about the course, the instructor wrote back in an email that clarified the entire course for you, so that you had fewer questions about the course and thus wrote fewer emails for clarification. This would be a negative feedback loop.
- It is important to understand that for feedback loops, the terms "positive" and "negative" do not mean good and bad. A positive feedback loop can be a bad thing, and a negative feedback loop can be a good thing or vice versa.

Climate change and feedback loops

- A feedback loop in the context of climate change refers to a process where an initial change in the climate system triggers a series of reactions, which can either amplify (positive feedback) or dampen (negative feedback) the original change.
- **Positive Feedback Loops (Amplify Warming)**
- **Ice-Albedo Feedback**:
  - **Initial Change**: Global warming melts ice and snow.
  - **Reaction**: Ice and snow, which reflect sunlight, are replaced by darker surfaces (e.g., oceans or land) that absorb more heat.
  - **Result**: Increased absorption of heat leads to further warming and more melting, creating a self-reinforcing loop.

Negative Feedback Loops (Stabilize Warming)

- **Cloud Formation**:
  - **Initial Change**: Warmer temperatures increase evaporation, leading to more clouds.
  - **Reaction**: Some clouds reflect sunlight back into space, reducing the amount of heat absorbed by the Earth's surface.
  - **Result**: This can moderate warming, though the type and altitude of clouds affect the net result.
- **Complex Feedback Interactions**
- Climate systems are highly interconnected, and feedback loops often interact. For instance:
- Melting ice can accelerate warming (positive feedback), but increased cloud cover from higher evaporation might offset some warming (negative feedback).
- These loops demonstrate the sensitivity and complexity of the Earth's climate system. Positive feedback loops are particularly concerning because they can push the system beyond tipping points, where changes become irreversible. Understanding and mitigating these loops is critical for addressing climate change.

IPAT/ EKC

Feedback loop

What is IPAT
(https://www.e-education.psu.edu/geog30/node/328)

- **The IPAT Equation: I = P x A x T**
- The equation I = PAT is a mathematical formula used to describe the impact of human activity on the environment..
- In this equation:
- I = Environmental Impact
  P = Population
  A = Affluence (typically measured as GDP per capita)
  T = Technology (often represented as resource use or pollution per unit of GDP)

I = P x A x T

$$\text{Impact} = \text{Population} \times \frac{\text{economic good}}{\text{population}} \times \frac{\text{pollutant}}{\text{economic good}}$$

