The basis for modelling with MCDA and ABM in decision making under uncertainties

Tim Müller

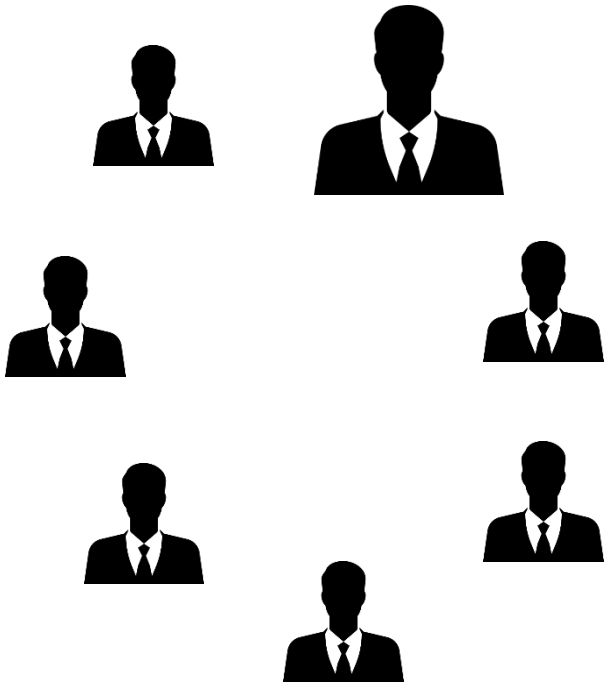
Karlsruhe Institute of Technology (KIT)

CONFIDENCE Workshop Milano, April 2019

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement No 662287

Introduction

Advisory Body



What is preferable?

Sheltering Evacuation

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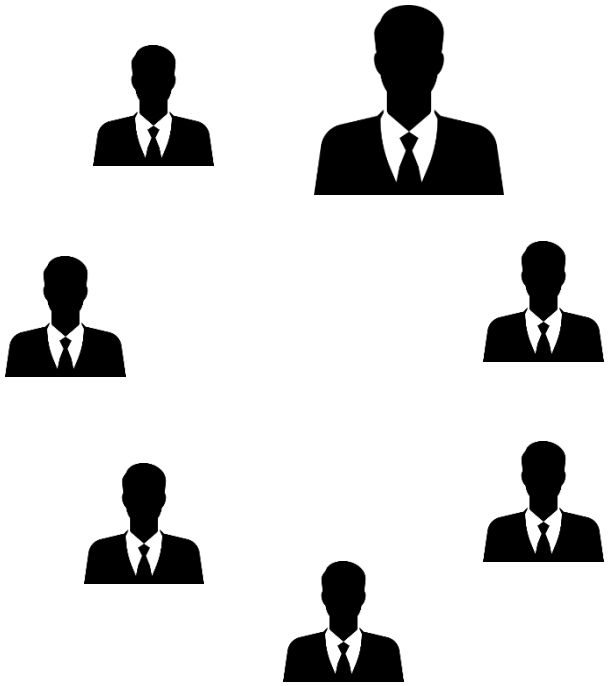

Simplified example

	Sheltering	Evacuation
Cost	0.1 M€	10 M€
Acceptance	low	very low
Cancer	0.001%	0.00001%

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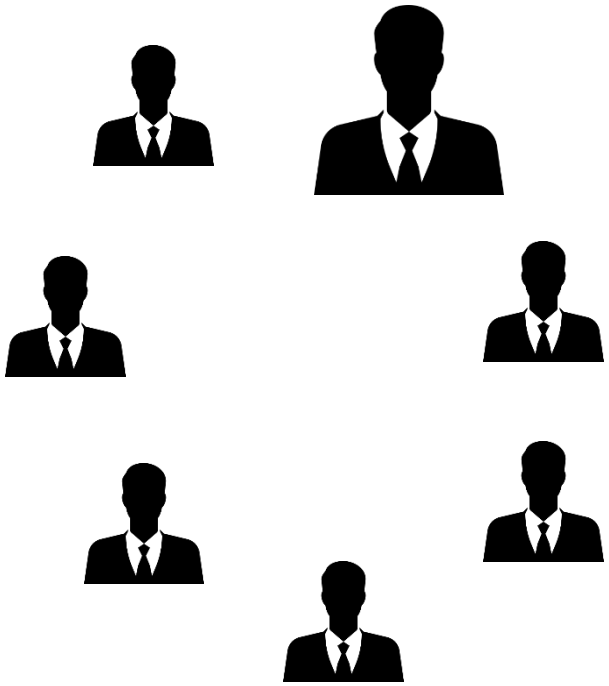

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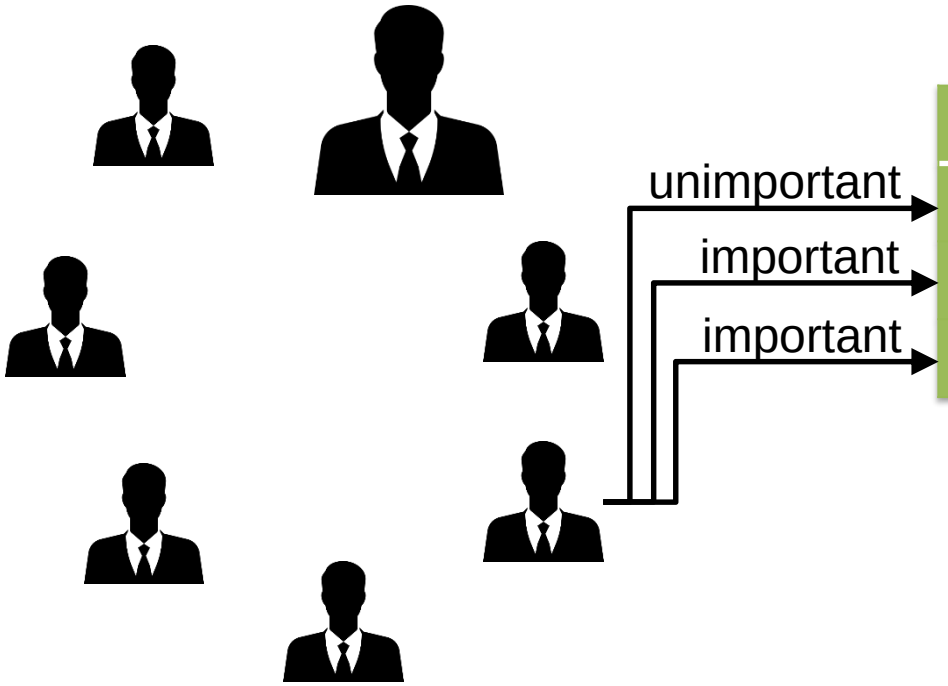

