A two-stage approach for assessment of distributional impacts in model-based delta planning

Exploration of plausible inequality patterns and justice-based evaluation of policies

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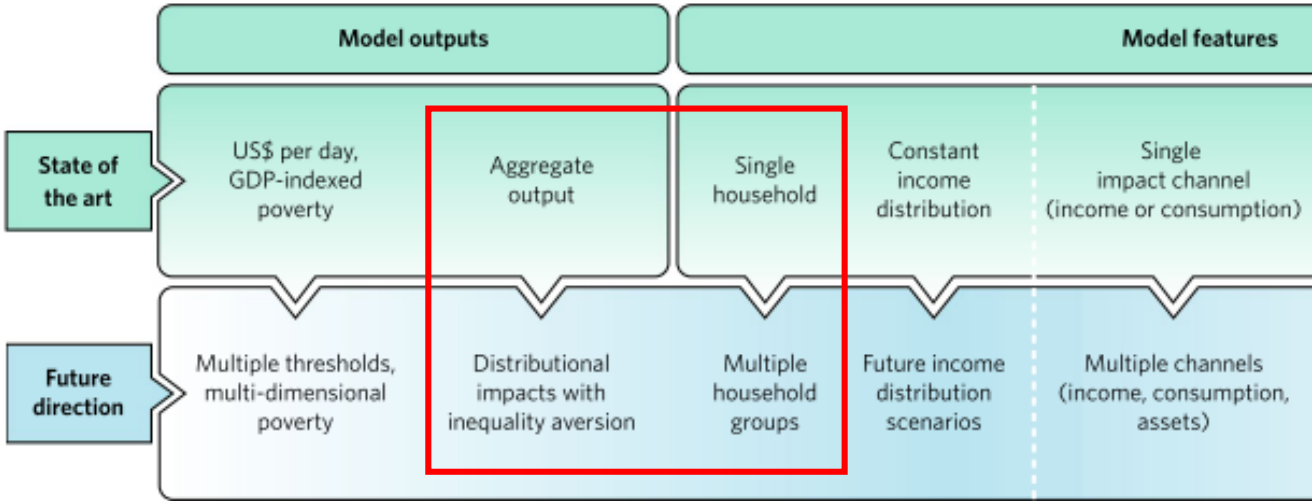
Motivation

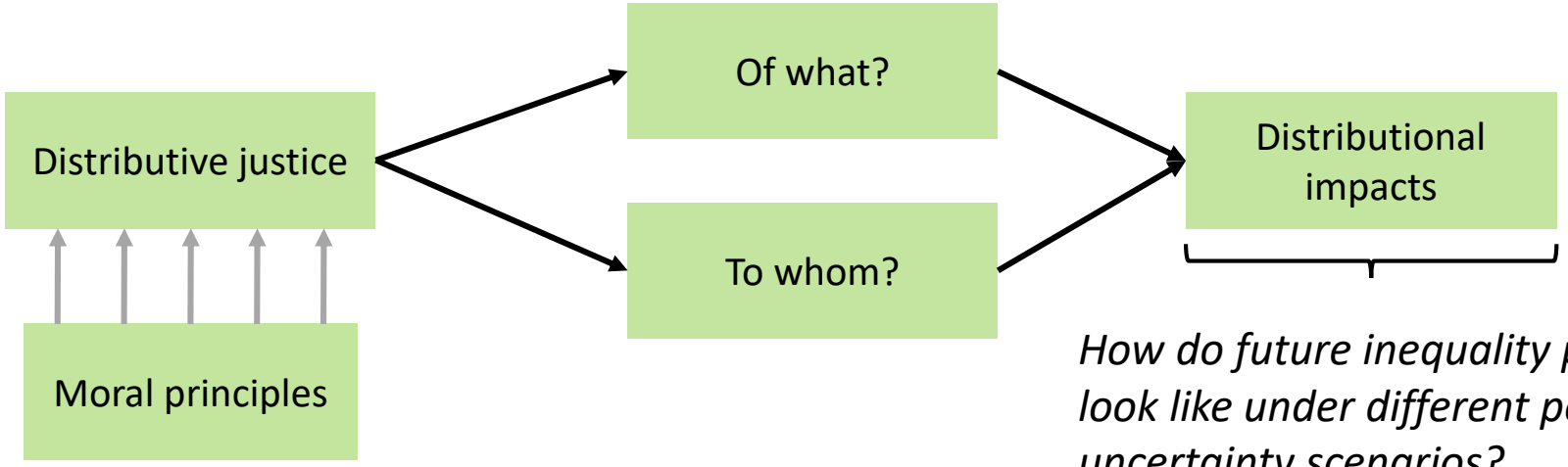
- SDG no 10: Reducing inequalities
  - Income growth for the bottom 40%
  - Policies aimed at greater equality

- Inequality in climate modelling (Rao et al, 2017)



- *"…imperfect indicator can easily lead to perverse incentives…"* (Hallegatte & Engle, 2019)

Using the concept of justice



How do future inequality patterns look like under different policy and uncertainty scenarios?