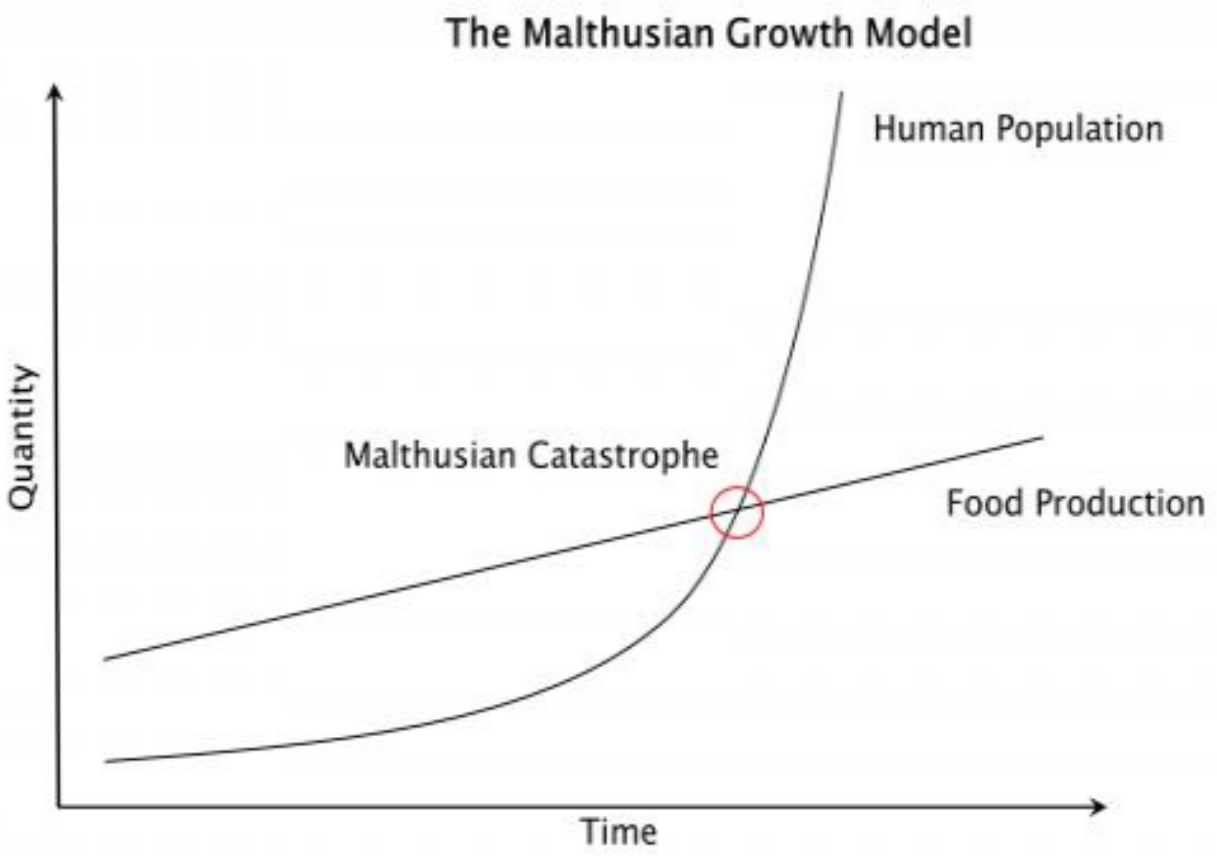
- The equation maintains that impacts on ecosystems (I) are the product of the population size (P), affluence (A), and technology (T) of the human population in question.
- This equation was developed by biologist Paul Ehrlich and environmental scientist John Holdren in 1971, and you might notice that the concept is very similar to the notion of carrying capacity presented earlier in this module.
- It is elegant in its simplicity, and compelling because it presents such an intuitive narrative.
- However, it has been criticized for being overly simplistic and not accounting for the complex interactions between these factors. Some argue that it's more accurate to express the relationship as a function: I = f(P,A,T), to better reflect the interdependencies between population, affluence, and technology

Perspectives on Population and Resource Scarcity.

- The IPAT equation and other environmental explanations based on population and resource scarcity became very popular in the 1970's with the birth of the modern environmental movement, and they have often dominated environmental activism and regulation since that time.
- But the ideas are actually much older than Paul Ehrlich.
- These arguments originated in late 18th Century England with the work of cleric and scholar **Thomas Robert Malthus**. In his 1798 book *An Essay on the Principle of Population*, Malthus argued that human population growth is exponential while natural resources (particularly food) are fixed, and their availability can only grow linearly.

Malthusian catastrophe.

