Bayesian Decision Analysis for climate decision-making

Sensitivity to decision attributes

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Overview

1. Example: Heat-stress in the UK
2. Prior work: Uncertain risk
3. Current work: Uncertain decision attributes
4. Results
5. Conclusions

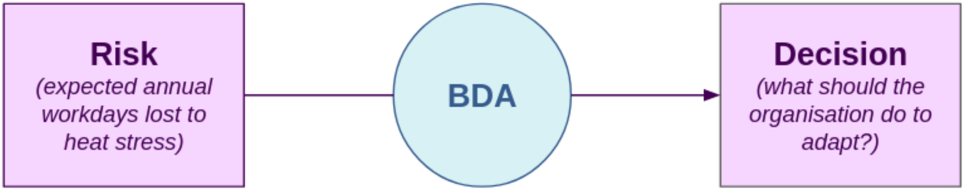
Example: Heat-stress in the UK

An idealised example

What should a UK company do to combat the effects of heat stress?

Using Bayesian Decision Analysis (BDA):

- **Risk:** How much is heat going to impact our workers?
- **Optimal Decision:** What action should we take given that risk level?



Goals

How does variation in decision-related attributes of the BDA framework affect the decision output?

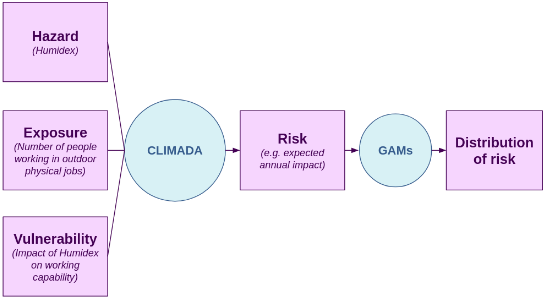
- Uncertainty: How robust is our decision to variation in financial cost?
- Sensitivity: Which parameters is our decision most sensitive to?
- How do uncertainty and sensitivity vary spatially?

Prior work: Uncertain risk

Uncertainty in risk

Following Dawkins et al. 2023[a]:

1. Risk is composed of hazard, exposure, and vulnerability inputs[b]
2. Apply the CLIMADA risk assessment platform[c] to each climate model ensemble member
3. Use generalised additive models to generate 1000 samples of risk in each location across the UK



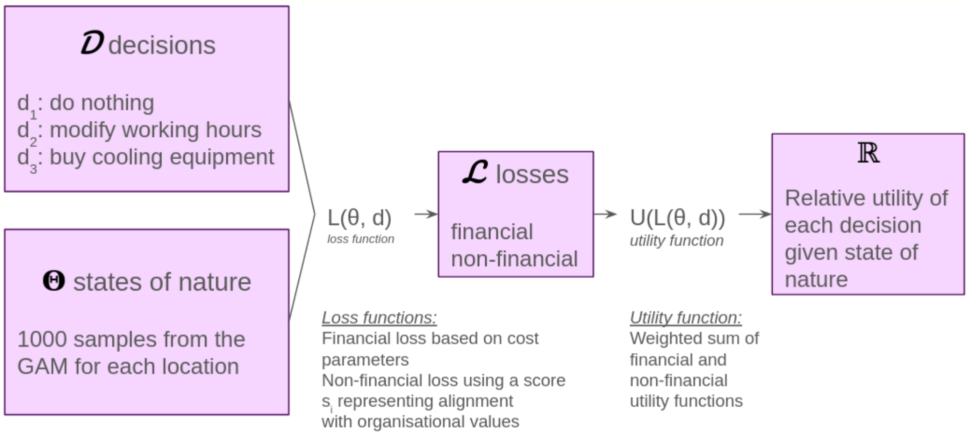
[a] Dawkins, Laura C. et al. (2023). *Climate Risk Management*.

[b] Reisinger, A. et al. (2020).

[c] Aznar-Siguan, G. and Bresch, D. N. (2019). *Geoscientific Model Development*.

Current work: Uncertain decision attributes

Bayesian Decision Analysis: Our framework



Bayes optimal decision

Pick the decision that maximises expected utility:

Bayes decision under utility U

Select the decision d^* such that

$$d^* = \arg\max_{d} \sum_{\theta \in \Theta} U[L(\theta, d)]p(\theta) = \arg\max_{d} \bar{U}(d)$$

In our case,

$$d^* = \arg\max_{d} \frac{1}{1000} \sum_{n=1}^{1000} U(\theta_n, d)$$

Varying financial costs

Took 1000 Latin hypercube samples of combinations of financial cost parameters for d_2 and d_3 from ranges of values:

Action	Cost per person	Added cost per day of use	Reduced cost per day	s_i
d_1	£0	£0	£0	5
d_2	[£80, £120]	[£20, £60]	[£40, £60]	7
d_3	[£350, £800]	[£1.50, £2.50]	[£60, £90]	4

Table: Loss function parameters for each decision

Calculated the Bayes optimal decision d^* in each location for every sample.