- Utilitarianism
- Egalitarianism
- Pareto principle
- Sufficientarianism
- etc…..

How do rankings of alternative policies change when different moral principles are adopted?

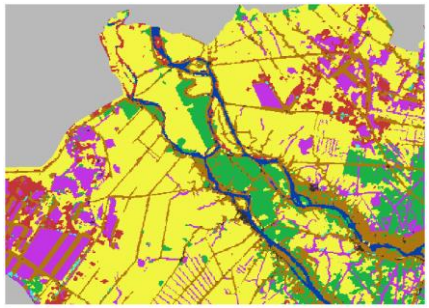
Two-stage approach in distributive justice

- Stage 1: How does the distributional pattern look like? Who are the ‘winners’ and the ‘losers‘?
  - Exploration of inequalty patterns under deep uncertainty
    - Run 2000 experiments -> clustering of inequality patterns -> scenario discovery

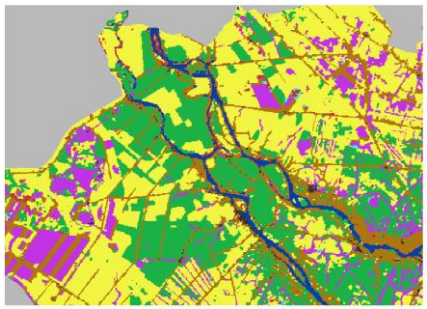
- Stage 2: Which policies yield more acceptable distributional patterns?
  - Normative evaluation of distributional impacts
    - Select distributive moral principles -> assess policies ranking under baseline scenario -> assess policies ranking under deep uncertainty

The context

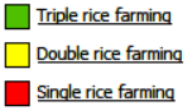
- Adaptation planning for rice farmers in An Giang and Dong Thap, Vietnam Mekong Delta
  - Profit: Income(rice) – Cost(fertilizer)
  - Aggregated at a district level, 2002-2030
- Triple, double, single rice-crop systems
- Ubiquitous dikes construction
  - Low dike: 2.5m, high dike: 4.5m