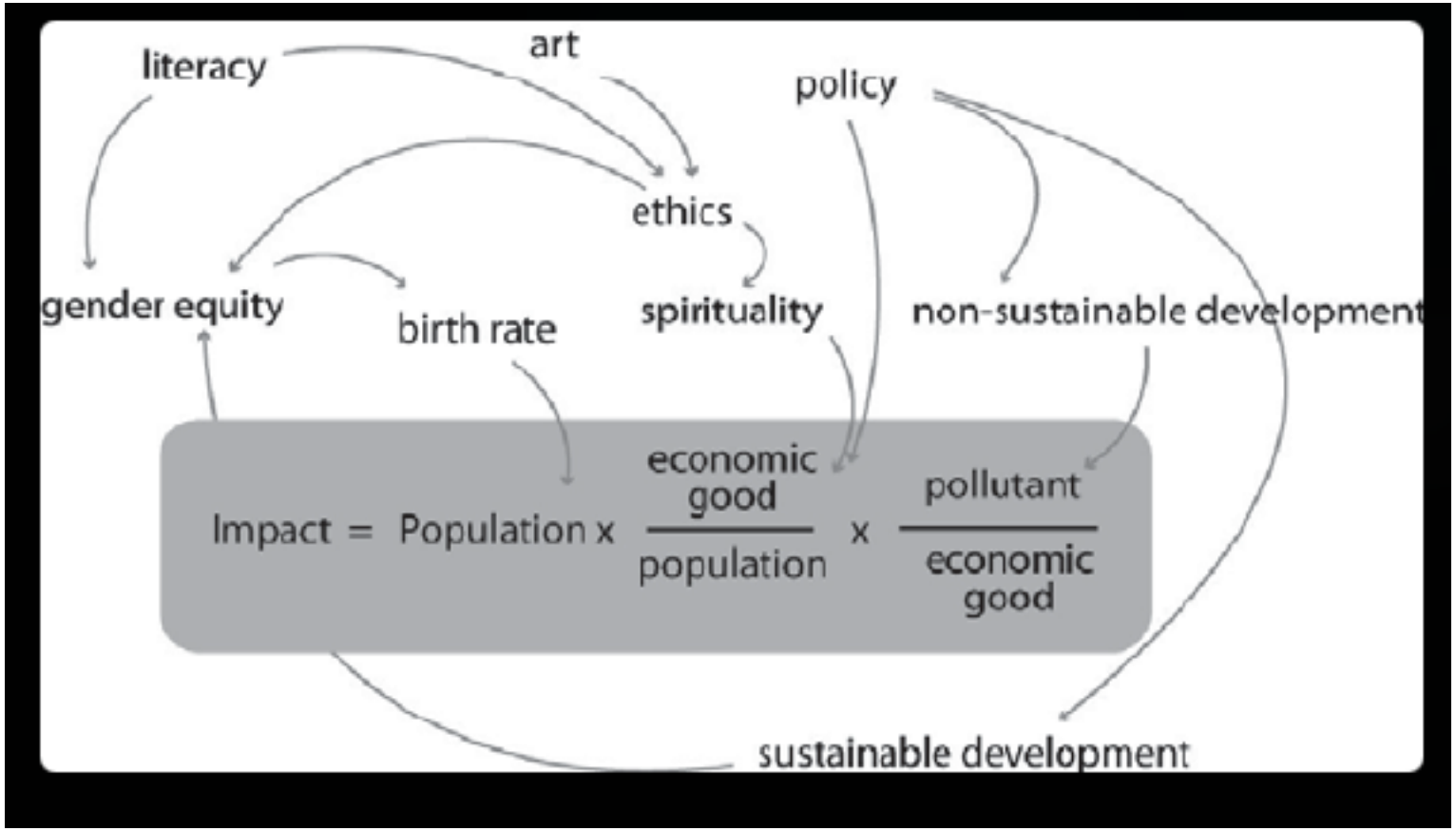
- Thus, he argued that unless the human population was regulated in some way, the population would surpass resource availability, leading to famine, disease, and population collapse (a moment dubbed the **Malthusian catastrophe**.



Neomalthusians

- Malthus placed most of the blame for human population problems squarely on the shoulders of the poor and people from less developed nations, finding fault with their ignorance and lack of moral discipline. You may think that this is a rather ugly position to take, and you are not alone.
- Malthusian arguments had lost prominence until the middle of the 20th Century when a new group of scholars took up the mantel of unchecked population and resource scarcity. These thinkers are known as **neomalthusians** because their theories are an update to the work of Malthus.
- The main difference in neomalthusian explanations is the acknowledgment that affluence and technology influence consumption and resource supply problems (and thus environmental impact) as well as total population. In other words, richer nations are also part of the problem - hence the IPAT equation.
- However, the basic premise still hinges on the notion of overpopulation and resource scarcity.

