

Towards robust decisions for sustainable management of natural resources

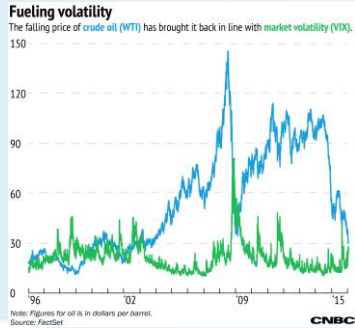
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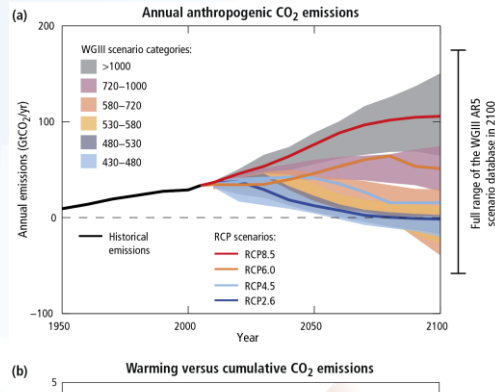
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Major challenges to decision making of modern age



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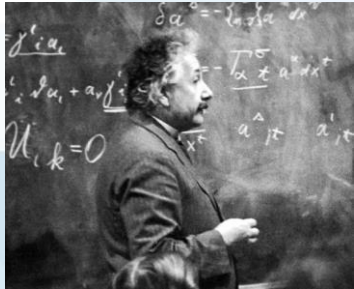
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Notion “VUCA” was introduced by the US Army College to describe the world as resulting from the end of the Cold War

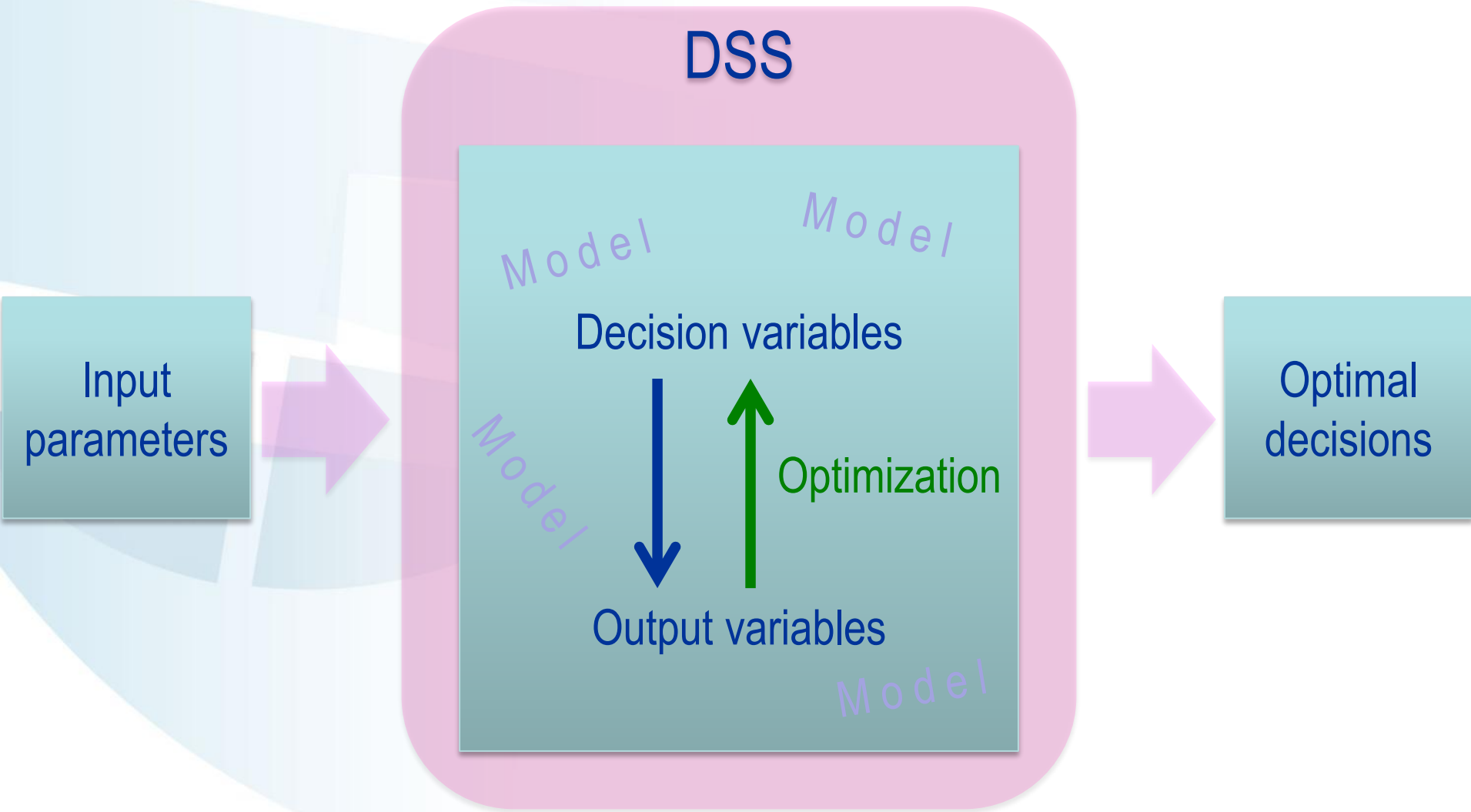
VUCA-world challenges require VUCA-powerful methods to derive effective and efficient solutions



