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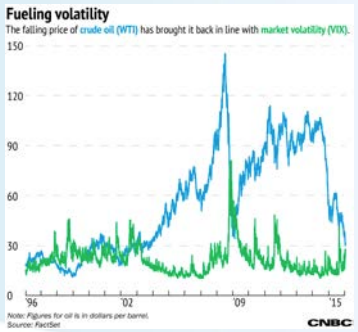
Towards robust decisions for sustainable management of natural resources

Elena Rovenskaya
Director, Advanced Systems Analysis Program
rovenska@iiasa.ac.at

International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria

Major challenges to decision making of modern age



V
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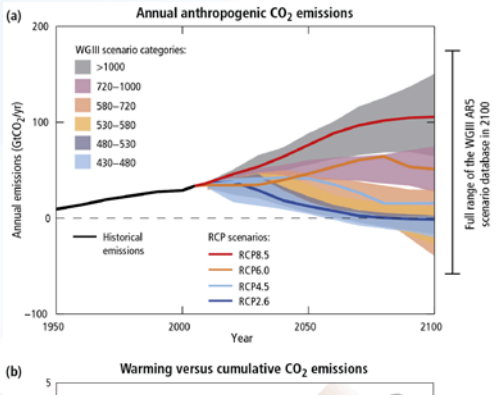

U
N C E R T A I N T Y

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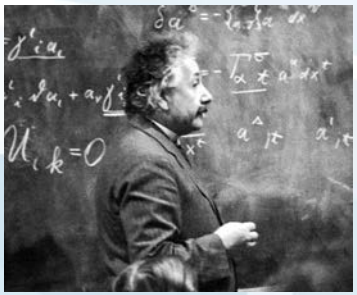
Notion “VUCA” was introduced by the US Army College to describe the world as resulting from the end of the Cold War

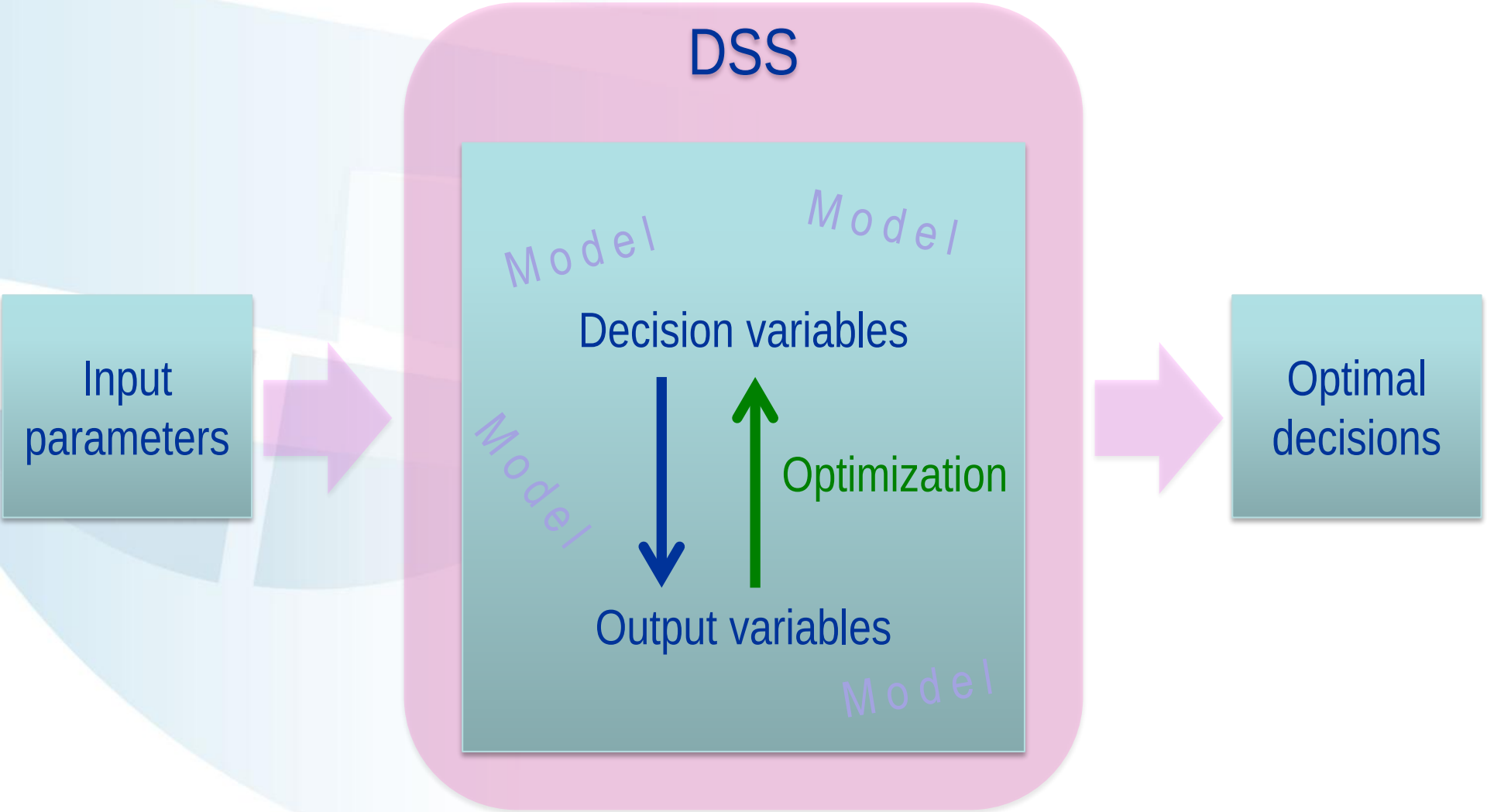
VUCA-world challenges require VUCA-powerful methods to derive effective and efficient solutions