Why It is more complex



Reducing P is an ethical and political concern

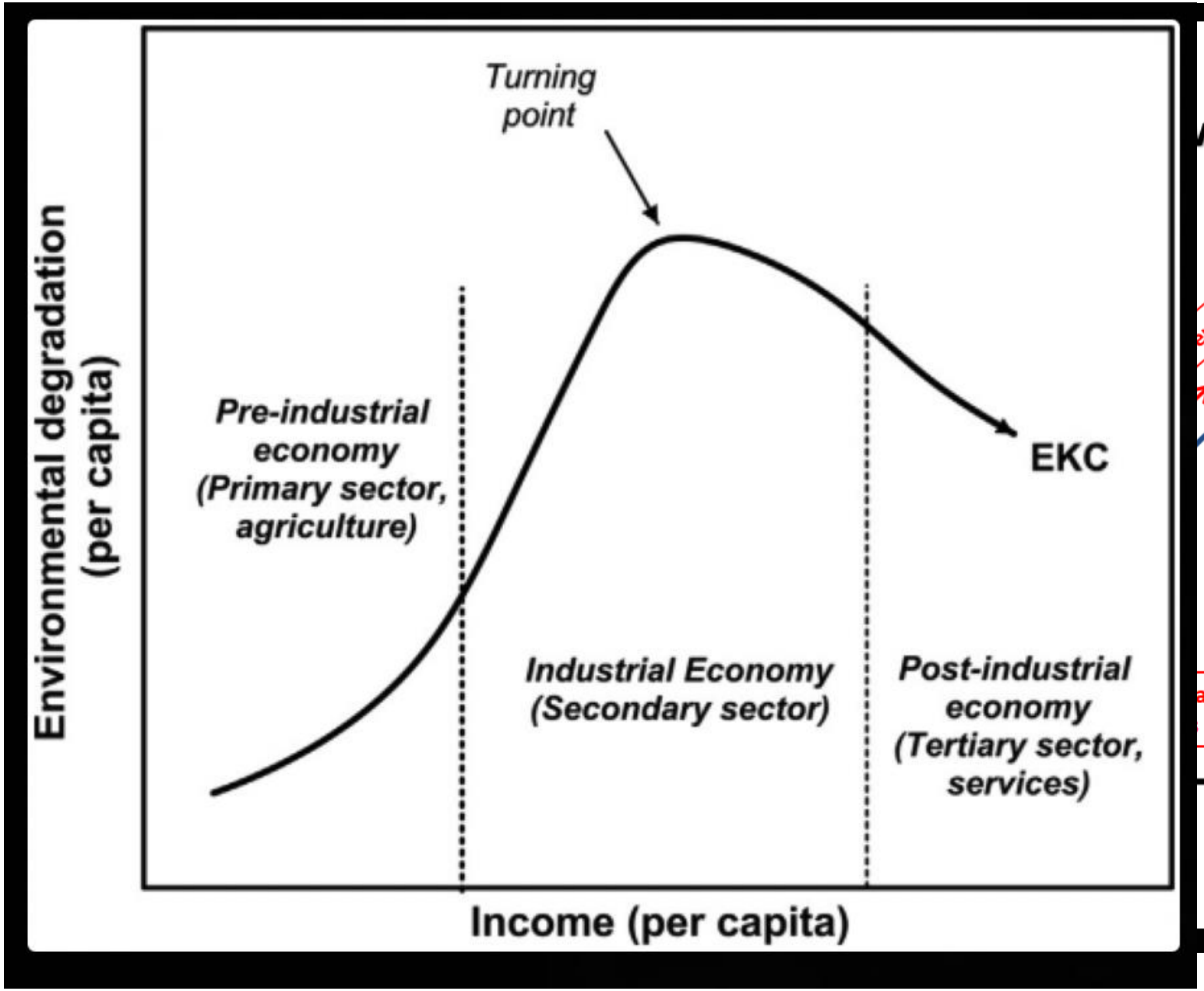
Affluence is a sign of living standard

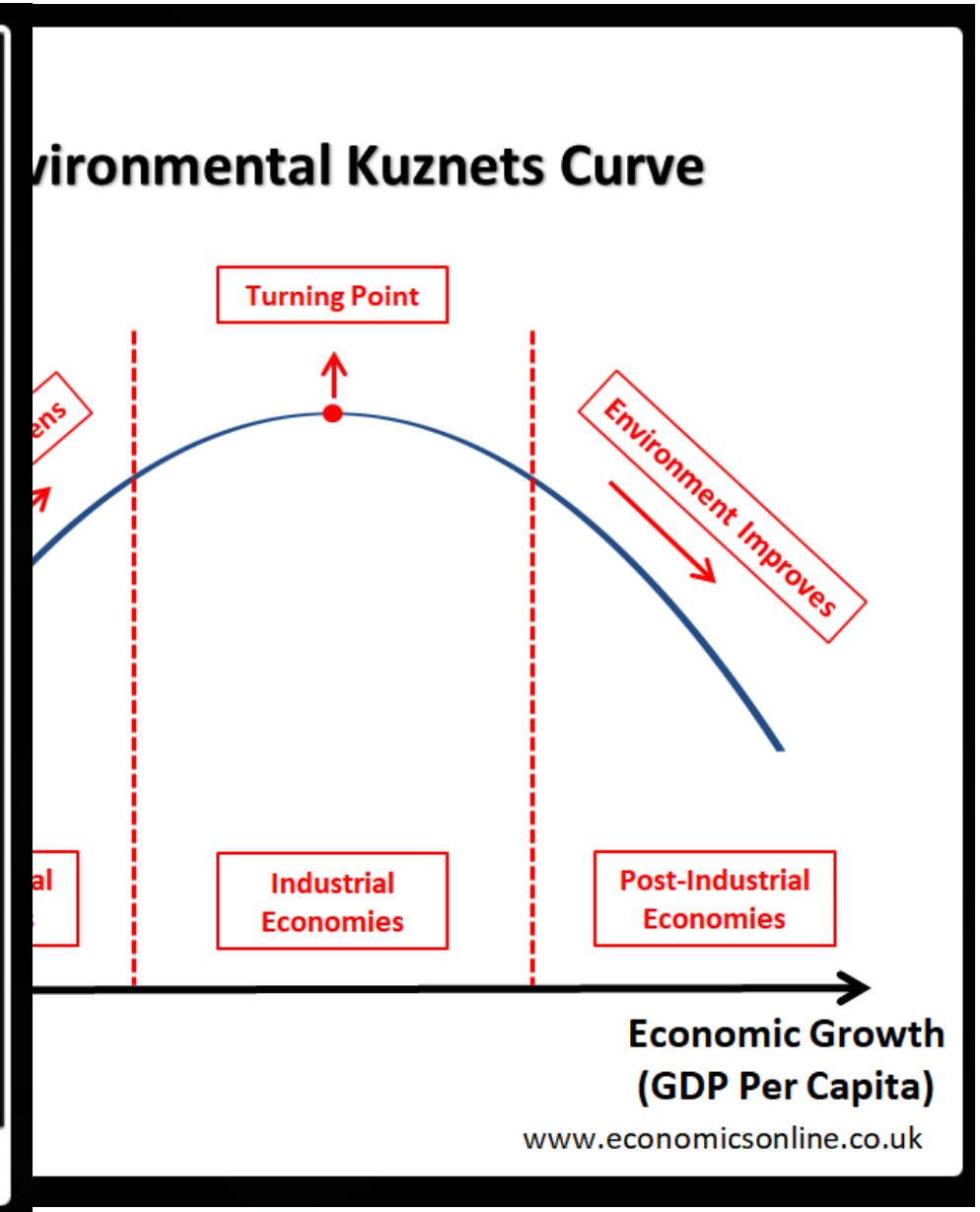
We are left with Technology

Technology in IPAT

- Future technologies will be able to address our environmental concerns. This type of solution to environmental problems is called a **technofix**, and it raises an important point about the “T” in the IPAT equation.
- While some technology certainly does increase environmental impact, other technology decreases it. For example, coal power technology generally increases our greenhouse gas emissions, whereas solar power technology generally decreases emissions.
- Alternative energy technologies and most other technological research and development happens in the richest nations. And wealthy countries are almost always the first to adopt these new technologies.