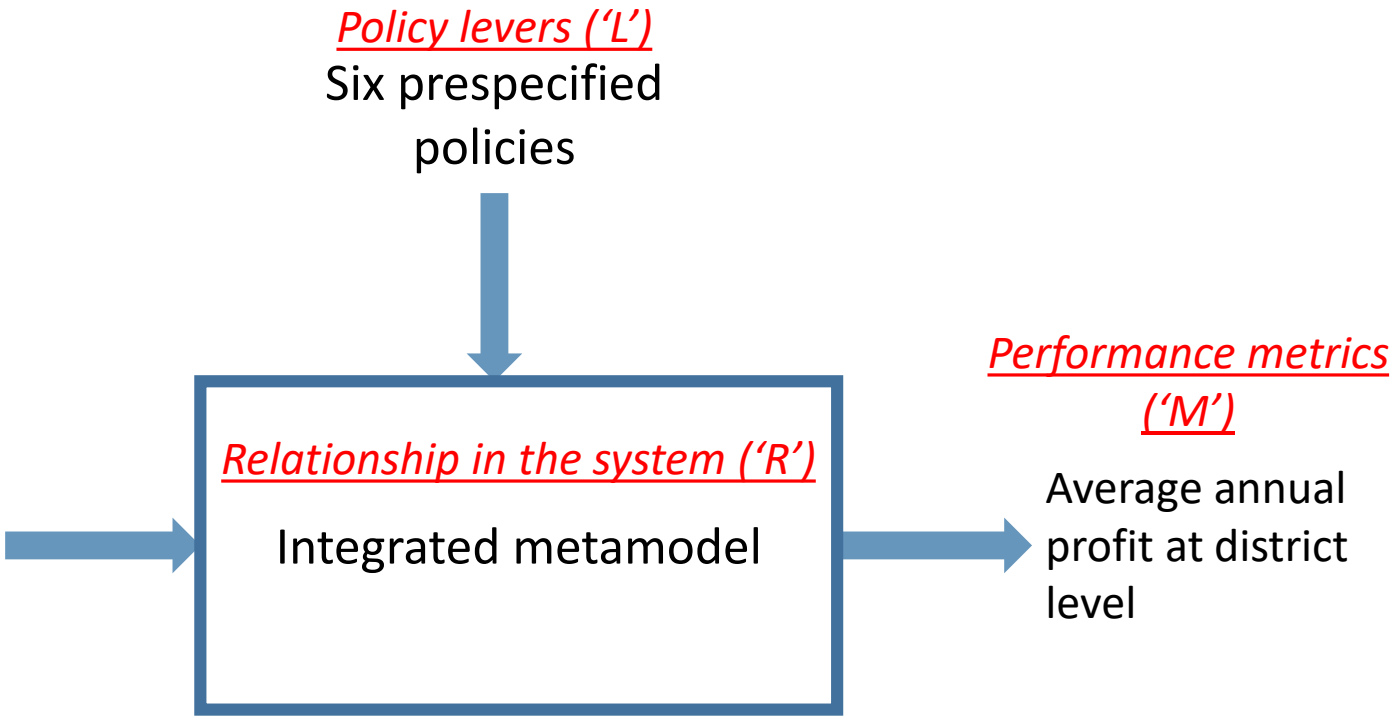
2002



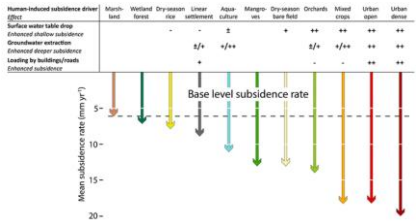
2011



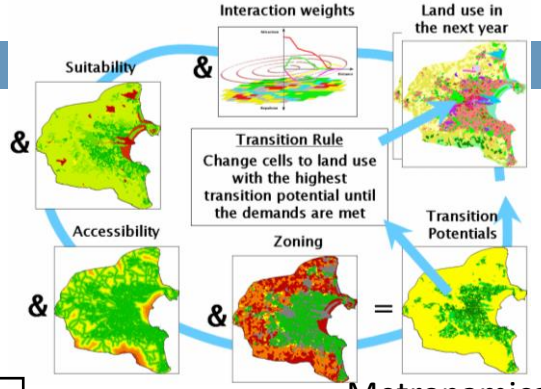
XLRM framing of the problem



Spatially explicit integrated metamodel



Land subsidence relation
(Minderhoud et al, 2018)



Metronamica
(Cellular automata approach)

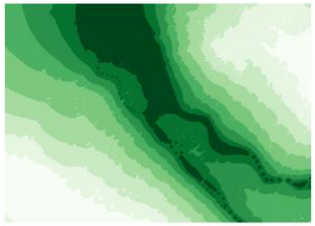
Land-use change

Flooding & sedimentation

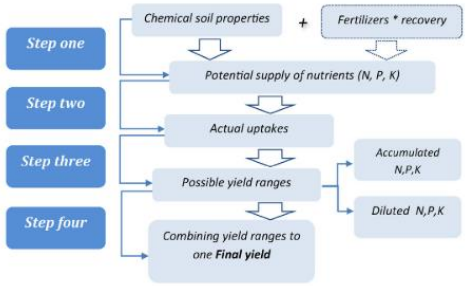
Farmers profitability

Nutrients stock & crop yield

Flood risk model
(Triet et al, 2018)



Sediment deposition model
(Manh et al, 2014, 2015)



QUEFTS (Sattari et al, 2014)

