

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

課程講義(15)：多目標規劃與多評準決策分析
Multiobjective Programming and Multi-Criteria Decision Making

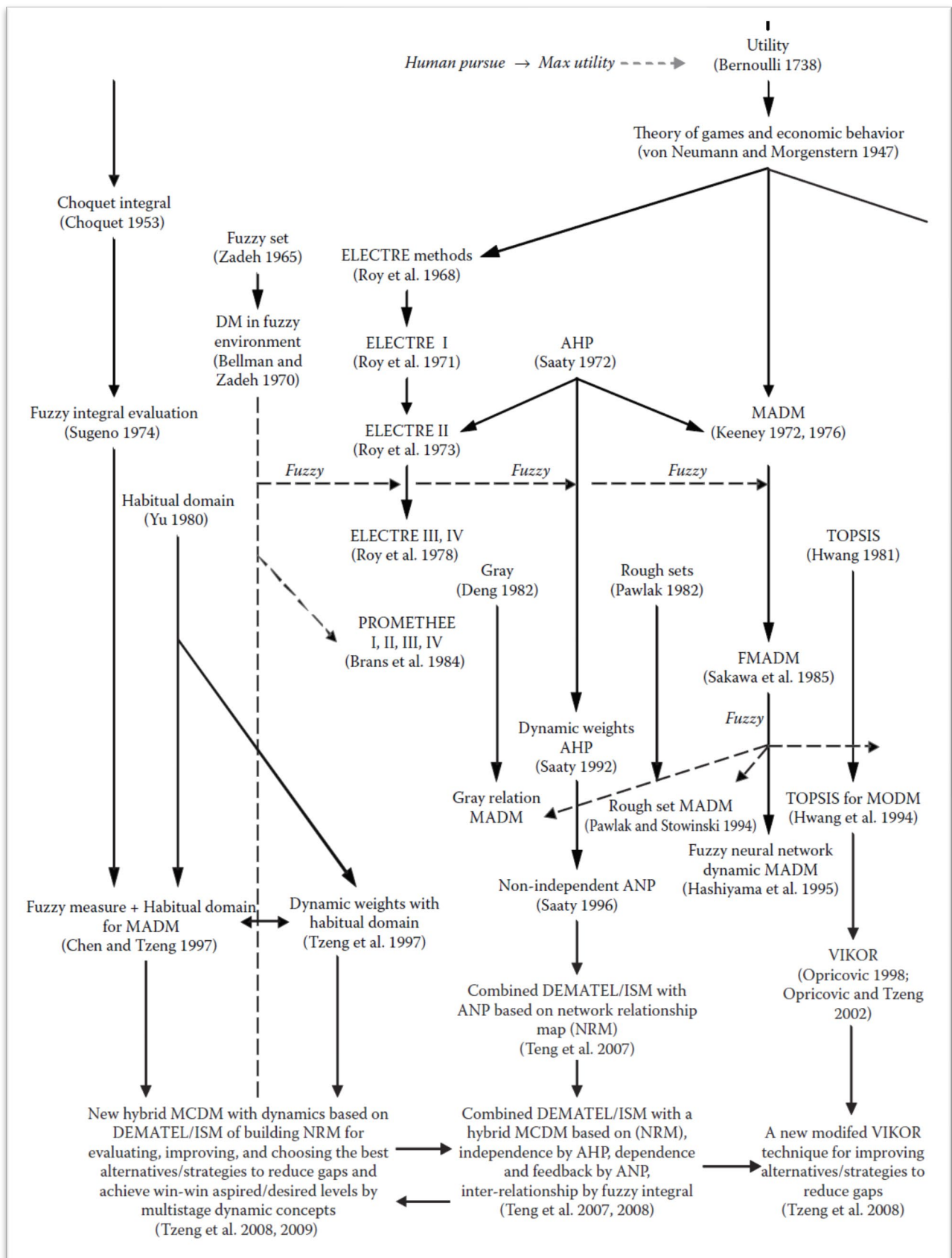
● **INTRODUCTION TO MULTIPLE CRITERIA DECISION MAKING**

- Multiple Criteria Decision Making (MCDM) refers to making decisions in the presence of multiple, usually conflicting, criteria. (Hwang and Yoon, 1981)
- [Zavadskas et al. \(2019\)](#) describe that:
Some authors (Zimmermann [1]; Chen and Hwang [2]) have divided multi-criteria decision making (MCDM) into two categories: (1) multi-attribute decision making (MADM), which concentrates on problems with discrete decision spaces; and (2) multi-objective decision making (MODM) problems, which naturally involve several competing objectives that are required to be optimized simultaneously. From a practical viewpoint, MADM is associated with problems where the number of alternatives are predetermined. The decision maker (DM) is to select/prioritize/rank a finite number of courses of action. Alternatively, MODM is associated with problems in which the alternatives have been non-predetermined. [MCDM = MADM + MODM]
- MDPI Encyclopedia [Multi-Criteria Decision Making \(MCDM\) Methods and Concepts](#)
- Main Features of MCDM ([Xu and Yang, 2001](#))
 - ⇒ Multiple attributes/criteria often form a hierarchy
 - ⇒ Conflict among criteria.
 - ⇒ Hybrid nature
 - ⇒ Assessment may not be conclusive
 - ⇒ Uncertainty
 - ⇒ Large Scale
- MCDM Solutions ([Xu and Yang, 2001](#))
 - ⇒ Ideal solution
 - ⇒ Satisfying solutions
 - ⇒ Non dominated solutions
 - ⇒ Preferred solutions
- Development of MADM Methods (Tzeng and Huang, 2011)

● **DECISION ANALYSIS AND MULTI-CRITERIA DECISION ANALYSIS METHODS**

- Decision Tree; Laplace, Maximin, Minimax, Hurwicz, Minimax Regret
- Weighted Sum and Weighted Product
- ELECTRE (ELimination Et Choix Traduisant la Réalité)
- TOPSIS (Technique for Order Preference by Similarity to Ideal Solution)
- The Example Problem

	1.Criterion	2.Criterion	3.Criterion	4.Criterion
1.Alternative	0.120	0.129	0.119	0.456
2.Alternative	0.065	0.185	0.064	0.071
3.Alternative	0.569	0.068	0.484	0.170
4.Alternative	0.200	0.067	0.223	0.100
5.Alternative	0.045	0.551	0.109	0.203
Weights	0.137	0.347	0.065	0.452