Environmental Kuznets curve

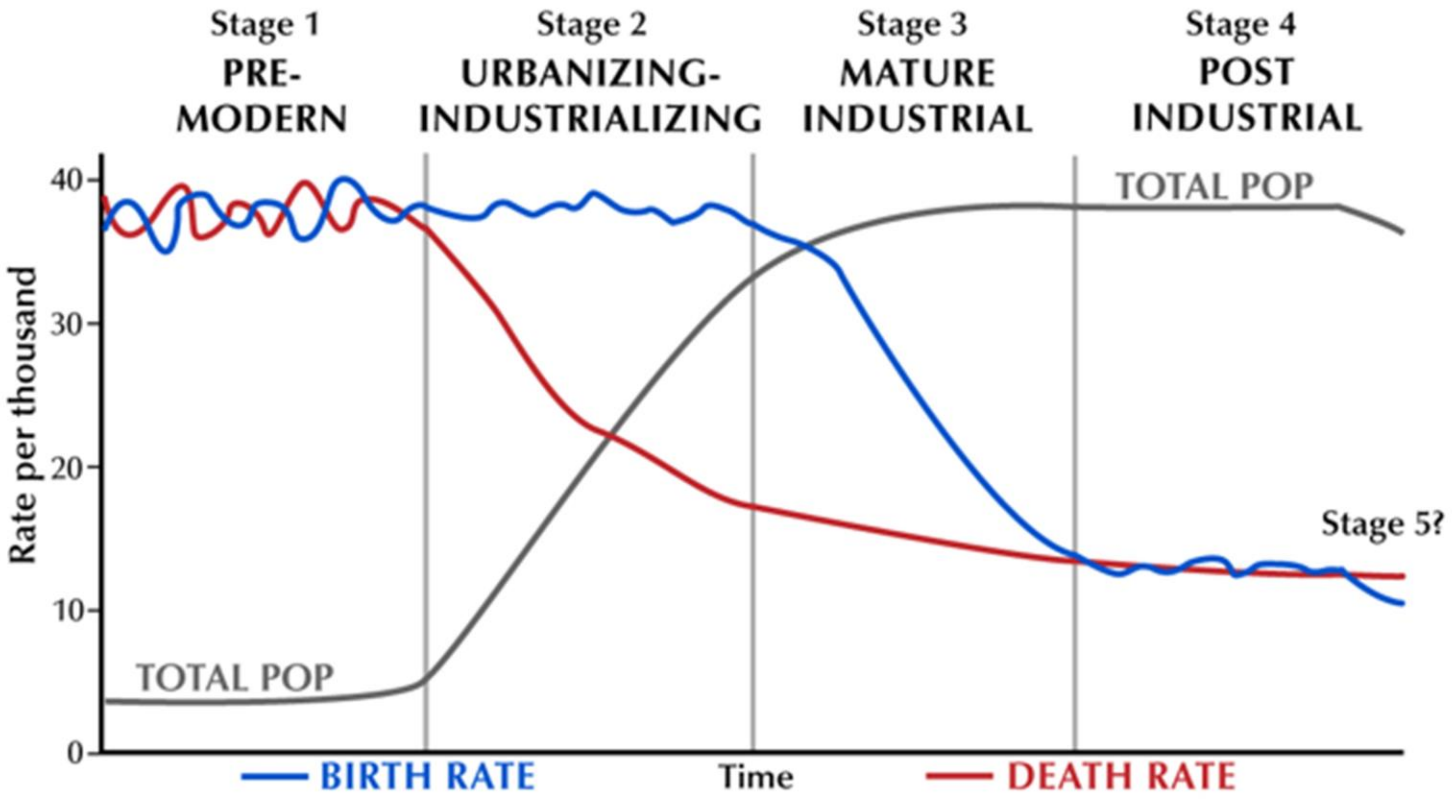




Why ‘Kuznets’ curve

- The term 'Kuznets curve' is named after Simon Kuznets, an American economist who first introduced this concept in the 1950s and 1960s.
- Kuznets was a Nobel laureate in economics who made significant contributions to the fields of economic growth and income inequality.
- The curve is called the Kuznets curve because it graphically represents Kuznets' hypothesis about the relationship between economic development and income inequality

The demographic transition model



the question mark after stage 5 indicates that human society has not developed enough to give conclusive evidence of the later stage trend.

Key Takeaway

- Malthus and his modern proponents like Ehrlich have made many dire predictions, none of which have come true. Does that mean that human population has *nothing* to do with human impacts on the environment? Of course not.
- What it does mean is that population is far from the whole story and that technology and human adaptation are also incredibly important. The Demographic Transition model suggests that the global population will eventually stabilize, or even contract. Does that mean that economic development and equal rights are the checks to population growth that Malthus called for?
- Perhaps. One thing we can say for sure is that these issues are far too complex for any one theory or approach to be completely correct.