# Moallemi, E., Kwakkel, J.H., de Haan, F. & Bryan, B.A. (2020) Exploratory modeling for analyzing coupled human-natural systems under uncertainty. Global Environmental Change 65.

Ways in which Exploratory modeling can be used:

1. Design of experiments: systematic sampling from the uncertainty/decision space to generate a series of computational experiments with good space filling properties 🡪 broad understanding of the implications and vulnerabilities of alternative assumptions.  
   Weakness: In complex situations, it fails to capture key trade-offs.
2. Stress-testing: find where the system breaks by sampling the uncertainty/decision space
3. Worst-case scenario discovery: find where your system performs the worst.
4. Many-objective optimization: close investigation of the reasons/assumptions behind the properties of interest and finds specific causal relations (answer to design of experiments weakness)
5. Many-objective robust optimization: many-objective optimisation but with sampled scenarios in stead of human defined ones.

Challenges of exploratory modeling:

* Computational limitations with large-scale assessment models
* Communication and interpretation of the results can be difficult
* Model-based decision-making has increasingly adopted an emerging exploratory approach.
* This approach addresses uncertainty explicitly through systematically exploring the implications of modeling assumptions, aiming to enhance the *robustness* of inferences from models. (optimization often lacks here because they close down the assumption space prematurely)
* Exploratory modeling is also a key model-based approach for supporting the design of adaptive policy pathways that aim to combine low-regret, short-term actions with long-term solutions to adapt (if needed) to uncertain future change.
* There is inherent complexity in the interactions and processes in the sustainability of coupled human-natural systems, such as climate, land-use, energy, and water.
* There are two main approaches:
  + Open exploration (systematic sampling)
  + Directed Search (optimizations)
* Three ways of designing experiments:
  + Co-design of a shared problem
    - The co-design of a shared decision problem involves the joint framing of a pressing sustainability challenge from relevant societal sectors through *participatory* processes (e.g., workshops, brainstorming).
  + Co-production of sensible results
    - Co-production also involves the generation of computational experiments and making sense of the results of the experiments for analyzing the efficacy of various decisions and making trade-offs between multiple objectives.
  + Co-dissemination of practical inferences
    - The co-dissemination of exploratory modeling results aims to enhance the ownership and accountability of outcomes and helps to influence policymakers’ decisions via deep and genuine engagement with stakeholders.
* Each way has a different level of stakeholder participation