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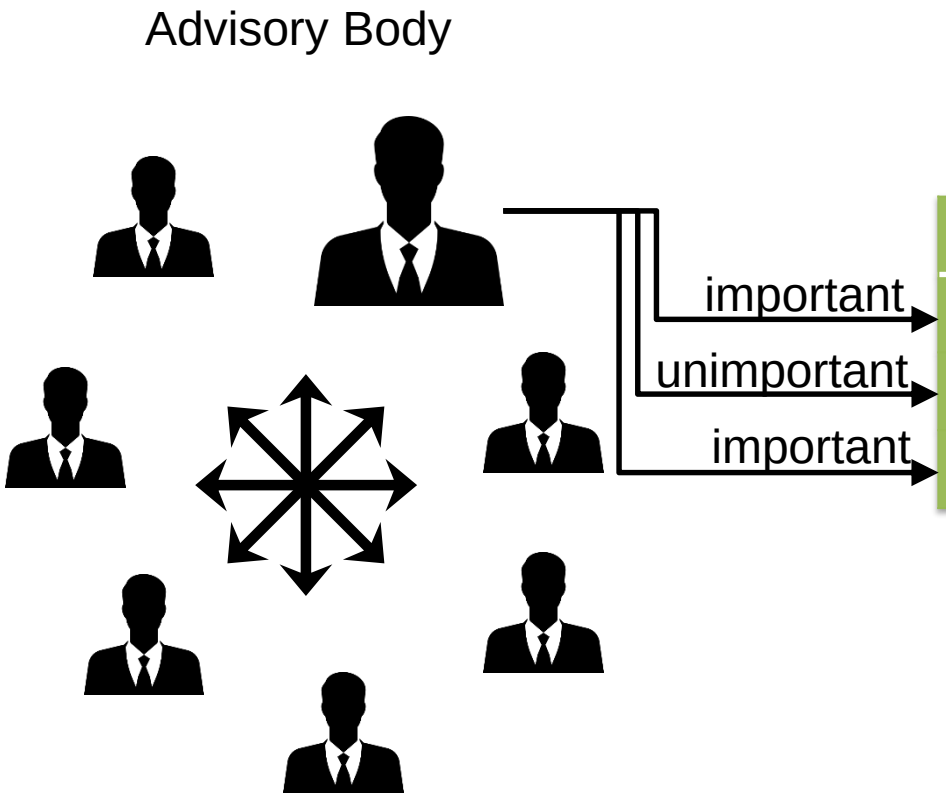

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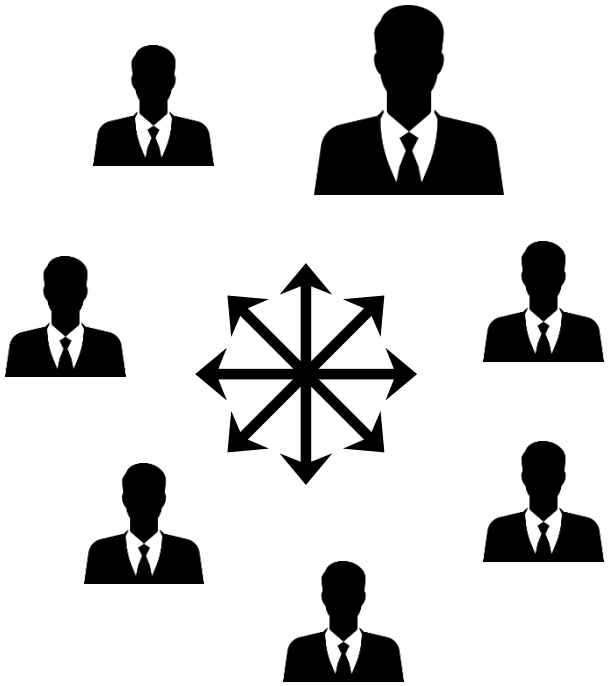

Simplified example

		Sheltering	Evacuation
important	Cost	0.1 M€	10 M€
unimportant	Acceptance	low (2)	very low (1)
important	Cancer	0.001%	0.00001%

⇨ Conclude a common ranking on alternatives

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Recall of Goals

- Understand how decisions are made in a group of decision makers if their preferences differ
  - What impact do variations have? How stable is the process?
  - What factors do cause variations? Can they be influenced?
- Develop a model and analyse the communication and negotiation in a group of decision makers (ABM - Agent Based Modelling)
  - Provide feedback and advice to the decision makers, authorities, …
  - Investigate new combinations of strategies and preferences, may result in additional scenarios as templates for decision making
- Adapt existing decision aiding tools to cope with uncertainties in scenarios (MCDA - Multi Criteria Decision Analysis)
  - Develop handling and visualisation for uncertainties in MCDA
  - Provide indicators of robustness to communicate the stability of a ranking based on uncertainty

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Introduction

ABM

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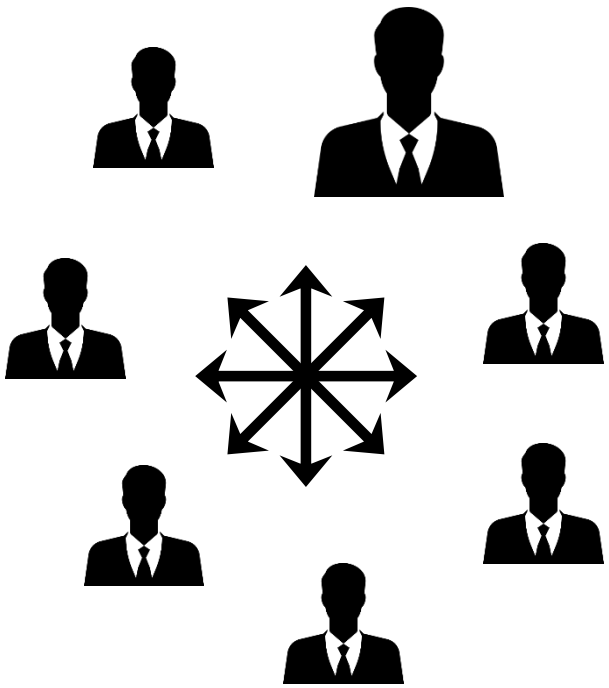

MCDA

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Some Agents…

Agent: originating from the Latin word *agere*
"to do, to act on someone's behalf"