"How can it be that mathematics, being after all a product of human thought, which is independent of experience, is so admirably appropriate to the objects of reality?"

Albert Einstein, 1921

Decision support tools (DSS) and uncertainty

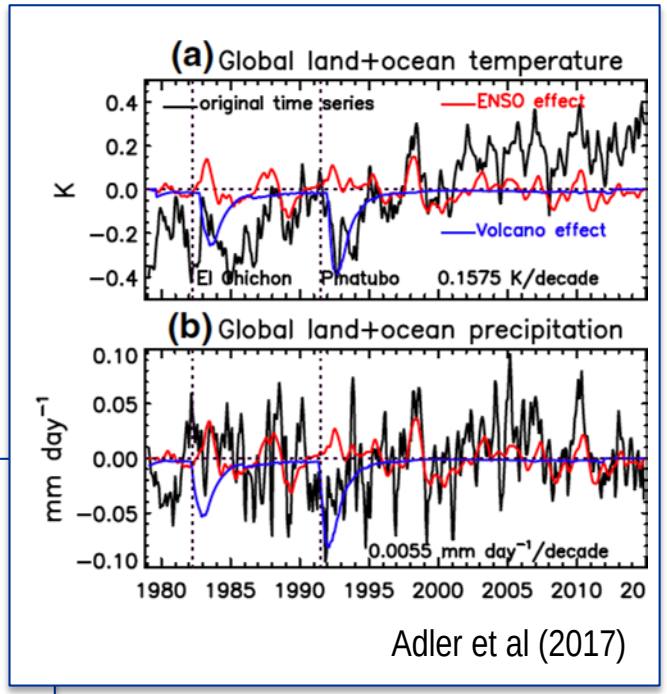


Resource management problems

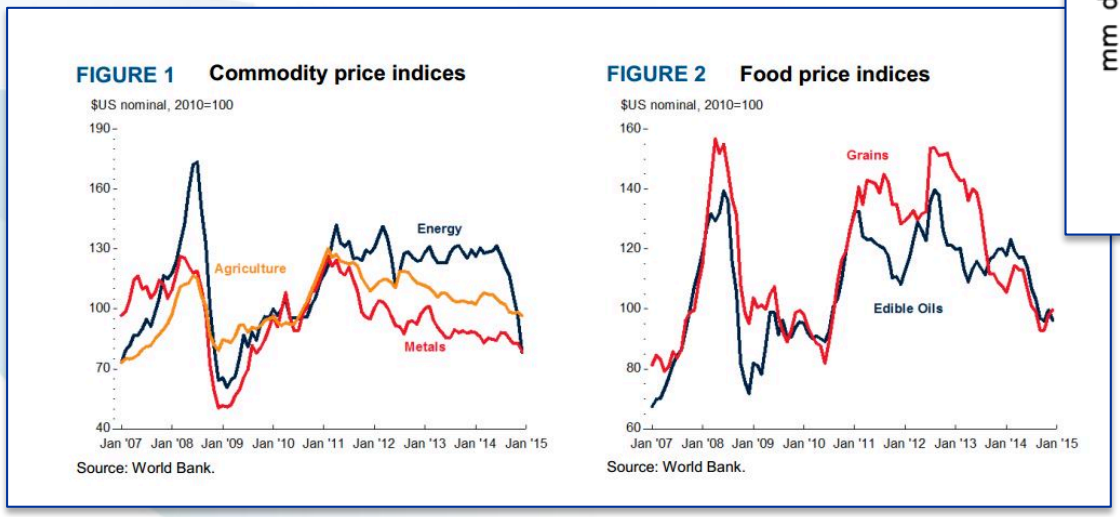
- Decisions:
  - Land allocation for various economic activities