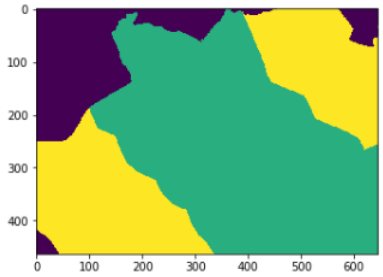
Environmental component

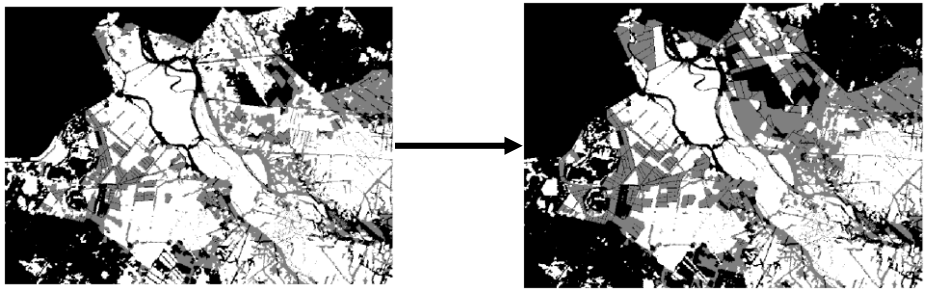
Semi environ-socioecon component

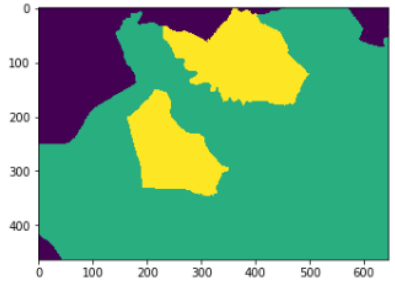
Socioeconomic component

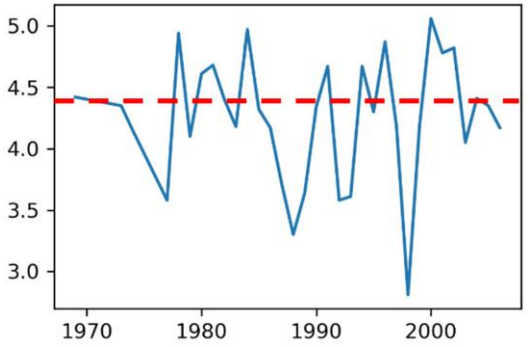
Policies

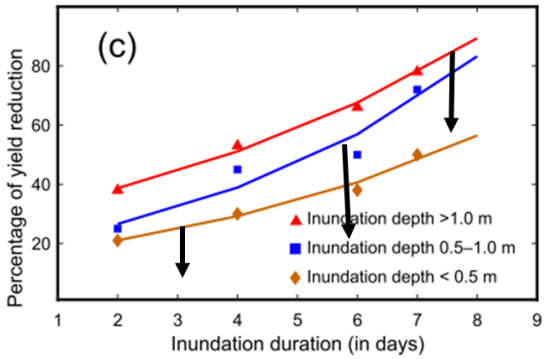
- Extra fertilizer to outskirt areas (areas far from rivers)
- Extra fertilizer to worse-off districts
- Expansion of high dikes
- Deconstructing high dikes
- Upstream cooperation (max water level <= 4.4m)
- Changing seed variety (reducing vulnerability to floods)