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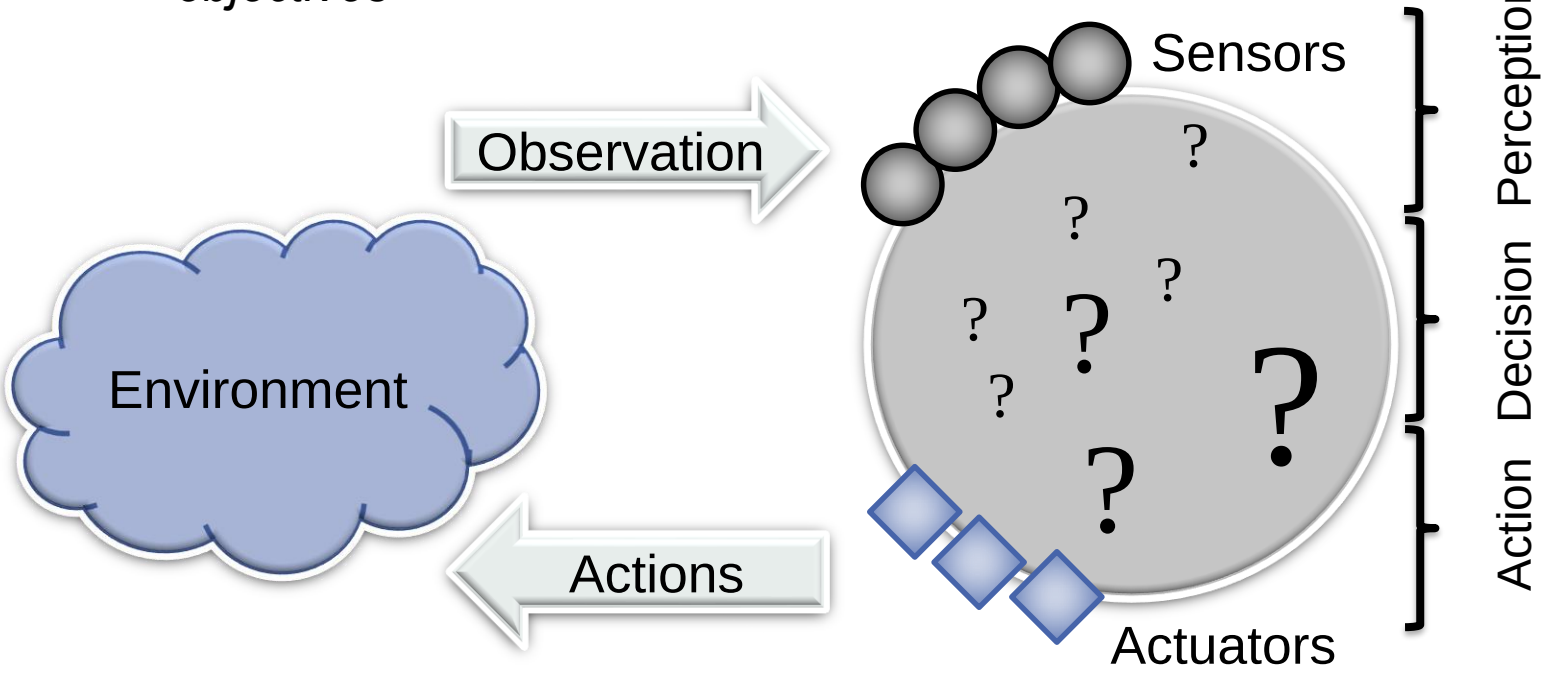
A Software Agent

Formal definition

"A (software) agent is a computer system that is situated in some environment, and that is capable of autonomous action in this environment in order to achieve its delegated objectives"



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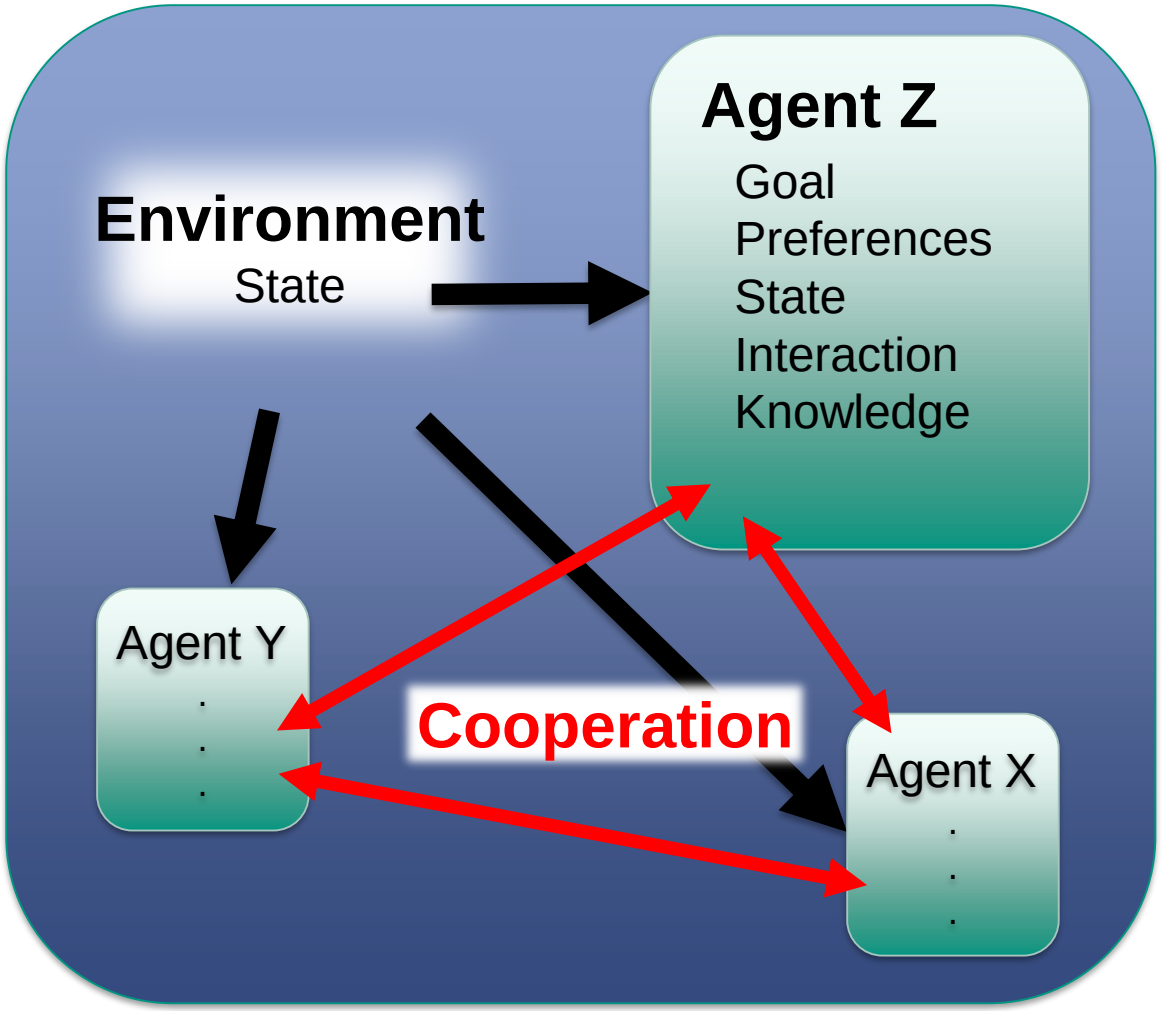
Agent Based Modelling (ABM)



Features
- Autonomous
- (Rather) Intelligent
- Goal oriented
- Flexible
- Adaptive
- Altruistic
- …

Cooperation
- With Environment
- With other Agents
- Strategies
- Behaviour

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Environment and Agents for CONFIDENCE

- Created knowledge database of scenarios for agents with JRodos based on HARMONE and PREPARE projects
  - Specified scenarios to be a set of different attributes like season, affected people, affected area, …
  - 96 Scenarios overall for different strategies in different phases
    - Evacuation (EMERSIM)
    - City decontamination (ERMIN)
    - Foodstuff (AGRICP)
- Defined 5 agent types with different preferences on attributes, that are randomly varied
- Implemented model and basic visualisation for evaluation

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Workflow and Negotiation Models

- Agents determine ranking for strategies
  - For each strategy (e.g. evacuation)
  - Preselect best strategies from knowledge database (e.g. 5)
  - For each of the agents (e.g. 24)
  - For each attribute (e.g. affected people)
  - Rank attribute weighted by preference of agent and combine with other attributes
- Agents discuss ranking to come to an agreement
  - For each preselected strategy
  - Tit-for-tat as current negotiation method
  - Each agent chooses a new ranking value between its old value and the average of all ranking values
  - Repeat until “changes are small” or time is up