"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
 - ...

FIGURE 1 Commodity price indices

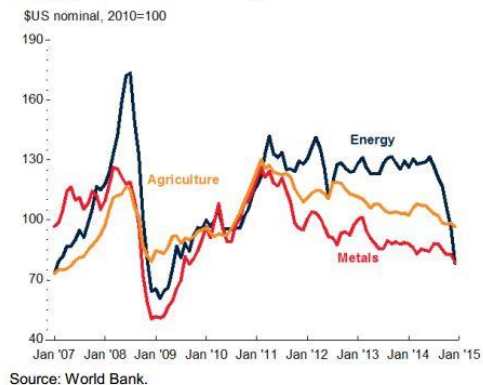
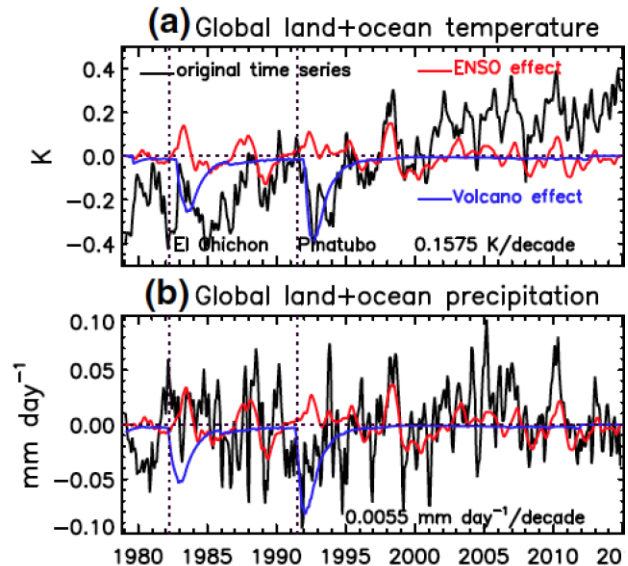
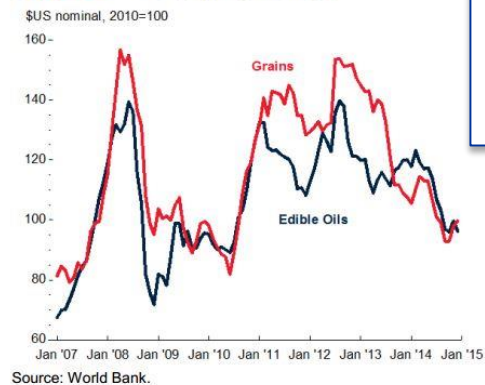