  - Technologies to be used
  - Investments in development
  - Crops
  - Fertilizer application rate
  - Cleaning
  - Imports and exports
  - ….

Resource management problems

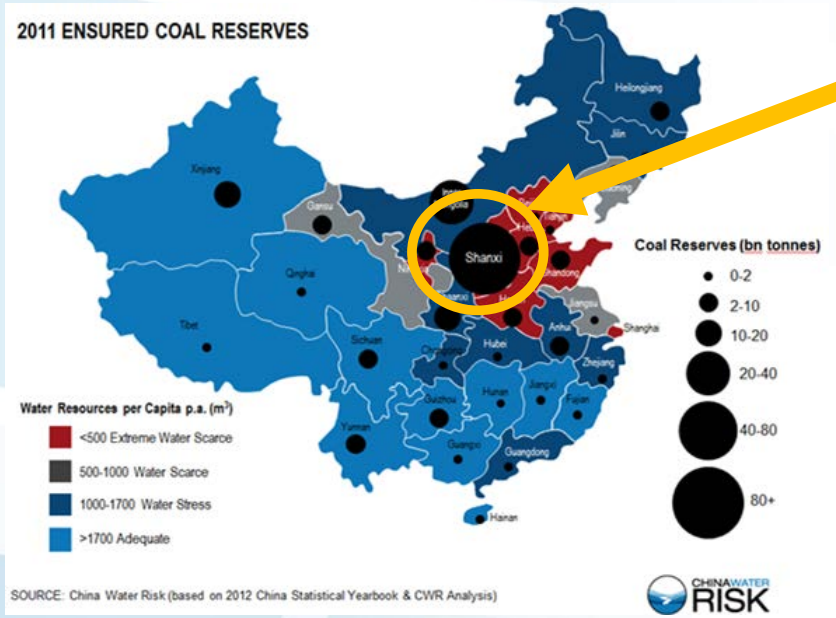
- Uncertainty in input parameters:
  - Water availability
  - Weather conditions
  - Prices
  - …



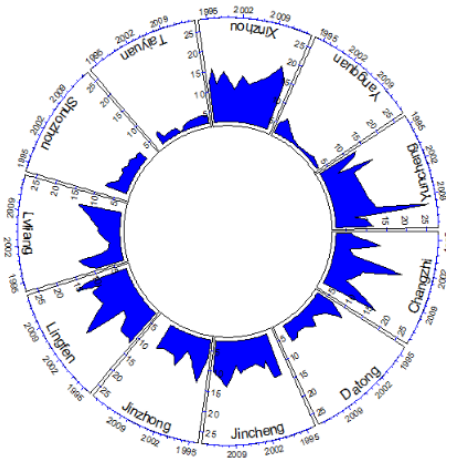
Adler et al (2017)