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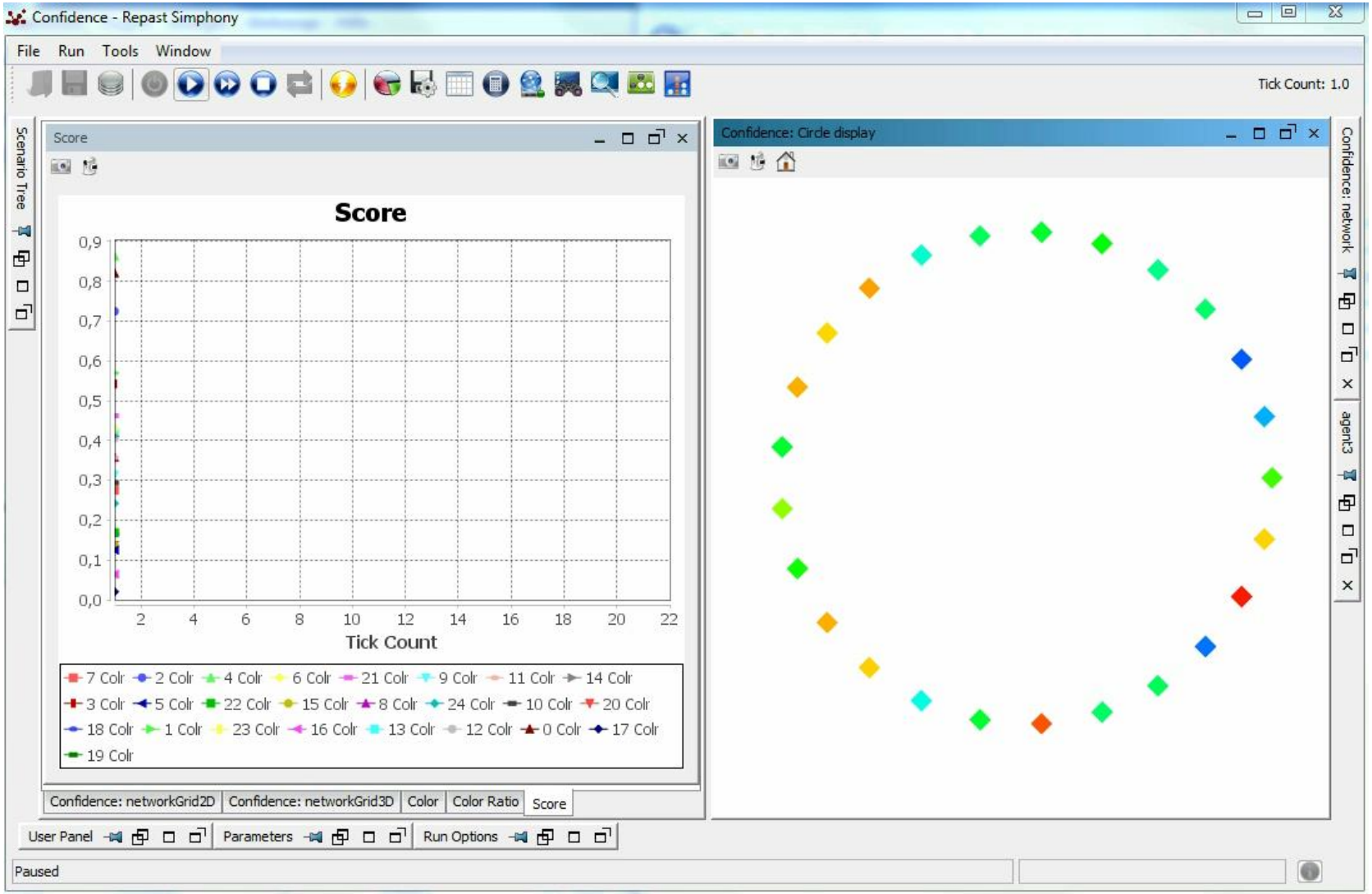
Visualization of Negotiation of a Strategy



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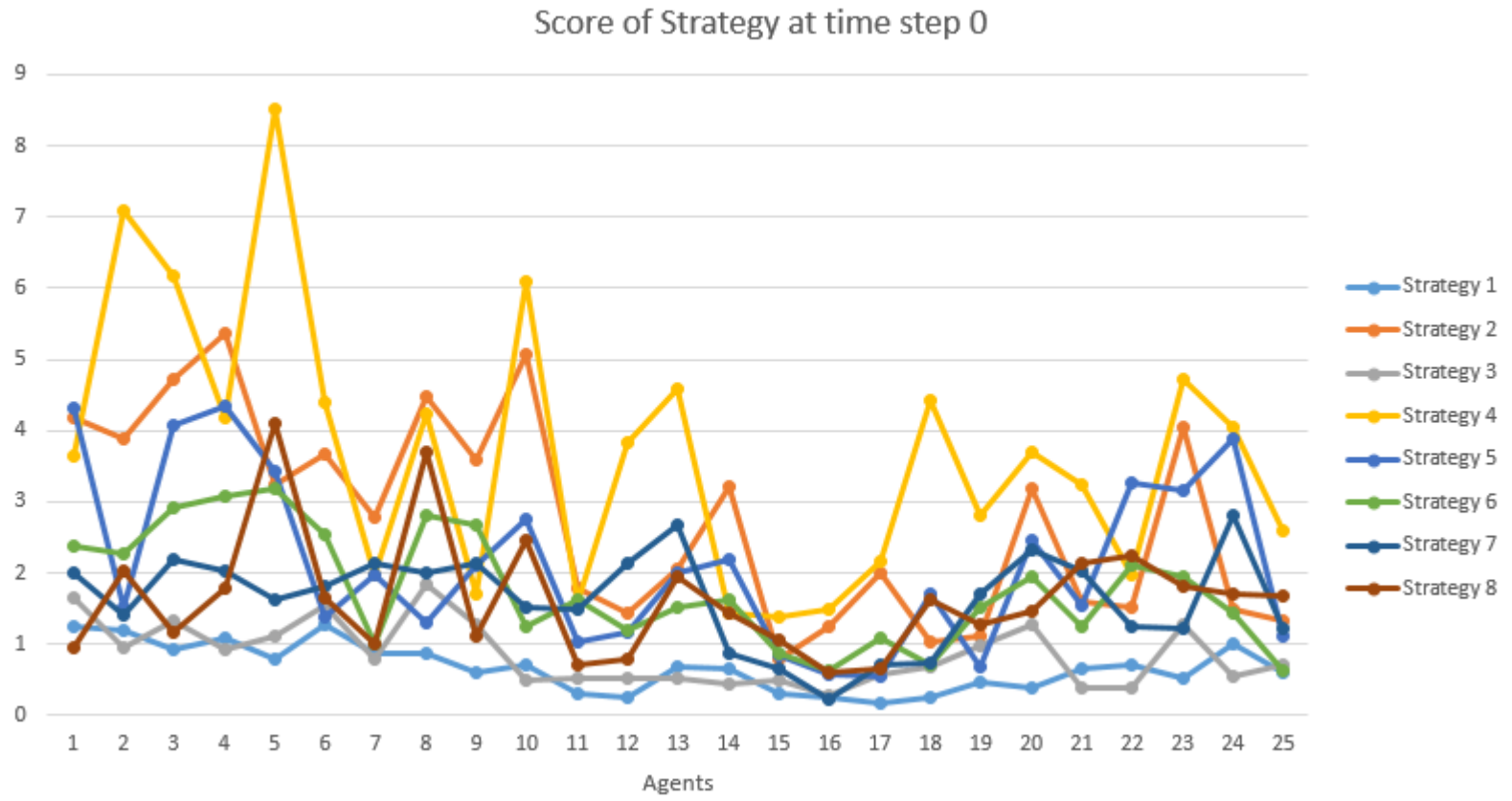
Visualization Test of Negotiation Process