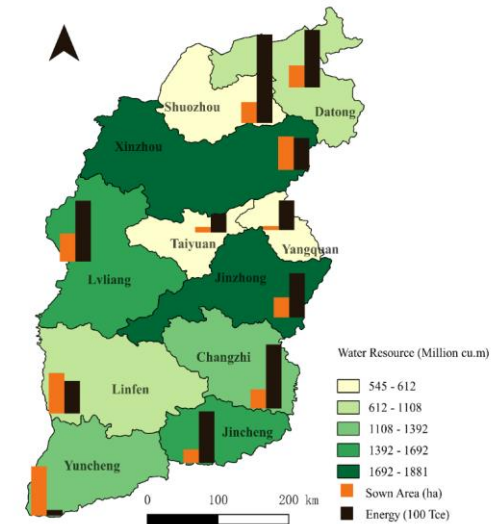
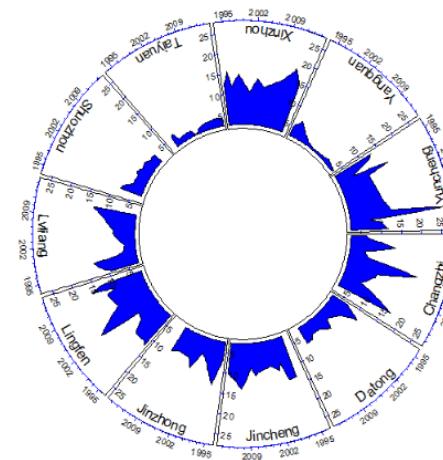
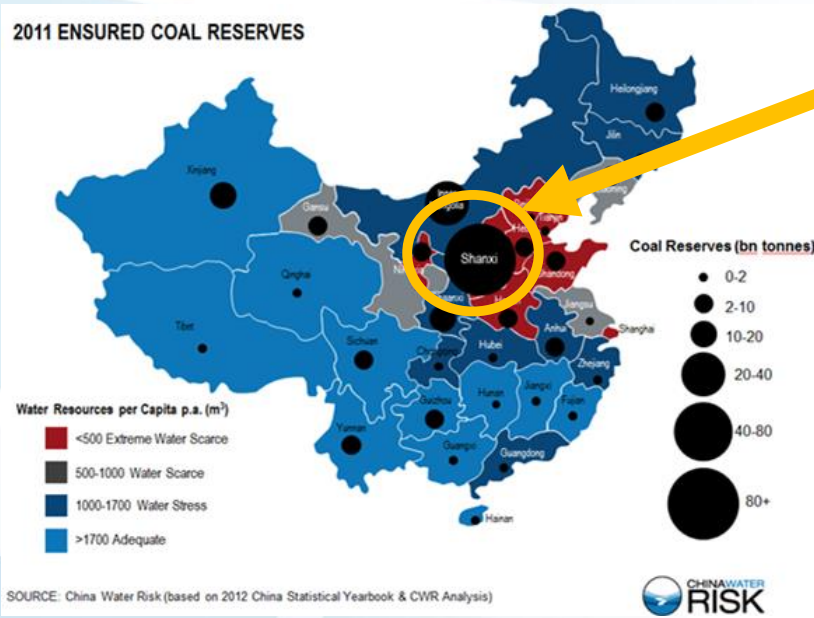
FIGURE 2 Food price indices



Adler et al (2017)