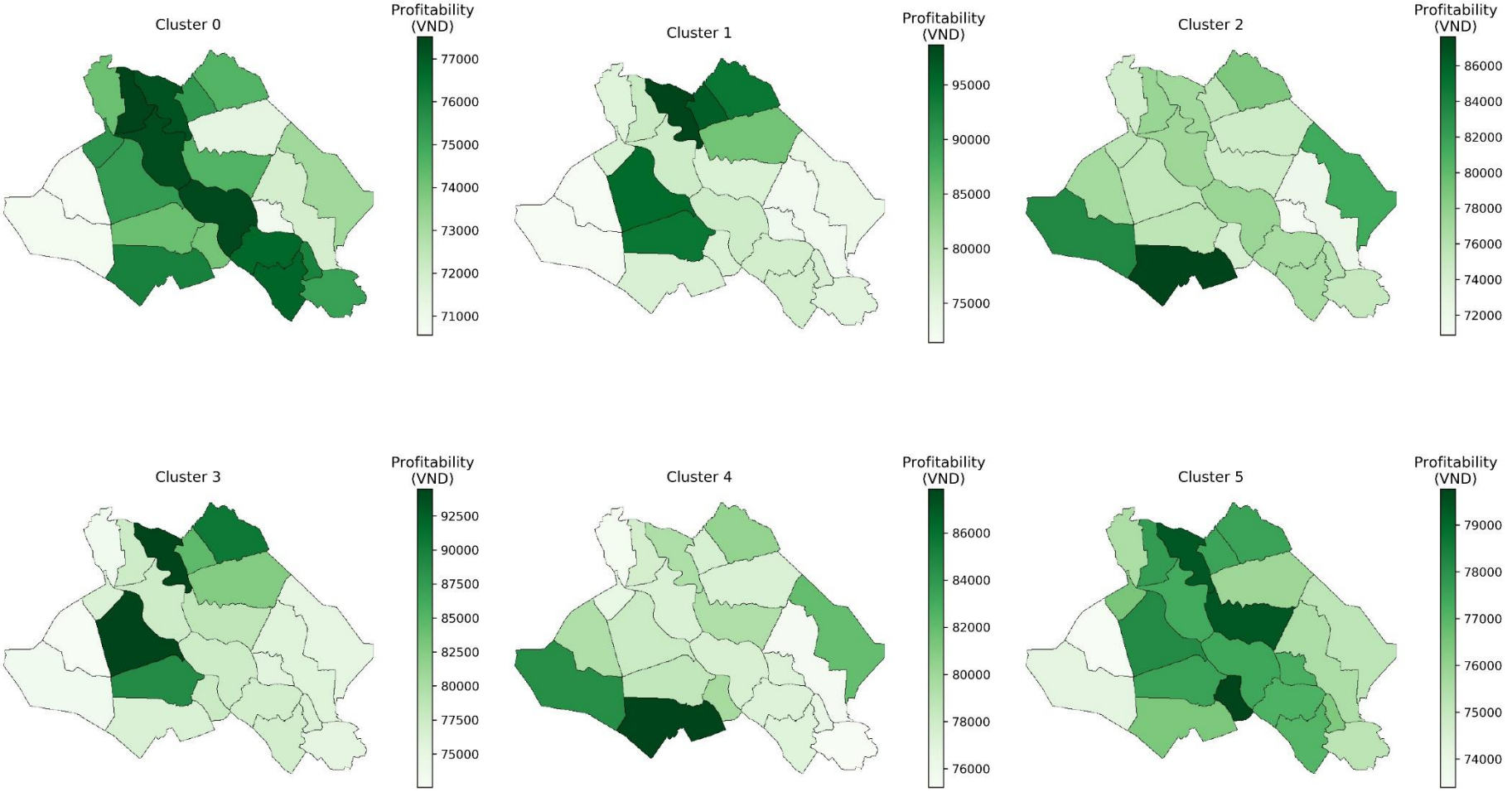




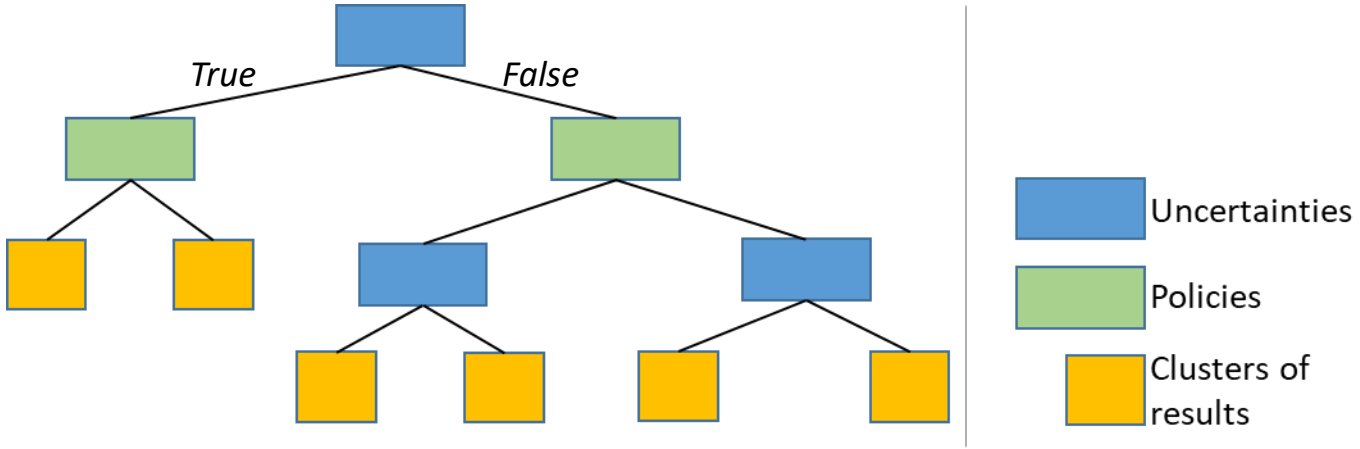


Stage 1: Exploration of inequalty patterns under deep uncertainty

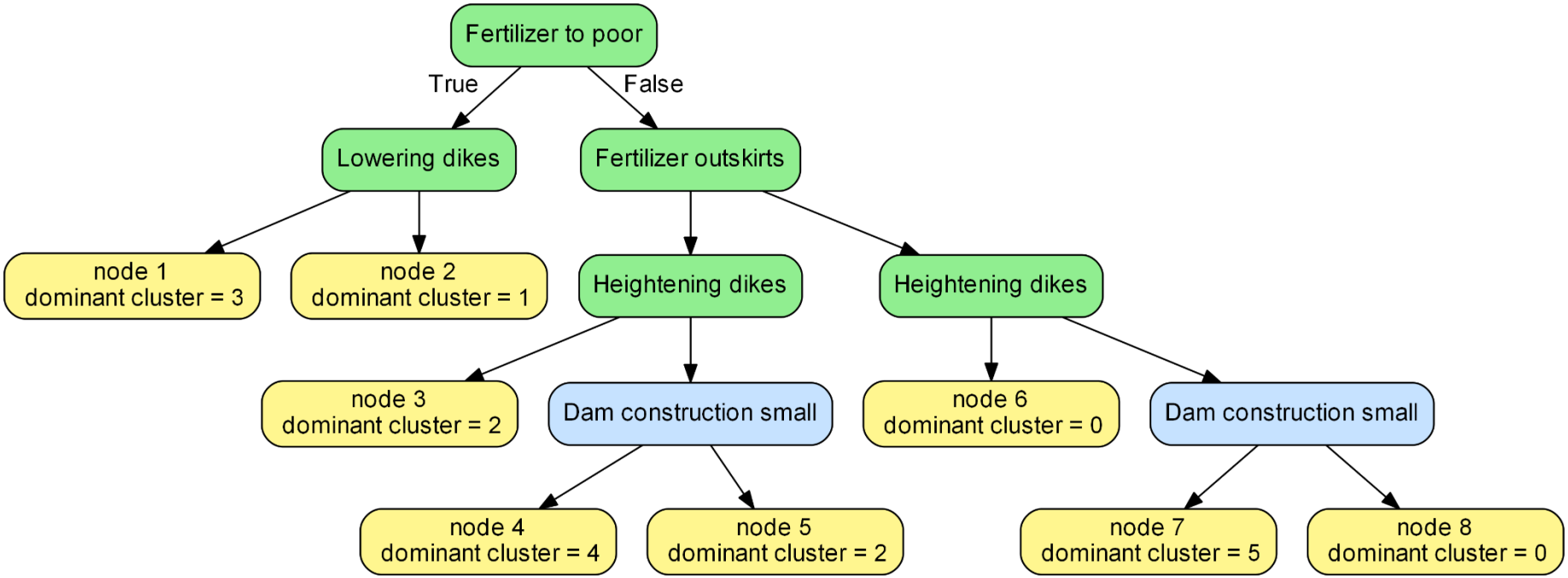
K-means clustering of 2000 simulation results