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Summary of ABM in CONFIDENCE

- An agent based framework for modelling the decision making process was developed and implemented
- Several different types of agents and their parameters have been identified and implemented
- A negotiation workflow between the agents is established. As initial negotiation strategy tit-for-tat is implemented
- Raw visualization of the negotiation process is available
- A Questionnaire was prepared and distributed to stakeholders to learn about the decision making process
- Development is continued
- **Not to be used by stakeholders directly.**
  For preparation and knowledge generation only.

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Introduction to MCDA

ABM

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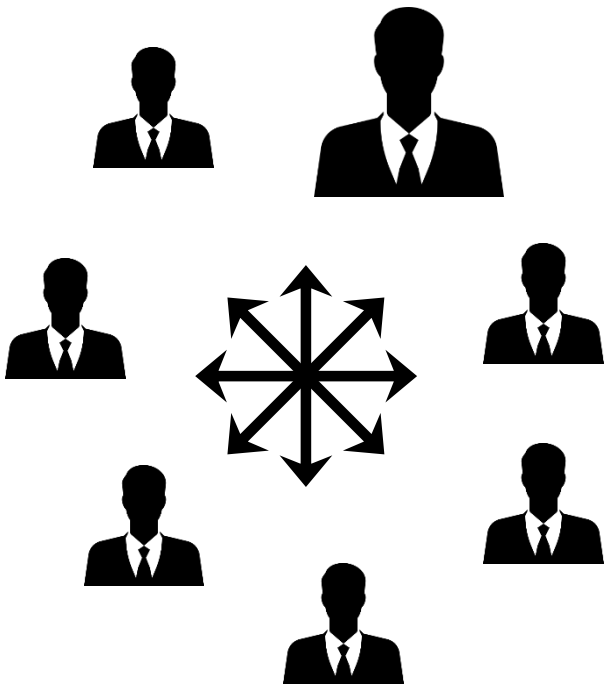

MCDA

Simplified example

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How MCDA works

a_{ij} Value of Criterion j for Alternative i

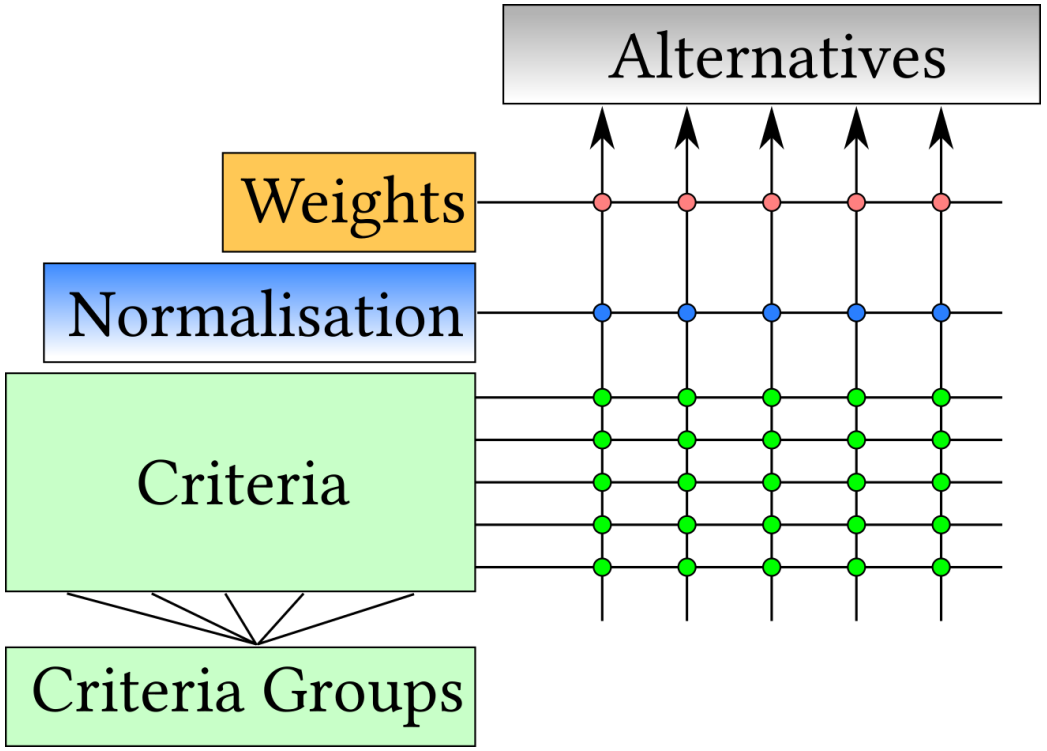
$N_j(\ldots)$ Normalisation of Criterion j