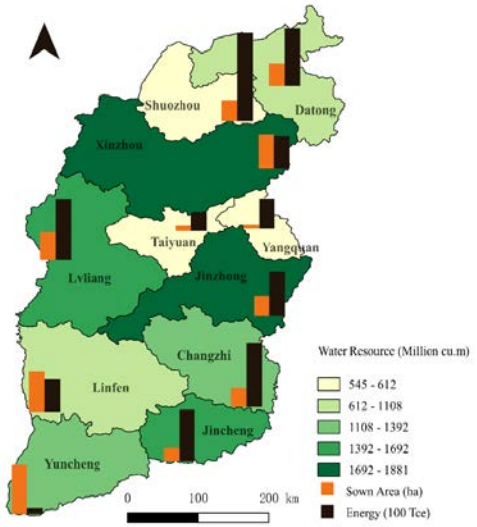


Example: Food-water-energy nexus in Shanxi, China



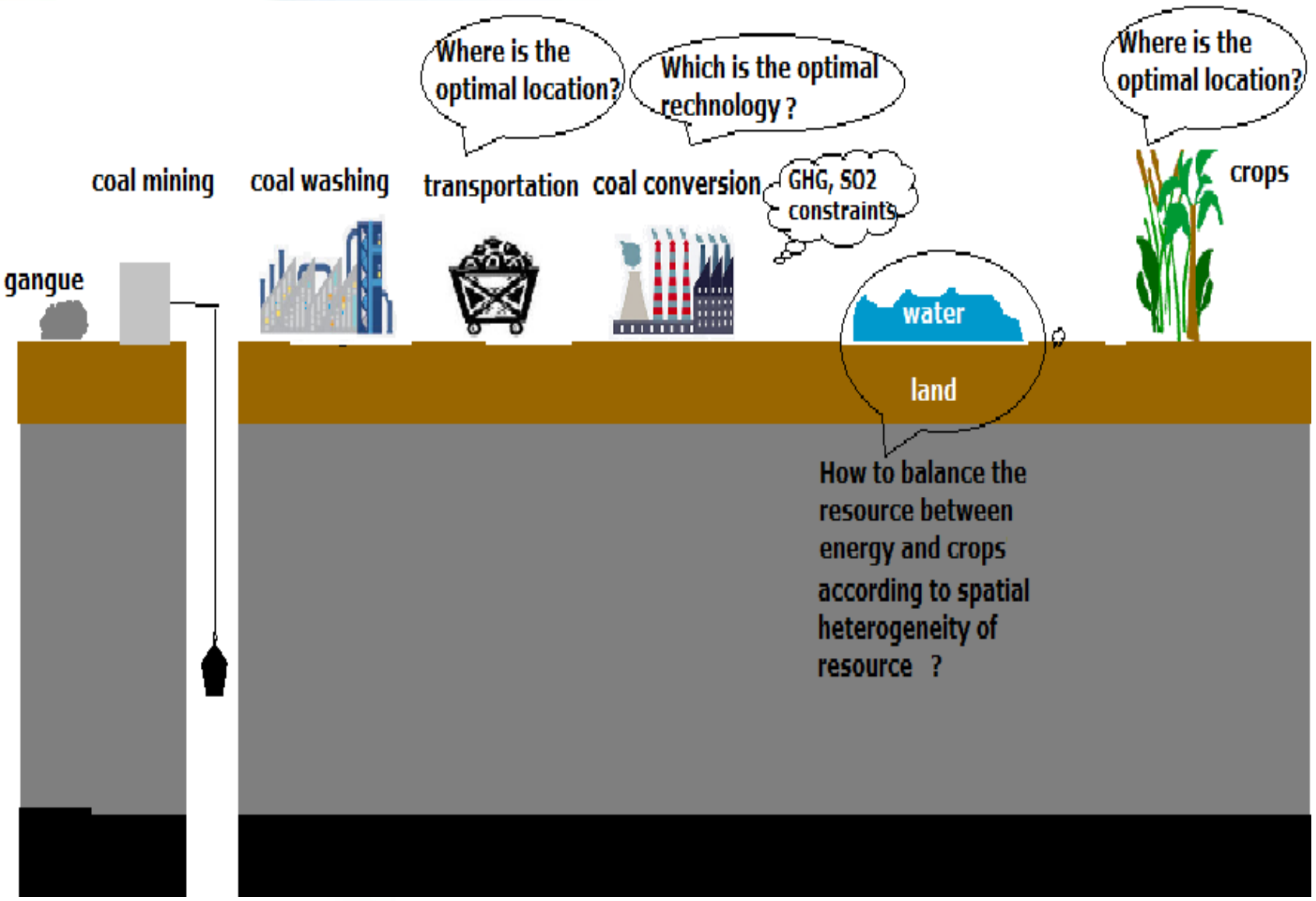
Case study area: Shanxi province with large coal mining and scarce water