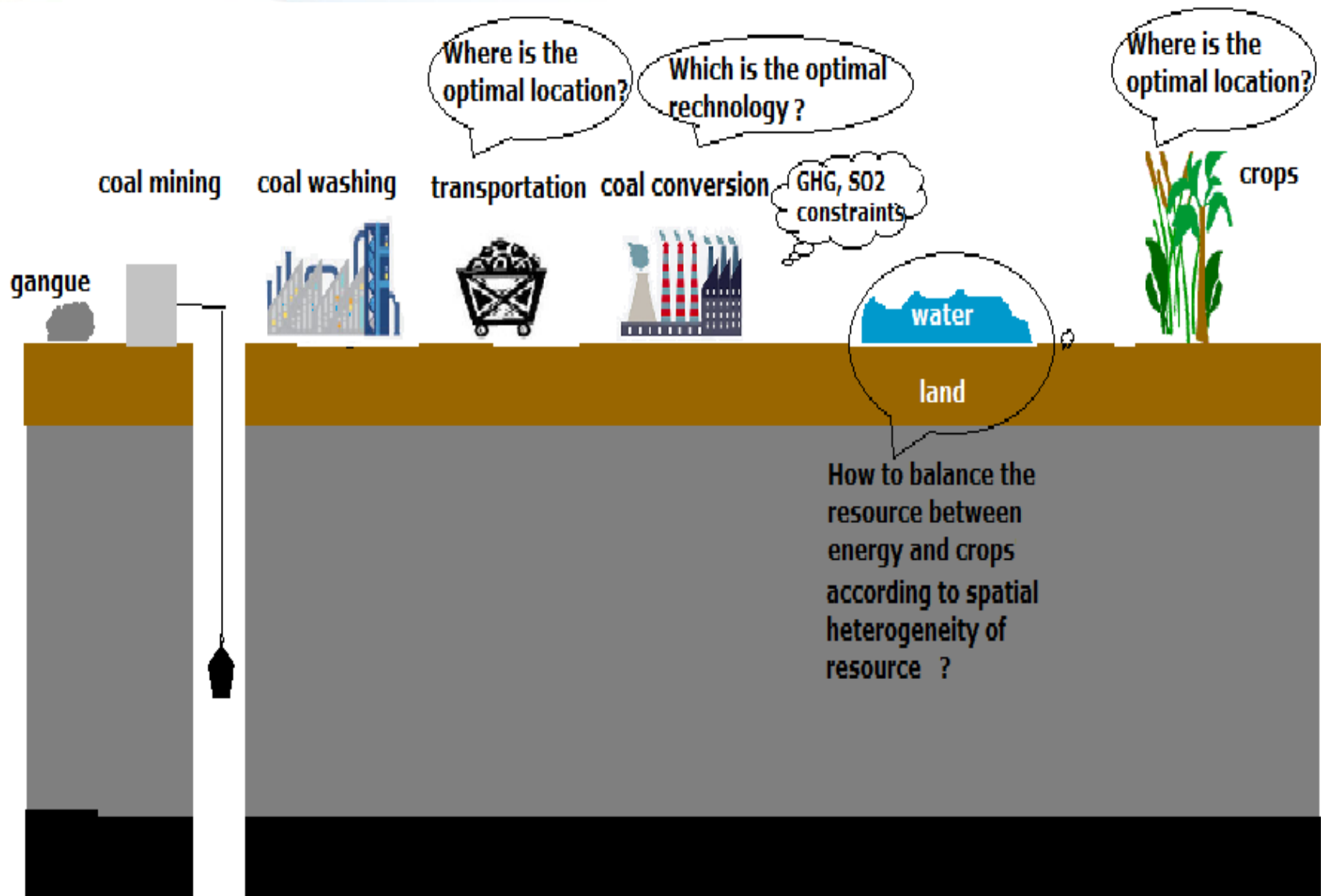
Example: Food-water-energy nexus in Shanxi, China

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

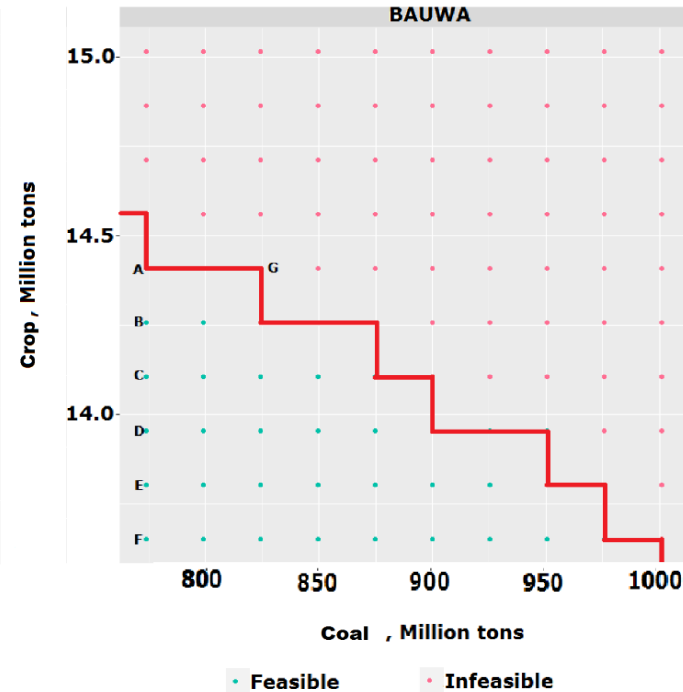
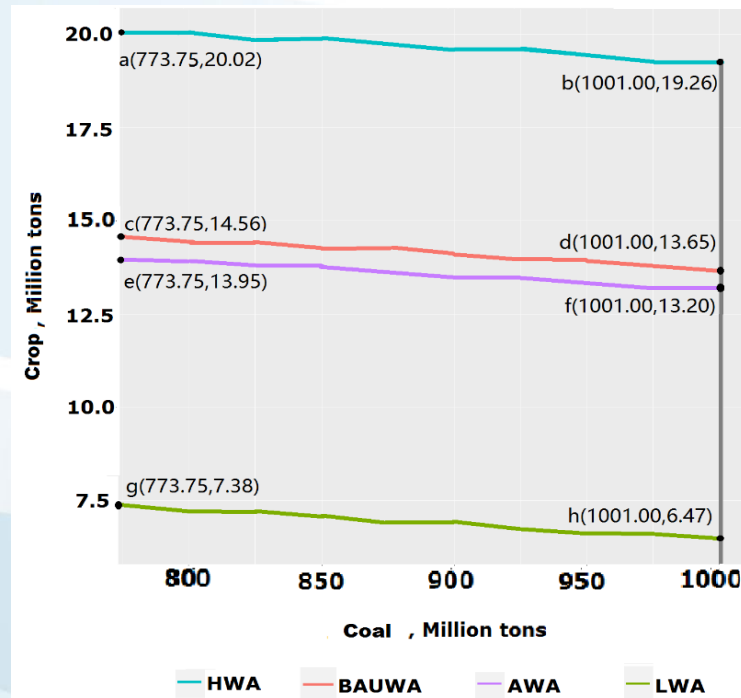


