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(08):系統思維與系統動力學 System Thinking and System Dynamics

• INTRODUCTION TO SYSTEM DYNAMICS

□ The system dynamics approach (https://systemdynamics.org/what-is-system-dynamics/)

System Dynamics is a computer-aided approach for strategy and policy design.

The main goal is to help people make better decisions when confronted with complex, dynamic systems. The approach provides methods and tools to model and analyzes dynamic systems. Model results can be used to communicate essential findings to help everyone understand the system's behavior.

It uses simulation modeling based on feedback systems theory that complements systems thinking approaches. It applies to dynamic problems arising in complex social, managerial, economic, or ecological systems. It can be applied to social, managerial, economic, ecological, and physiological systems.



□ From Systems Thinking to Systems Dynamics

Systems thinking is a way to describe and understand the causality and interrelations between variables within a system. System Dynamics quantifies the impact of those interactions.

Systems thinking is a causality-driven, holistic	System Dynamics complements systems thinking by
approach to describing the interactive	quantifying interactions and develops a time-dependent view of
relationships between components inside a	how the system behaves. The approach focuses on building
system as well as influences from outside the	computer models that represent and simulate complex
system. Its background emerges from various	problems in which behavior changes. These models bring to
fields including philosophy, sociology,	light less visible relationships, dynamic complexity, delays, and
organizational theory, and feedback thought.	unintended consequences of interactions.

□ Jay W. Forrester 1918-2016 (https://systemdynamics.org/news/memorial/jay-w-forrester/)

Jay Wright Forrester was a pioneering American computer engineer and systems scientist. He is credited with being one of the inventors of magnetic core memory, the creator of the first computer animation, and the father of the field of System Dynamics.

- ⇒ Industrial Dynamics
- ⇒ Urban Dynamics
- ⇒ World Dynamics
- ⇒ Social Dynamics (https://collections.systemdynamics.org/jwf/social-dynamics/)

□ What is System Dynamics (https://www.uib.no/en/rg/dynamics/39282/what-system-dynamics)

System Dynamics...can help solving problems arising in complex socio-economic systems (economic, social, managerial, political, public health or etc.) and as well as physical and/or natural systems where humans interact with them (physiological, environmental, ecological, or

etc.). In addition, modeling language is intuitive, and it is common for all these fields which makes it an ideal tool for interdisciplinary work. Like Systems Thinking, System Dynamics has also a holistic and causality driven approach to describe and understand the relations between components or variables within a system which influences it internally or externally. But unlike the Systems Thinking, System Dynamics quantifies relations between variables to develop a view of behavior of the system over time through computer simulations.

- □ Core System Dynamics Software (<u>https://systemdynamics.org/tools/core-software/</u>)
 - ⇒ DYNAMO (<u>https://github.com/bfix/dynamo</u>)
 - \Rightarrow iThink[®] and STELLA[®] by <u>isee systems</u>
 - ⇒ Powersim Studio form <u>Powersim Software</u>
 - \Rightarrow Vensim[®] from <u>Ventana Systems, Inc</u>.
 - ⇒ Software Extending the System Dynamics Methodology: Anylogic, Dynaplan[®], GoldSim, TRUE, <u>Simcision</u>...
 - ⇒ Comparison of system dynamics software Wikipedia
- □ System Dynamics Simulation of Oxygen Sag Curve (the Streeter-Phelps Equation)
- Systems Thinking
 - Systems Thinking (<u>A system dynamics glossary Ford 2019 System Dynamics Review</u>) the use of conceptual system models and other tools to improve the understanding of how the feedback, delays, and management policies in a system's structure generate the system's behavior over time. Systems thinking does not use computer simulation. Systems thinking involves
 - (1) seeing interrelationships (feedback loops) instead of linear cause-effect chains, and
 - (2) seeking processes of change over time rather than snapshots. Systems thinking helps people see things on three levels: events, patterns of behavior, and system structure.
 - □ Senge, Peter, 1994. The Fifth Discipline -- The Art and Practice of the Learning Organization (彼得·聖吉, 1994,《第五項修練》,天下文化) => rev. 2006
 - ➡ 五項修練:自我超越 (Personal Mastery);改善心智模式 (Improving Mental Models);建立共同 願景 (Building Shared Vision);團隊學習 (Team Learning);**系統思考 (System Thinking)**
 - ⇒ 系統基模 (Systems Thinking Archetypes):
 - 1. 反應遲緩的調節環路(Balancing Loop with Time Delay)(反應遲緩)
 - 2. 成長上限(Limits to Growth)
 - 3. 捨本逐末(Shifting the Burden)
 - 4. 目標侵蝕(Eroding Goals)
 - 5. 惡性競爭(Escalation)
 - 6. 富者愈富(Success to the Successful)
 - 7. 共同悲劇(Tragedy of the Commons)
 - 8. 飲鴆止渴(Fixes and Fail)
 - 9. 成長與投資不足(Growth and Underinvestment)

<u>思考的魔術 — 系統思考基模 | 天下雜誌</u> <u>系統基模簡介 實踐大學資管系 張良政</u> <u>http://en.wikipedia.org/wiki/System_Archetypes</u> <u>System Archetypes (albany.edu)</u> <u>The Systems Thinker – How-To Guides Archives - The Systems Thinker</u>

□ Mind Mapping => Concept Map vs. Mind Map (<u>Concept Map vs. Mind Map</u> | <u>MindMaster</u>)