Scenario Discovery by Decision Tree Classifier (DTC)



Resulting classification trees

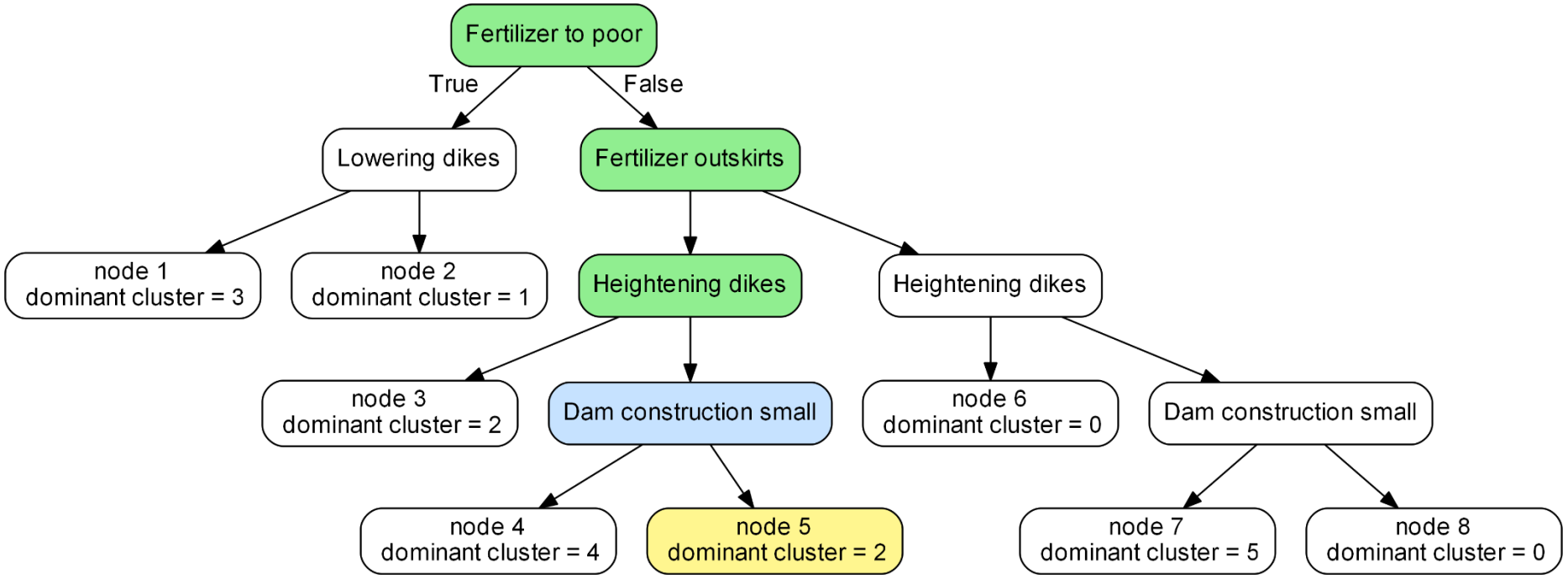


Policy levers

Uncertainties

Resulting nodes

An example of one branch of the tree

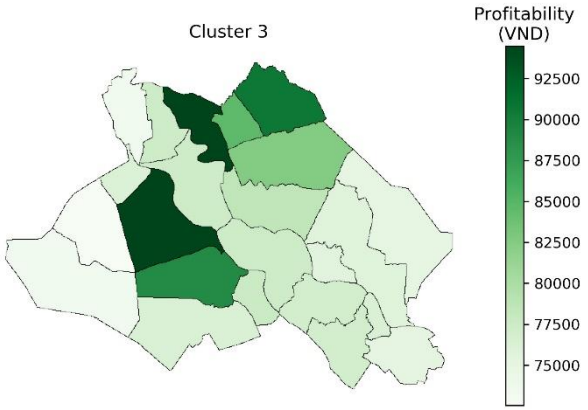


Policy levers

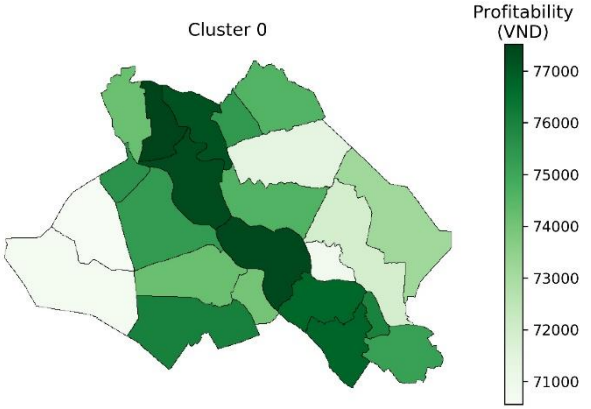
Uncertainties

Resulting nodes

Creating narratives from the classification tree



- Fertilizer to poor
- Removing high dikes



- Heightening dikes

- Large upstream dam development

Stage 2: Normative evaluation of distributional impacts

Operationalization of alternative moral principles

Different social welfare functions to aggregate the utility of multiple actors in the system

x_i = utility of actor *i*
n = total number of actors

In the case study, the actor is represented at a district level, resulting in a total of 23 actors (23 districts in An Giang and Dong Thap)