- How to ensure compatibility between energy security goals and food security goals given a scarce and volatile water supply?

Model structure



Modeling results: Tradeoffs and sensitivity to water availability

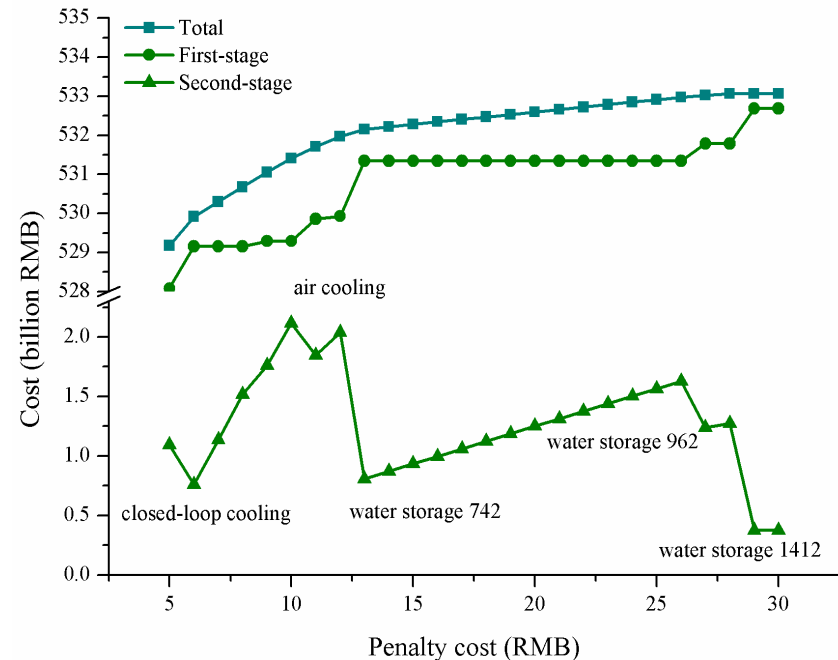
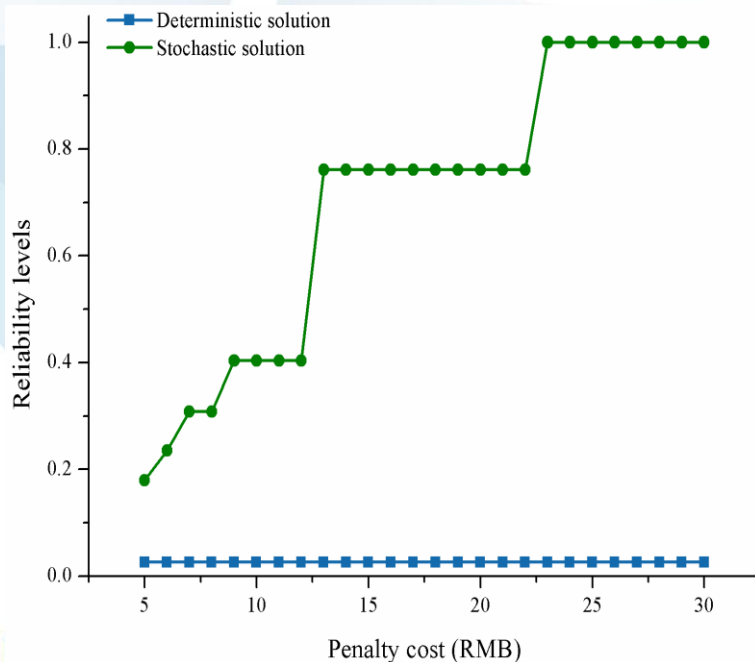


