

國立臺北大學自然資源與環境管理研究所
113 學年度第二學期『資源管理與環境系統分析』

課程講義(01)：環境系統、模式與量化指標
Environmental Systems, Modeling, and Indicators

• THIS COURSE: A GENERIC INTRODUCTION

- Business Analytics, Operations Research, Environmental Systems Analysis
 - ⇒ Descriptive, Predictive, and Prescriptive Analytics => Chats with AI and Refs
 - ⇒ Environmental Informatics => Geographic Information Systems
 - ⇒ Life Cycle Assessment, Material Flow Analysis, and Industrial Ecology



- Content => Systems Analysis Models and Applications Concerning the *Environment*
 - ⇒ Systems vs. Systems Analysis
 - ⇒ Systems Analysis vs. Operations Research (Operational Research)
 - ⇒ Systems Analysis vs. System Simulation => Systems Thinking and System Dynamics
 - ⇒ Programming vs. Planning => Simulation and Optimization
 - ⇒ Conceptual models => Mathematical models (Analytical and Numerical) => Simulation/Optimization models => Visualization
- Mathematical Models (Quantitative Models)
 - ⇒ Classification: Prescriptive vs. Descriptive; Deterministic vs. Stochastic
 - ⇒ Solution Techniques: Symbolic/Graphical Interpretation; Analytical vs. Numerical
 - ⇒ Algorithms, Numerical Methods => Linearity, Convexity, and Complexity
- Computer Applications
 - ⇒ Command Line Interface vs. Graphical User Interface (GUI)
 - ⇒ [Imperative Programming](#) vs. Object Oriented Programming
 - ⇒ Commercial Packages vs. GNU General Public License; Open Source & Open Data
 - ⇒ Cloud Computation and Cloud Storage => AI Chatbot (e.g., ChatGPT, DeepSeek)

• SOFTWARE TO BE COVERED

- Microsoft Office Applications: Excel, Visio, and Project
- [R](#) and [RStudio](#): a free software environment for statistical computing and graphics.
- [EULER Math Toolbox](#): A powerful math program combining numerical and symbolic tools (using the computer algebra system [Maxima](#)) in one free and open source package.
- [GNU Octave](#): Scientific Programming Language
- [pyDEA](#): A software package developed in Python for conducting data envelopment analysis (DEA).
- [Super Decisions](#): Decision support software that implements the AHP and ANP.
- [FreeMind](#) / [Freeplane](#): free mind mapping software.

● ENVIRONMENTAL SYSTEMS ANALYSIS: MODELING AND DECISION MAKING

- Environmental Systems and Environmental Modeling
 - ⇒ A **system** is composed of interrelated components, connected together in order to facilitate information, matter and energy flows.
 - ⇒ **Modeling** can be defined as the process of application of fundamental knowledge or experience to simulate or describe the performance of a real system to achieve certain goals.
 - ⇒ Physical modeling, Empirical modeling, and Mathematical modeling
 - ⇒ **Environmental Systems**: Ecological/Biological, Chemical (Engineering) and Socio-Economical Phenomena/Processes
 - ⇒ **Environmental Modeling** => e.g., Streeter-Phelps Equation of Oxygen Sag Curve
- Environmental Systems Analysis and Environmental Informatics (Environmatics)
 - ⇒ **Environmental Systems Analysis**: Applications of system approaches to dealing with problems/issues of environmental modeling and decision making
 - ⇒ **Environmental Informatics** is a part of applied Informatics and supports methods and procedures of information technologies that contribute to environmental data analysis and environmental protection.
 - ⇒ **Environmental Data**: Cross section, Time series, Spatial data, Panel data.
- Environmental Systems Analysis and [Systems Analysis for Sustainable Engineering](#)
 - ⇒ Systems analysis and sustainable management strategies
 - ⇒ Economic valuation, instruments, and project selection => Statistical forecasting models
 - ⇒ Linear, nonlinear, integer, and dynamic programming models => Multicriteria decision analyses
 - ⇒ System dynamics models and simulation analyses => System thinking

● INDICATOR, INDEX AND METRIC SYSTEM

- Metric System: Performance, Benchmarking, Indicator, and Index
 - ⇒ Index, Sub-indices, and Indicators
 - ⇒ UN Sustainable Development Goals => Goal, Target, Indicator
- OECD [Handbook on Constructing Composite Indicators: Methodology and User Guide](#)
 - ⇒ The construction of composite indicators:
 1. Theoretical framework
 2. Data selection
 3. Imputation of missing data
 4. Multivariate analysis
 5. Normalisation
 6. Weighting and aggregation
 7. Robustness and sensitivity
 8. Back to the real data
 9. Links to other variables
 10. Presentation and Visualisation
 - ⇒ OECD/JRC Handbook on constructing composite indicators - Putting theory into practice (Michela Nardo & Michaela Sai - [PowerPoint PPT Presentation](#))
- Examples of Index Systems
 - ⇒ Environmental Indices: PSI vs. AQI; RPI vs. WQI => CTSI
 - ⇒ Yale University: 2024 [Environmental Performance Index](#)
 - ⇒ World Economic Forum (WEF) [The Global Risks Report](#)
 - ⇒ IEA [Global Energy and Climate Model](#) => [Net Zero Emissions by 2050 Scenario \(NZE\)](#)

● Homework Assignment #1 (Reading Assignments)

請閱讀 OECD (2008) Handbook on Constructing Composite Indicators，以進一步了解複合性指標之建構步驟，並嘗試操作 Normalization and Visualization。