Utilitarianism

$$\sum_{i=1}^{n} u(x_i)$$

Envy measure

$$\sum_{i=1}^{n}\sum_{j=1}^{n} max\{u(x_j) - u(x_i), 0\}$$

Weighted utilitarianism

$$w_u * f(\sum_{i=1}^{n} u(x_i)) + (1 - w_u) * f(max(u(x_i)) - min(u(x_i)))$$

Rawlsian difference

$$min(u(x_i))$$

Absolute inequality

$$max(u(x_i)) - min(u(x_i))$$

Prioritarianism

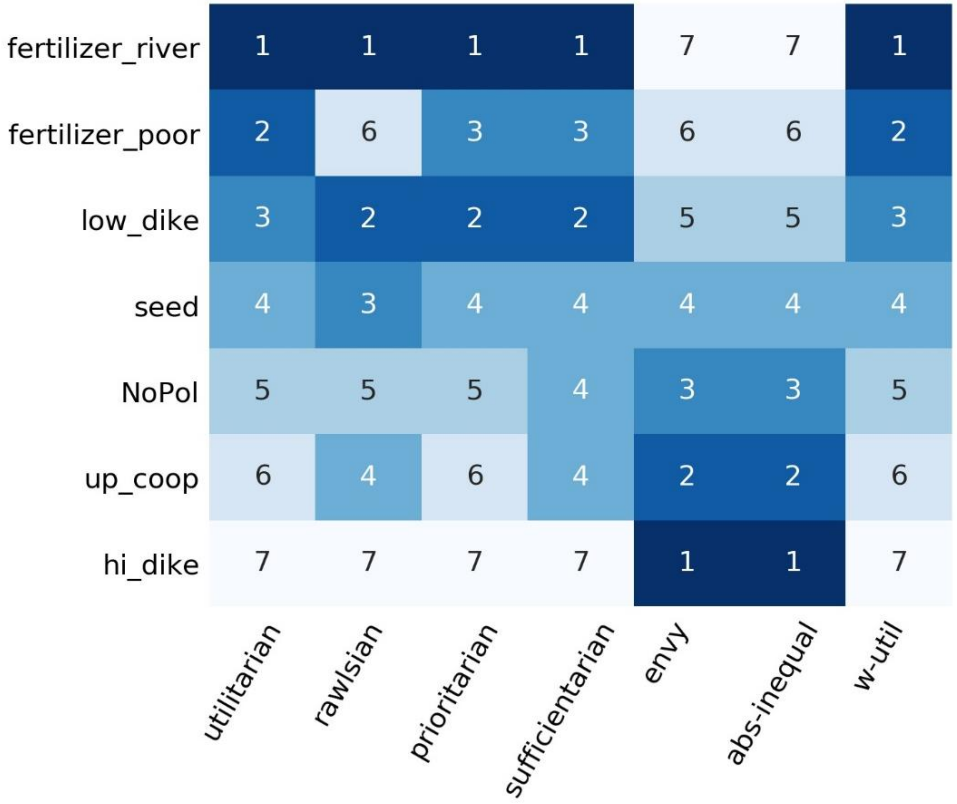
$$\frac{1}{1-\gamma}\sum_{i=1}^{n}(u_i^{\star})^{1-\gamma}$$