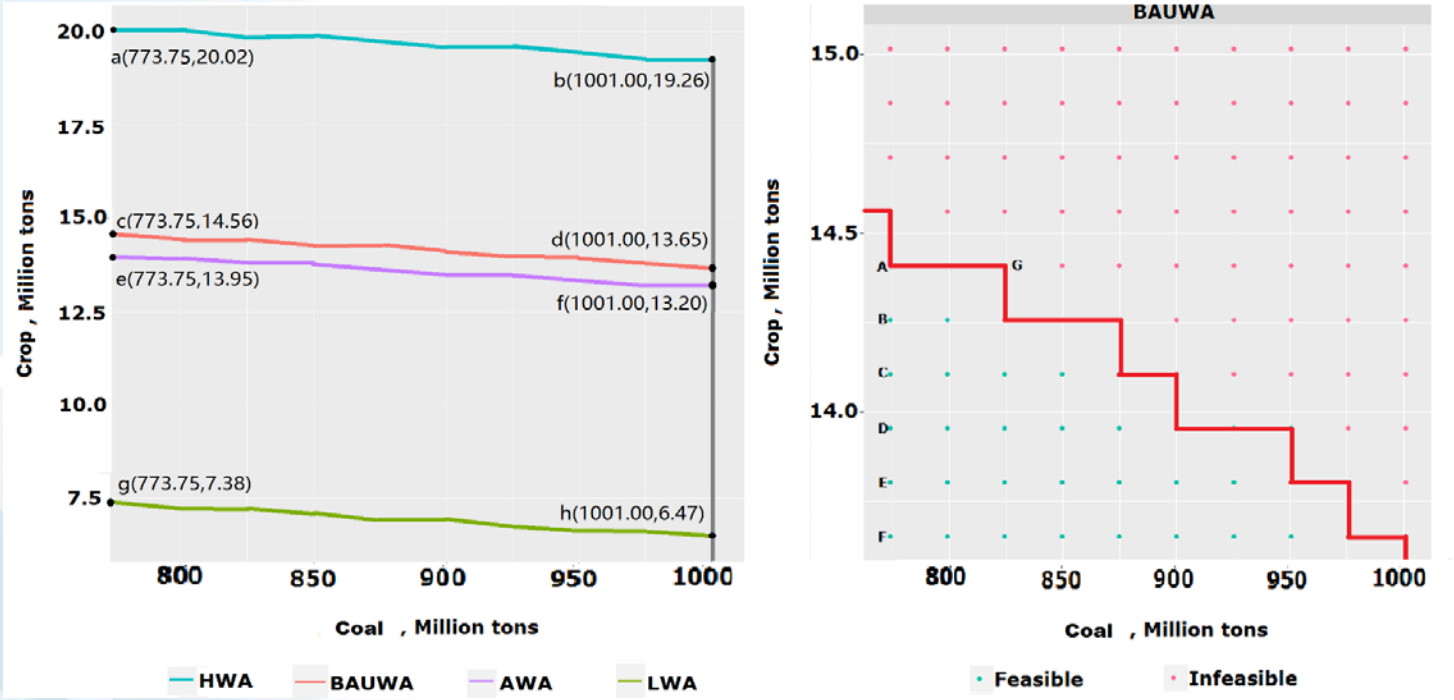


- How to ensure compatibility between energy security goals and food security goals given a scarce and volatile water supply?