HWA/LWA/AWA assumes the maximal/minimal/average observed water availability in each city over 1994-2012

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

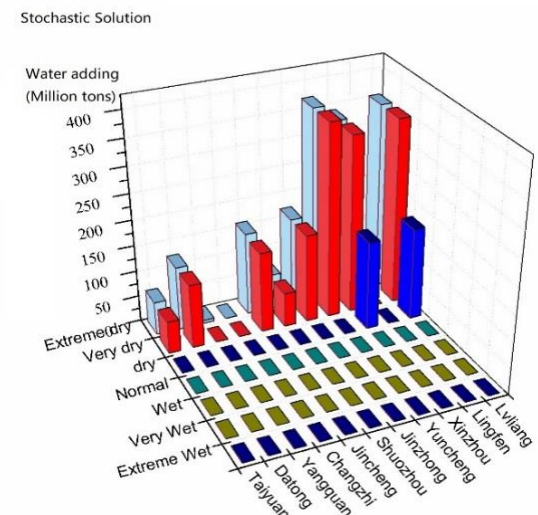
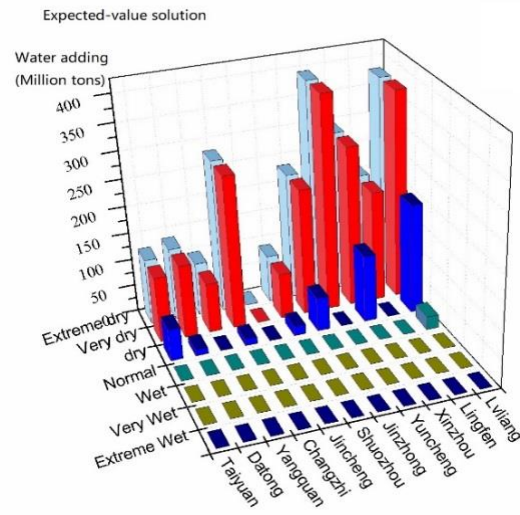
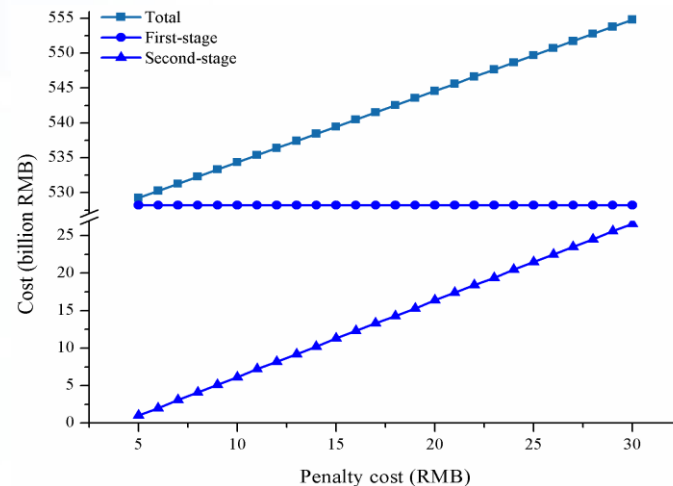
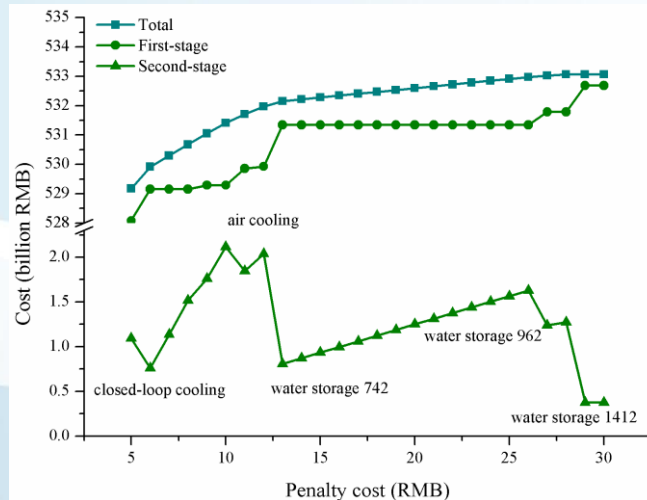
Stochastic optimization to compute robust solutions