w_j Weight of Criterion j

A_i Value for Alternative i

$$A_i = \sum_{j=1}^{n} w_j \cdot N_j(a_{ij})$$

Result: **Ranking of alternatives**



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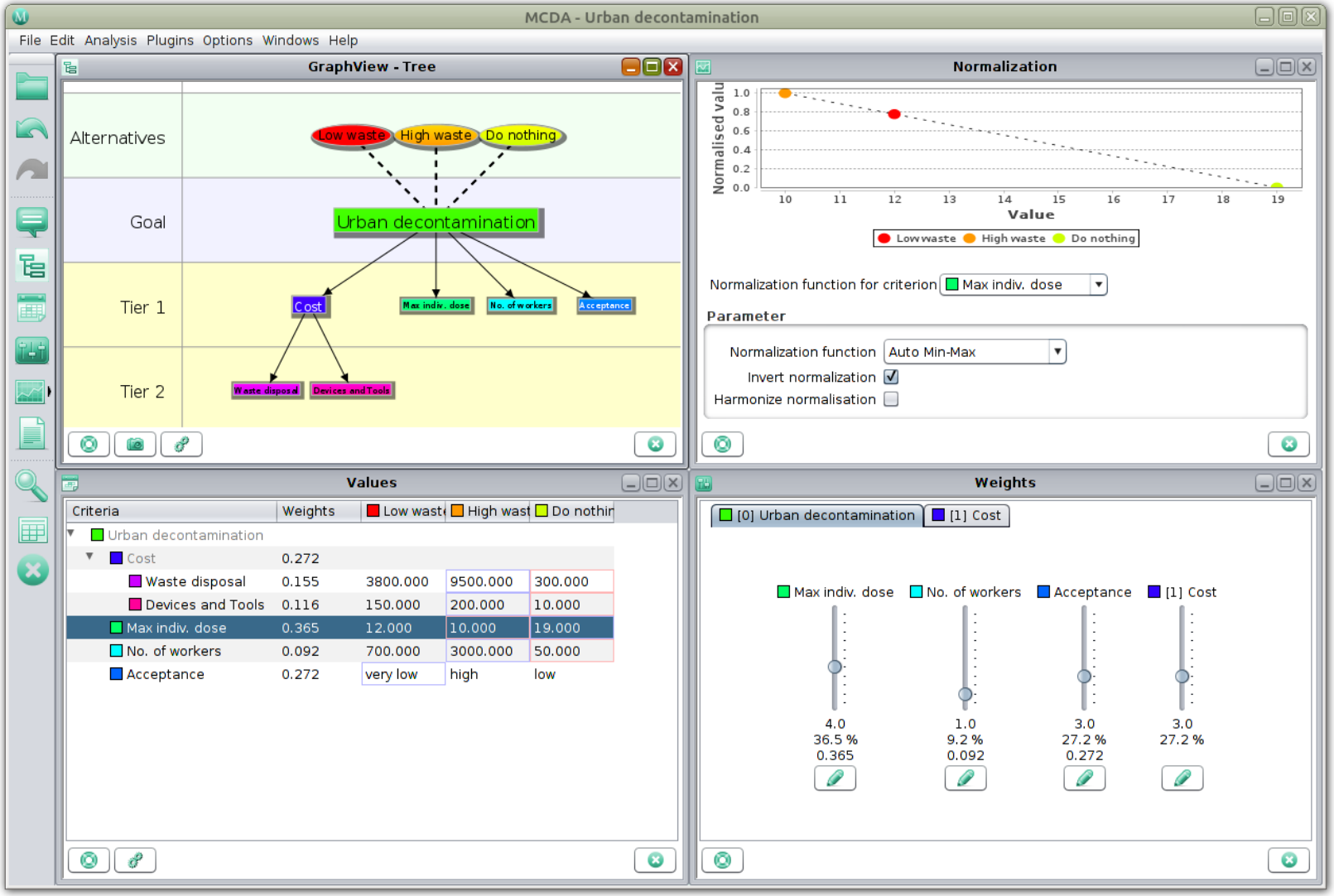
The MCDA Tool



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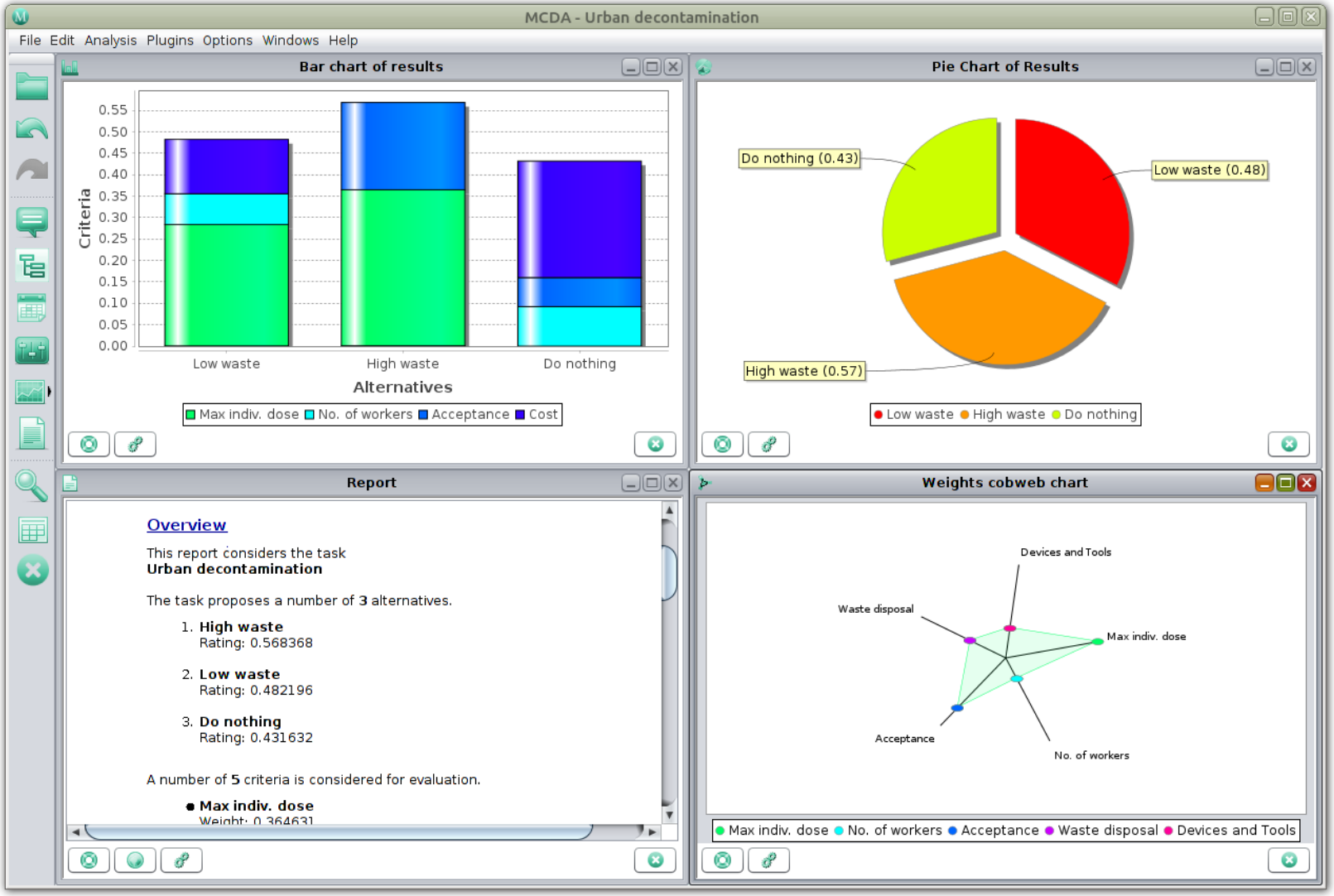
Visualisation of Results