Model structure



Modeling results: Tradeoffs and sensitivity to water availability

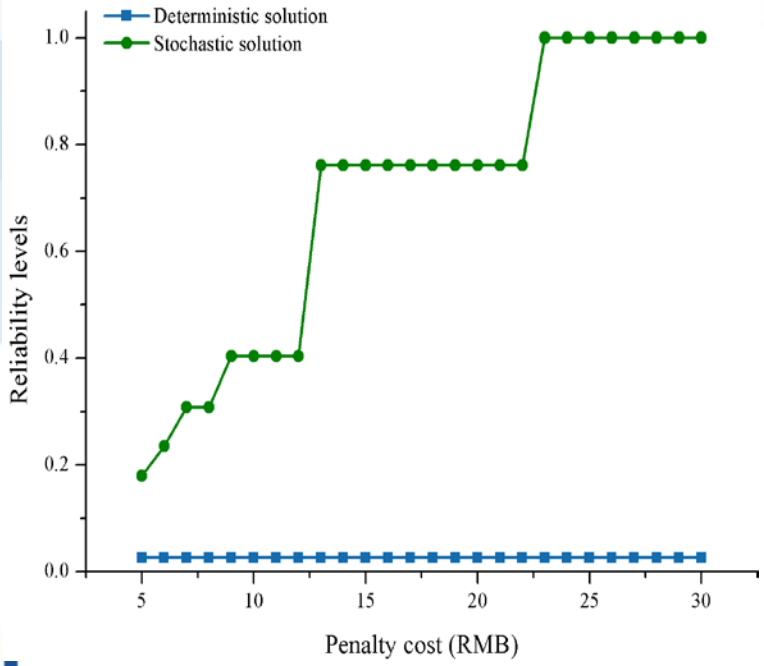


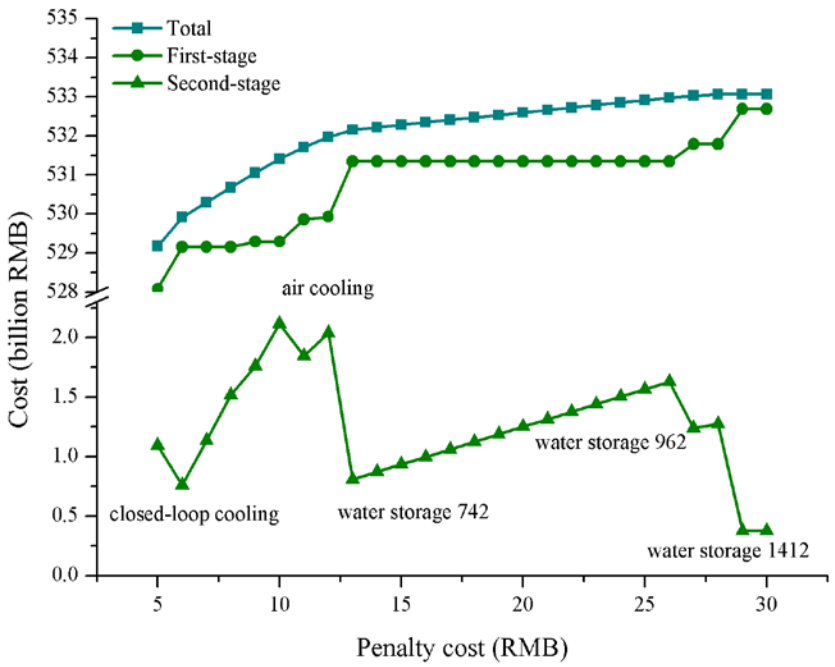
HWA/LWA/AWA assumes the maximal/minimal/average observed water availability in each city over 1994-2012

- Solutions are sensitive to the water availability => we need robust solution, which are good enough for any realization of uncertainty