Development of MADM (Tzeng and Huang, 2011)

- **MULTIOBJECTIVE PROGRAMMING**

- Conflicting between Objectives (Goals) => Trade-off among objectives
- Non-dominance, Non-inferiority, “Efficiency,” or “Pareto Optimality”
- Terminology
 - ⇒ Decision Space vs. Objective Space
 - ⇒ Tradeoff 抵換 vs. Pay-off 償付
 - ⇒ Noninferior Solution or “Best-Compromise Solution” 非劣解
- Categories of MOP Solution Methods
 - ⇒ Information Flow: Bottom-Up or Top-Down
 - ⇒ Techniques that Incorporate Preferences
- Generating Techniques: Evaluating Alternatives, Decision Support
 - ⇒ Weighting method, Constraint method
 - ⇒ Multiobjective simplex method, and others
- Number of Decision Makers

<p>Maximize $\mathbf{Z}(x_1, x_2) = [Z_1(x_1, x_2), Z_2(x_1, x_2)]$</p> <p>where</p> $Z_1(x_1, x_2) = 5x_1 - 2x_2$ $Z_2(x_1, x_2) = -x_1 + 4x_2$ <p>s.t. $-x_1 + x_2 \leq 3, \quad x_1 + x_2 \leq 8$</p> $x_1 \leq 6, \quad x_2 \leq 4$

- **THE ANALYTIC HIERARCHY PROCESS (AHP)**

- Top Objective, Criteria, Sub-criteria, Sub...-criteria, Alternatives
- Complete Hierarchy and Partial Hierarchy
- Mathematical Fundamentals: Properties a Positive Reciprocal Matrix
- Priority (Weighting) Vectors and Eigenvector
- Inconsistency Index and Eigenvalues
 - ⇒ The Maximum Eigenvalue and Random Index
 - ⇒ Consistency Index or Consistency Ratio
- Variations of AHP: Fuzzy AHP and Grey AHP (Preference Programming)
- Analytical Network Process ([ANP](#))
 - ⇒ A network is comprised of the clusters, elements and links. The ANP is a descriptive theory that combines these measures to match what people actually do or guides them to do better than they were previously using only qualitative thinking and hunches, and not limited to the top-down thinking of the hierarchic models. A simple network can be extended to complex multi-level models of networks of benefits, opportunities, costs and risks.
- [Super Decision](#): Software for AHP and ANP
 - ⇒ Rather than prescribing a "correct" decision, these methods help the decision makers to find a solution that best suits their goal and their understanding of the problem. It provides a comprehensive and rational framework for structuring a decision problem, for representing and quantifying its elements, for relating those elements to overall goals, and for evaluating alternative solutions.