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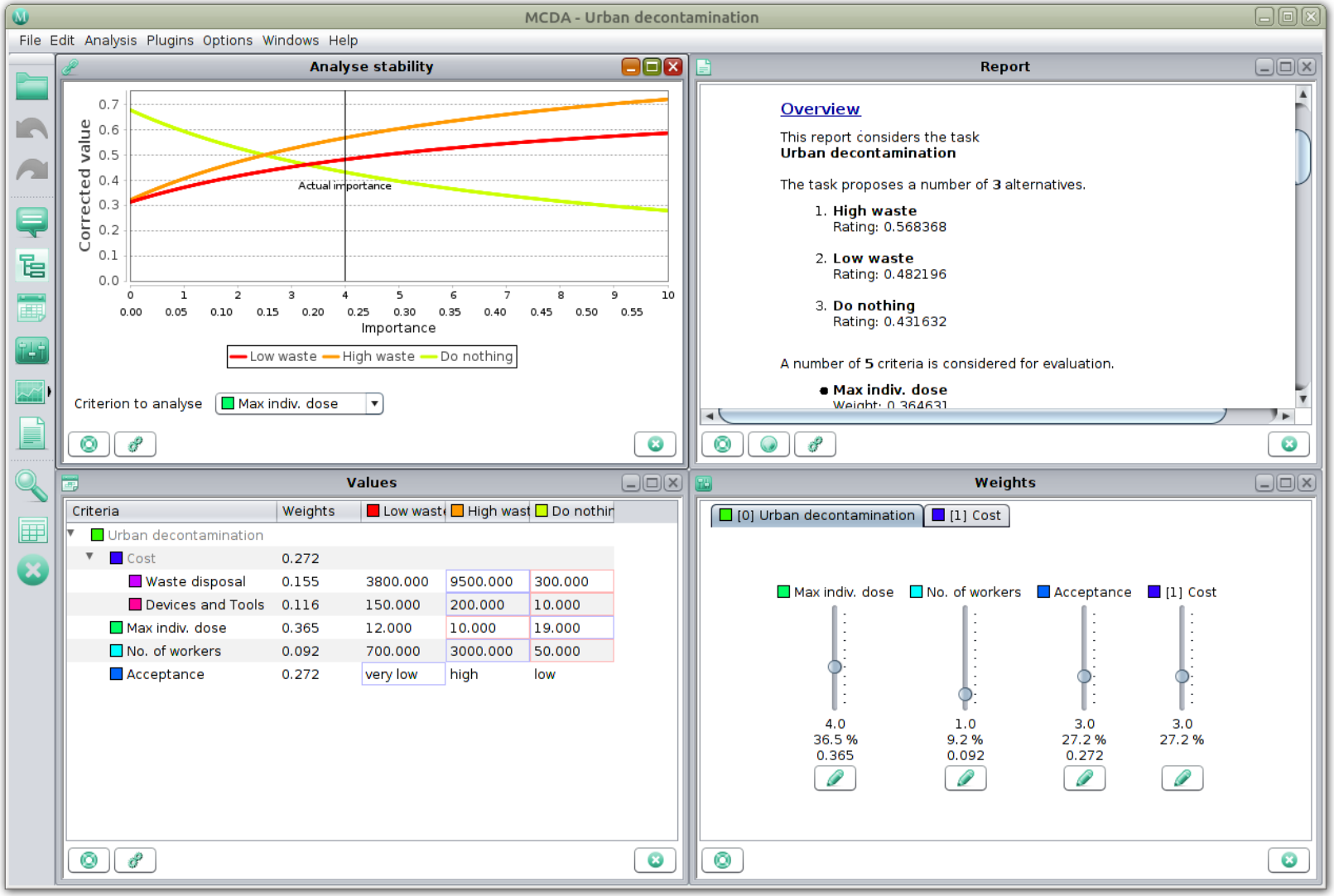
Robustness and Stability



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Uncertainty handling in MCDA

- Values and preferences may be affected by uncertainties
- Define uncertainties as probability functions
  - Measured or counted as histogram
  - Defined as probability distribution
- MCDA cannot be normally processed anymore. Analysis is performed by ensemble evaluation
  - Take a random snapshot of the probabilistic MCDA to create a static MCDA
  - Evaluate the static MCDA
  - Repeat many times and aggregate the results
- Values, preferences, and results have to be visualised differently

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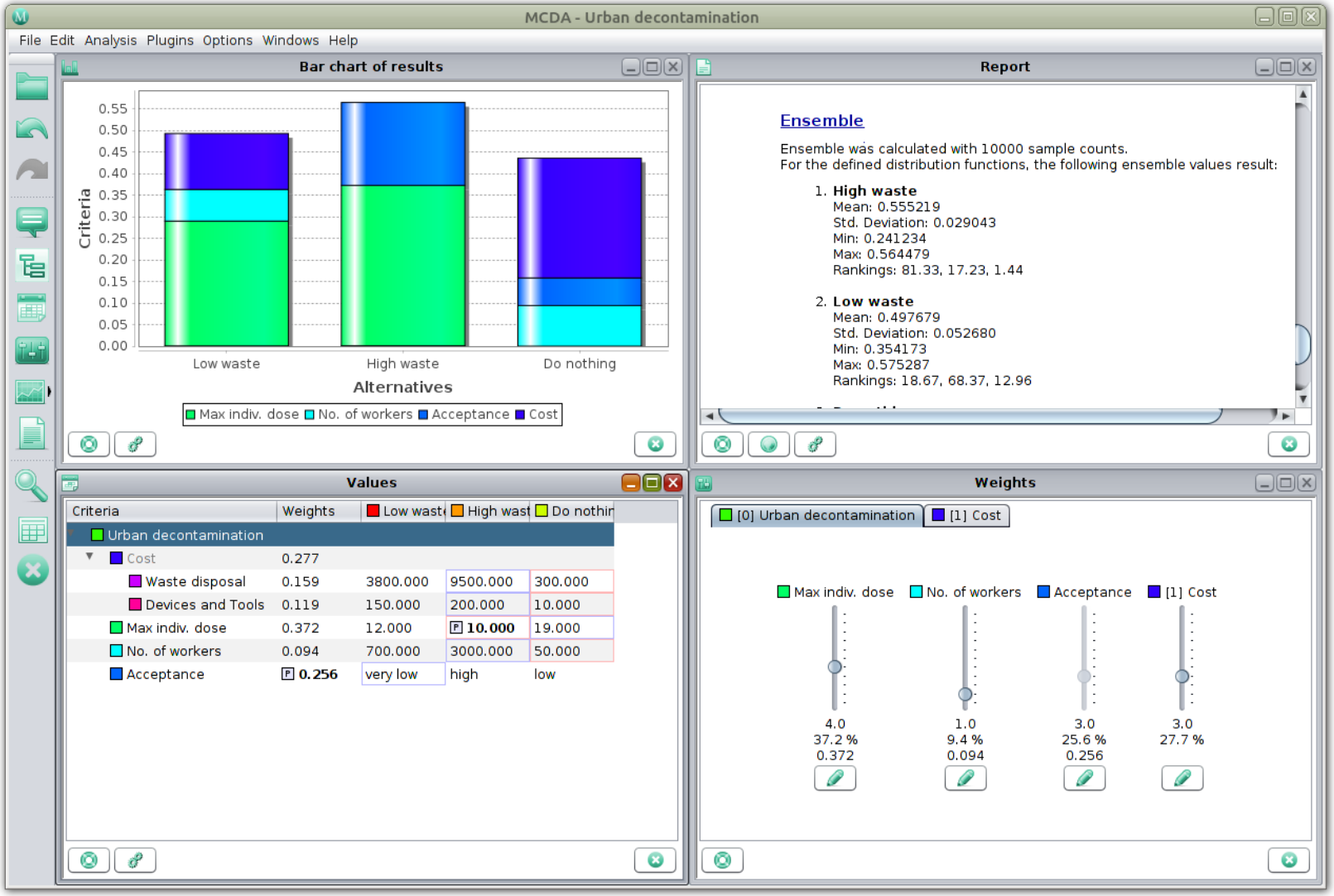
Defining Uncertainties