Stochastic optimization to compute robust solutions

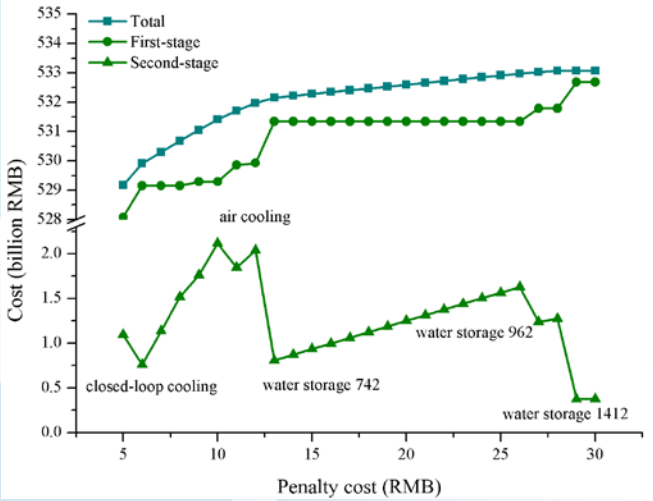
- The traditional and widely-used approach to rely on mean parameter values can be misleading -> **risk-adjusted optimization** accounting for **uncertainty distribution** is required instead
- Employ “chance” constraints, i.e., require to meet the water availability constraint with a certain probability
- Impose “penalty” for violating water constraints and introduce **adaptive measures** (imports of water)

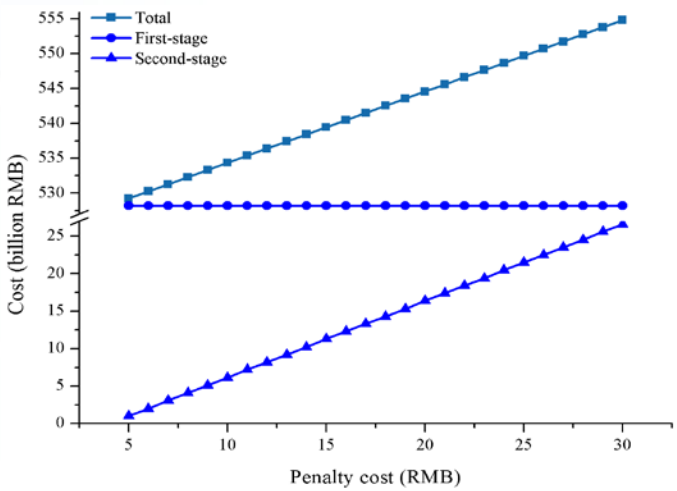


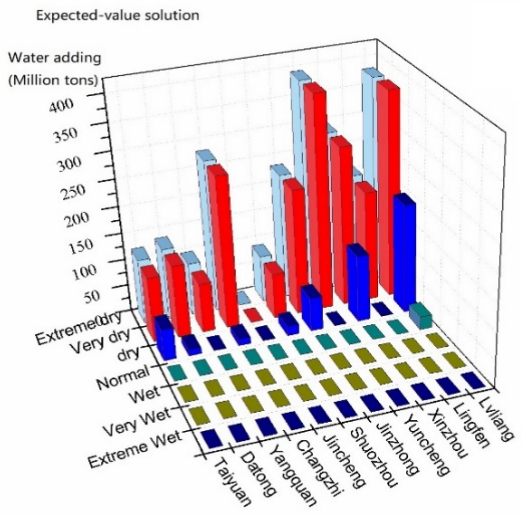


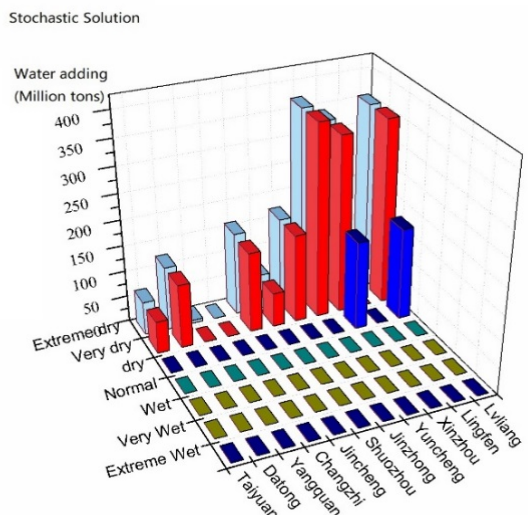
Stochastic optimization to compute robust solutions

- Costs consist of upfront costs and adaptive measures costs
- Robust decisions allow to save up to 5% of total cost
- Stochastic solution enables saving on ex-post adaptation measures