Sufficientarianism

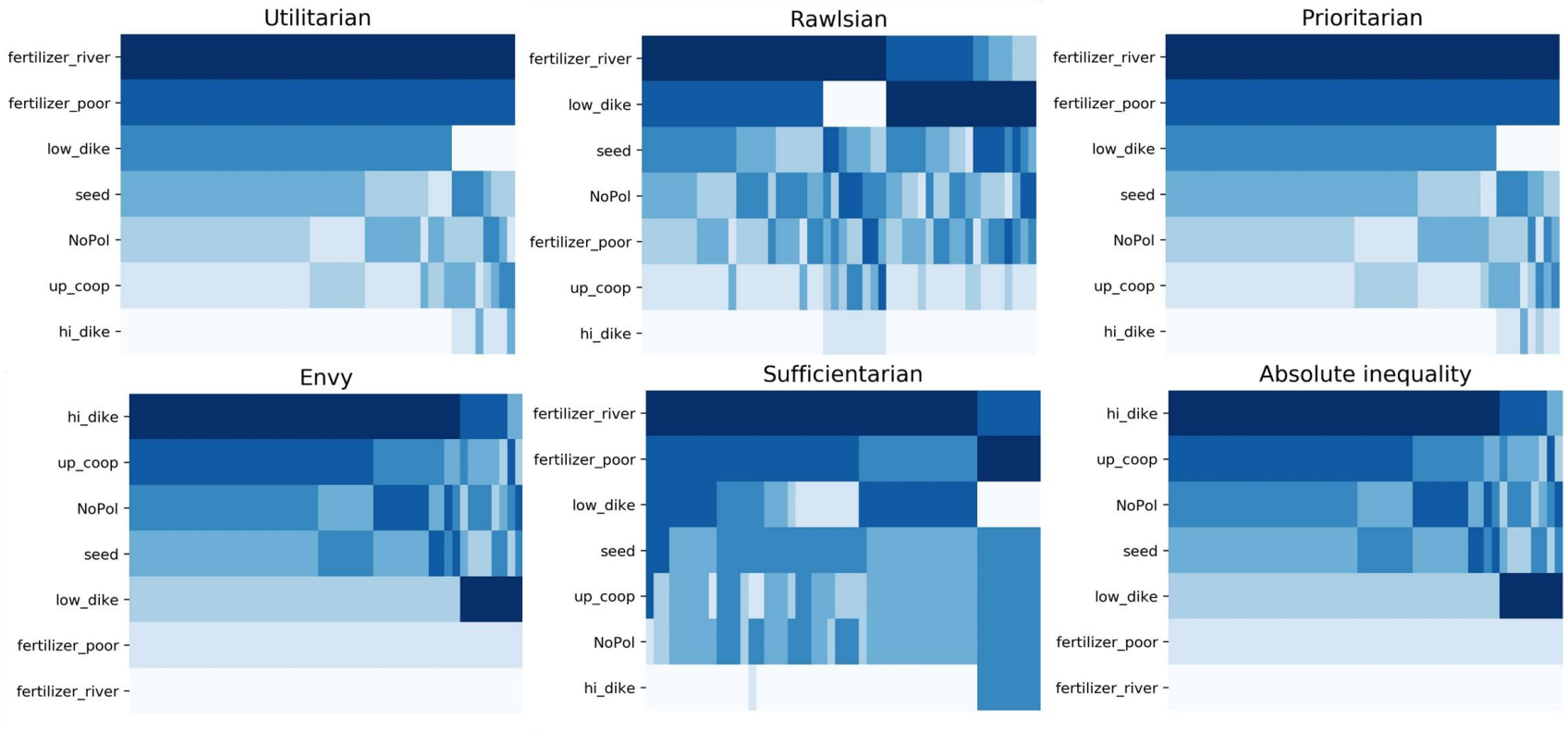
$$|\{i \in n : u(x_i) \geq u(S)\}|$$

Ranking of alternative policies under baseline scenario

- The fertilizer to outskirt areas policy (fertilizer_river) is the most preferrable policy in most of the moral principles



Ranking of alternative policies under 2000 different uncertainty scenarios

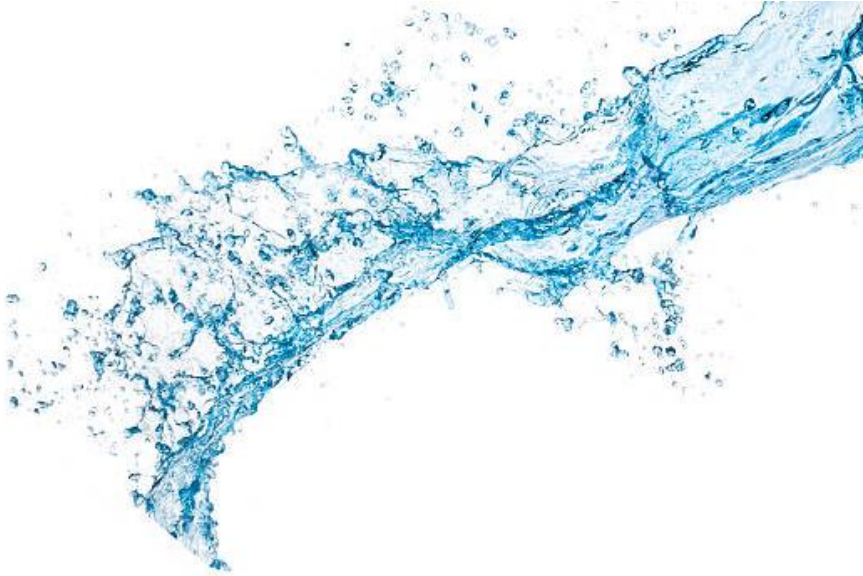


- Each plot is a horizontal barchart of how often a policy sits on a particular rank across the 2000 scenarios.
- Thicker color implies higher rank (more preferable)

Conclusions, next steps, foods for thought

- Policy
  - Inequalities can be driven by both uncertainties and policy levers
  - Understanding inequality patterns can help in identifying additional 'redistribution' policies
  - Moral principles are available to help with justifying the appropriateness of distributional impacts from alternative policies
  - Preference of alternative policies are affected by uncertainties and moral principles

- Methodological
  - Application of multinominal scenario discovery to both 'X' and 'L'
  - First step towards inclusive adaptation pathways
    - Actor-specific signposts and triggers
    - Inequality-pattern-based signposts and triggers



Thank you

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