Results

Uncertainty

How robust is our decision to variation in the financial cost parameters?

In the majority of cells, any of the three decisions could be optimal depending on the combination of financial cost parameters.

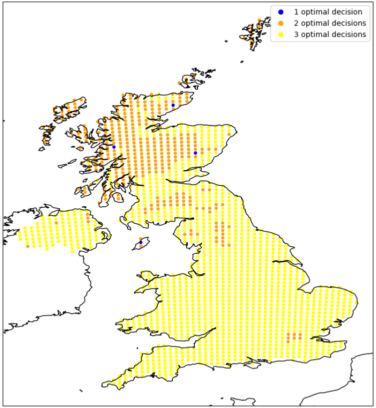


Figure: Number of optimal decisions per location across the 1000 combinations of financial cost parameters.

Uncertainty

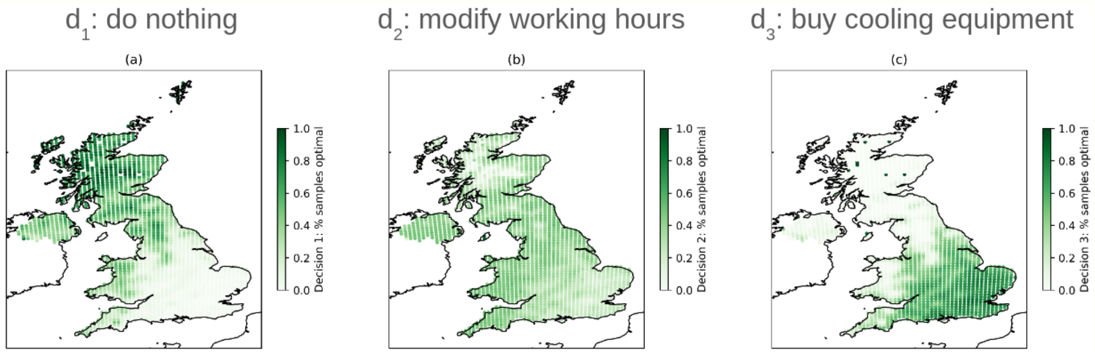


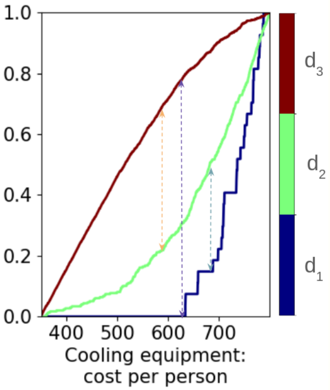
Figure: Proportion of Latin hypercube samples for which each decision was the optimal decision selected by BDA for (a) d_1: do nothing, (b) d_2: modify working hours, and (c) d_3: buy cooling equipment.

Sensitivity: Regional Sensitivity Analysis

For a given financial cost parameter x_i, how different are the conditional CDFs of x_i given a particular optimal decision value?

Take the average Kolmogorov-Smirnov (KS) statistic between each conditional CDF $F_{x_i|d_j}$:

$$\text{mean}_{j,k}[KS(x_i)] = \text{mean}_{j,k}[\max_{x_i} |F_{x_i|d_j}(x_i|d^* = d_j) - F_{x_i|d_k}(x_i|d^* = d_k)|]$$



Sensitivity

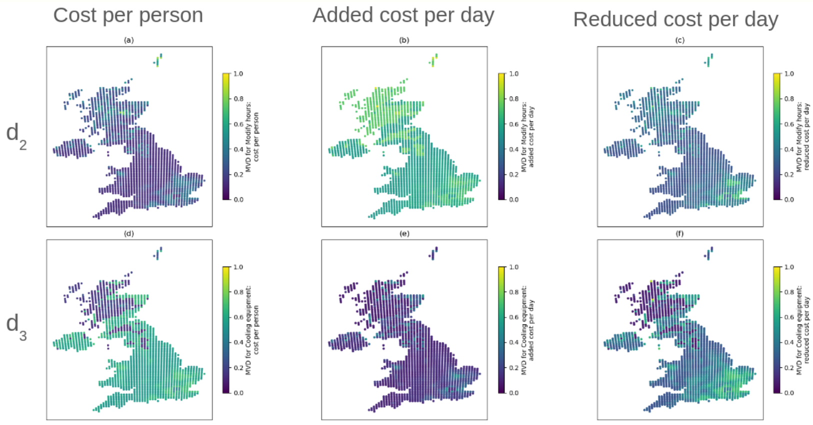


Figure: Mean KS statistic for each financial attribute of d_2 and d_3.

Conclusions

Conclusions

So far...

- The optimal decision is not very robust to variation in financial cost parameters
- Decision sensitivity to the various financial cost parameters varies
- The optimal decision *may* be more sensitive to variations in the decision attributes than to variations in risk[1]

What's next?

- What happens when we vary other decision attributes? Both risk and decision attributes? Utility function?
- How can we use this information to improve how we make climate-related decisions?

[1] Dawkins, Laura C. et al. (2023).

Questions?

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