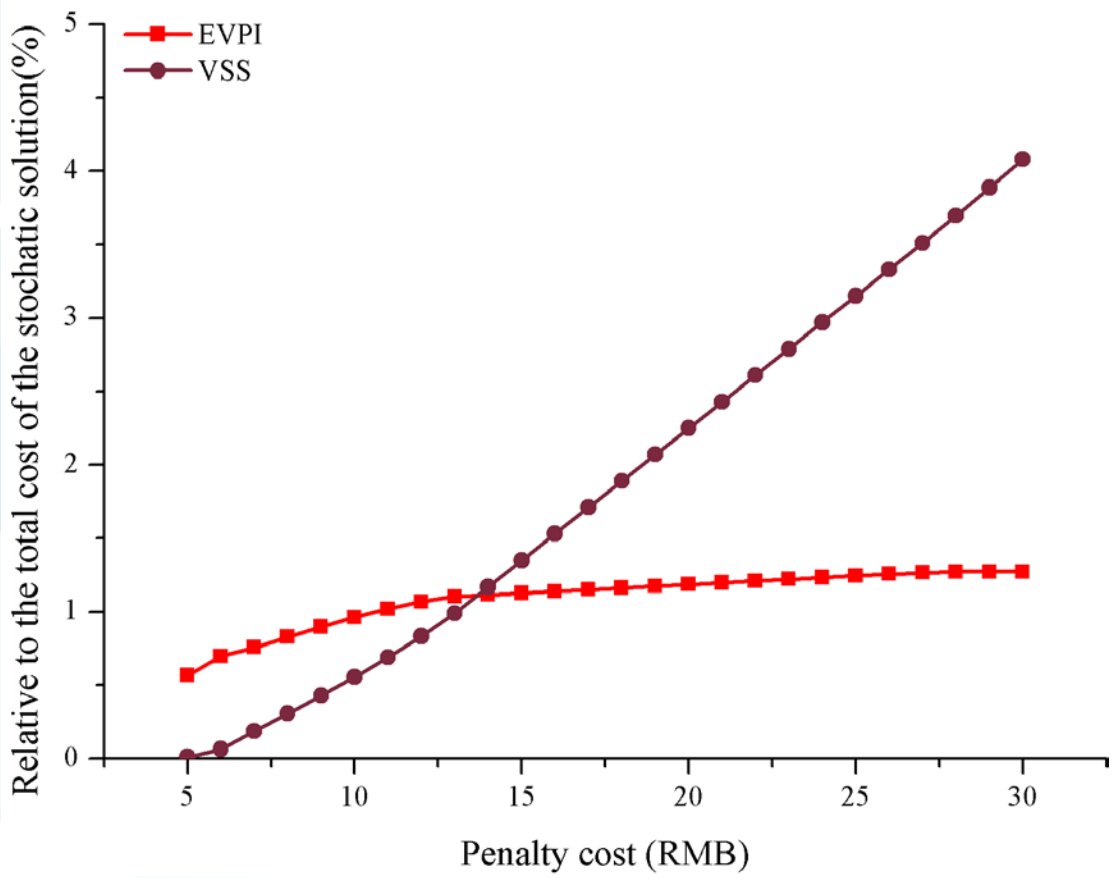






Stochastic optimization to compute robust solutions

- *Expected value of perfect information* (EVPI) = economic gain of having complete information about uncertainty
- *Value of the stochastic solution* (VSS) = economic loss from ignoring uncertainty



Decisions under uncertainty need to be taken in various areas related to resource management

- Energy production, energy portfolio planning
- Food production
- Renewable natural resource extraction (fisheries, forestry, etc.)
- Pollution control
- …

Interested in trying this approach in your area? Let us discuss!

Options how to engage with IIASA

- Young Scientist Summer Program (YSSP)
  - 50 PhD student participants per year
  - June-August
  - Main goal: conduct a research project with an IIASA supervisor(s)

Options how to engage with IIASA

- Postdoc program
  - Two-year term
  - Possibility to carry out own research project

Options how to engage with IIASA

- Sabbatical
  - “Guest” contracts
- Open positions
  - All are publicly advertised on the website
  - Can be project based

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