

國立臺北大學自然資源與環境管理研究所
112 學年度第二學期 『清潔生產與工業生態學』

課程進度(05)：工業生態學：架構性觀念與指標工具
Introduction to Industrial Ecology: Framework Concepts and Tools of Indicators

● TECHNOLOGY AND RISK

- Dimensions of Industrial Ecology:
 - ⇒ Ecological (Biological Analogy), Social, and Technological
- Historical Patterns in Technological Revolution (G&A, pp.67-71)
 - ⇒ Trends in Anthropogenic Environmental Transformation (Fig. 6.1)
 - ⇒ Technological Revolution => Product lifecycle; Market penetration rate; Clusters
- Approaches to Risk (G&A, pp.71-75)
 - ⇒ Risk => Opportunity => Degree of adverse effect and probability of occurrence
 - ⇒ Annual mortality rate => one-in-a-million (ppm)
- Risk Assessment (G&A, pp.75-77)
- Perception of risk and Risk Communication (G&A, pp.77-78)
- Risk Management (G&A, pp.78-80)

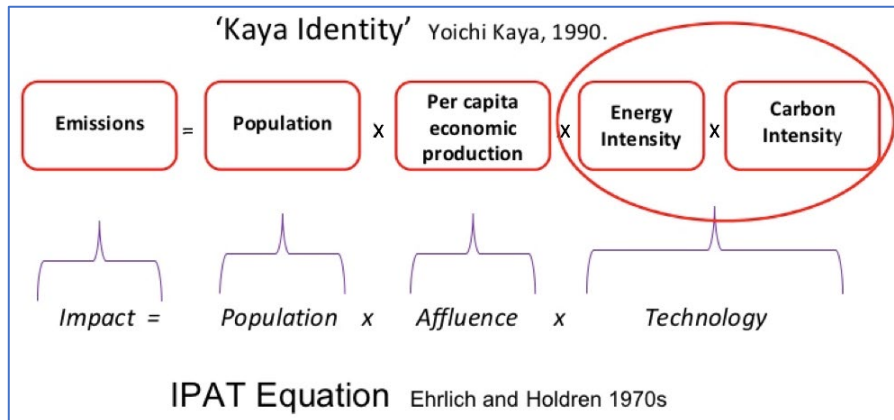
● REVISIT THE SOCIAL DIMENSIONS OF INDUSTRIAL ECOLOGY

- Cultural Constructs and Temporal Scales: Paradigm Shift (G&A, pp.83-86)
 - ⇒ Social System Structure over Different Timescales
 - ⇒ Belief systems regarding the economy, individual liberty, the environment, and sustainability
- Social Ecology (G&A, pp.86-87)
- Consumption (G&A, pp.88-89)
- Governmental Agencies and NGOs (NPOs) => Ayres and Ayres (2002): Chp.6 (Allenby)
- Economics and Industrial Ecology (G&A, pp.93-97)
 - ⇒ The Private Firm and Business Activities
 - ⇒ Valuation, Discount Rates, and Green Accounting

● THE “MASTER EQUATION” OF INDUSTRIAL ECOLOGY

- The Master Equation (G&A, p.28)
 - Environmental Impact**
= Population × [GDP/person] × [(Environmental Impact)/(Unit of GDP)]
 - ⇒ The IPAT Equation: I=Impact; P=Population; A=Affluence, T=Technology
 - ⇒ Ayres and Ayres (2002) P.8: *The IPAT equation has provided an analytical basis for parsing the relative contributions of population, economic growth (or, viewed in another way, consumption) and technology on environmental quality.*
 - ⇒ Sustainability ~ (AP/I) = 1/T => Ratio of human quality of life to environmental impact (*)
 - ⇒ The Kaya's identity: a mathematical expression for energy-related carbon emission
C = (P) × (GDP/P) × (E/GDP) × (C/E)
where the total energy-related carbon emissions C is expressed as a product of Population P, GDP per capita, energy intensity E/GDP and carbon intensity of energy use C/E.
 - ⇒ The IPAT Equation and Its Variants ([Chertow, 2000](#))

⇒ ImPACT and Kaya Identity (https://unfccc.int/sites/default/files/2.4_cicero_peters.pdf)



(<https://blogs.ntu.edu.sg/hp3203-1718-s2-15/overview/>)

⇒ The IPAMDH Equation: $I = P \times A \times M \times D \times H$ (Kapur and Graedel, 2004)

M is the materials intensity, D the dissipation factor, and H the hazard factor, which depends on the chemical form of the material lost and the susceptibility of the receiving ecosystem.

Environmental Impact

$$= \text{Population} \times [\text{GDP/person}] \times [(\text{Units of Material})/\text{GDP}] \\ \times [(\text{Units of Pollution})/(\text{Unit of Material})] \times [\text{Impact}/(\text{Unit of Pollution})]$$

⇒ STIRPAT (York et al., 2003):

STochastic Impacts by Regression on Population, Affluence, and Technology

$$I_i = aP_i^b A_i^c T_i^d e_i$$

⇒ Application IPAT to assess resource productivity (Wang et al., 2014)

□ From Equations to Indicators

⇒ [Handbook on Constructing Composite Indicators: Methodology and User Guide](#)

⇒ [The Human Development Index and related indices](#)

⇒ [國發會-景氣指標查詢系統-景氣對策信號\(ndc.gov.tw\)](#)

⇒ [Environmental Performance Index \(yale.edu\)](#)

⇒ 許明華碩士論文：我國飲用水水質適飲性指標化評估之研究--2.1 環境指標系統

● HUMANITY AND TECHNOLOGY

□ The Tragedy of the Commons (G&A, pp.2-4; <http://zh.wikipedia.org/zh-tw/公地悲劇>)

⇒ The Maximum Sustainable Yield

⇒ Free Riders and Externality

□ Technology at Work (G&A, pp.4-5)

□ Technological Evolution (G&A, pp.7-10)

□ The ‘Past Goods’ and the ‘New Bads’ (G&A, p.31)

□ Decoupling of ‘Economic Goods’ and ‘Environmental Bads’

⇒ The Environmental Kuznets Curve ([Kuznets curve - Wikipedia](#))

□ *Metabolic* “Dissipativeness” of Materials vs. *Anthropic* “Concentration” of Pollutants

□ Final Sink of Materials: Consumption vs. Production

● HOMEWORK ASSIGNMENT #4 (Due 2024/04/02):

請參考 IPAT 方程式之指標定義與計算方式，整理能源生產力、能源密集度、電力排碳係數等指標之計算方式，並繪製三項指標近 10 年之趨勢變化圖。