- 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)



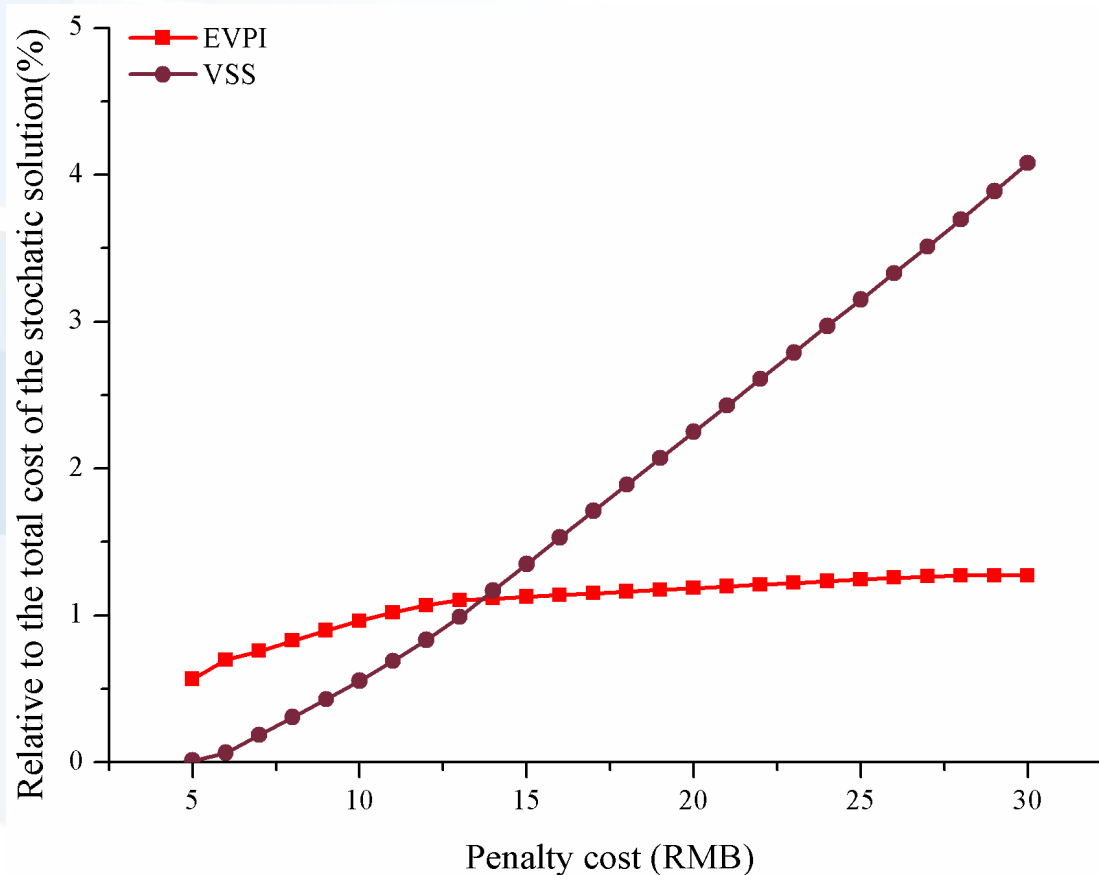
Stochastic optimization to compute robust solutions

- 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

"It's a great opportunity to gain a huge career boost, solve holistic and complex problems, and become part of a global research network."

Julian Hunt
IIASA-CAPES postdoc

www.iiasa.ac.at/postdocs

"I chose IIASA because it is an international environment with high profile researchers doing interdisciplinary work that translates from science to policy."

Franziska Gaupp
IIASA postdoc

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"I love IIASA because it combines good science with a wonderful place and a sense of community."

Katya Perez Guzman
IIASA postdoc

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"Being at IIASA has developed my modelling skills and given me access to an international network that has expanded my work beyond China."

Shaohui Zhang
IIASA postdoc

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Options how to engage with IIASA

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

Join us!

Thank you for your attention!