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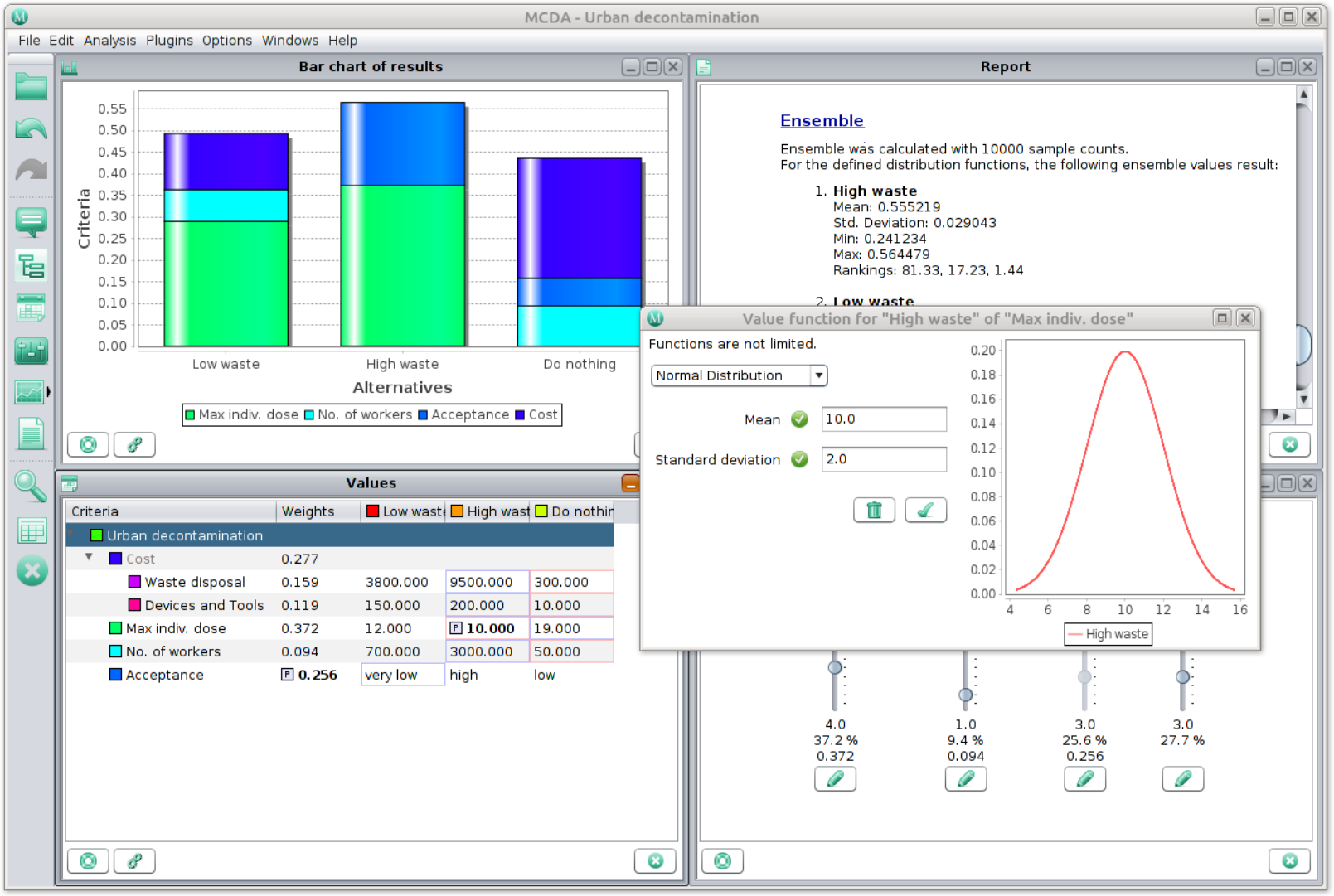

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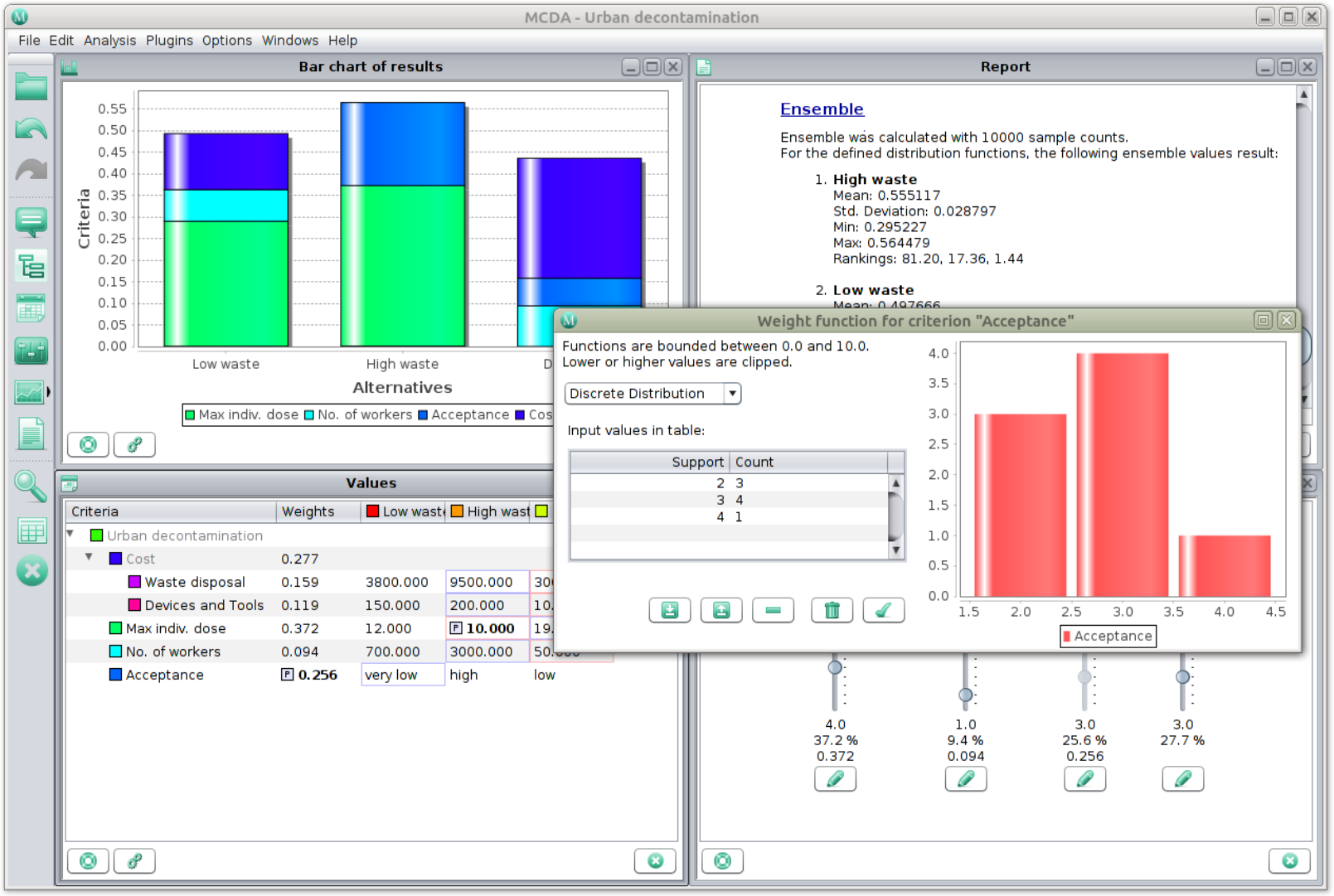

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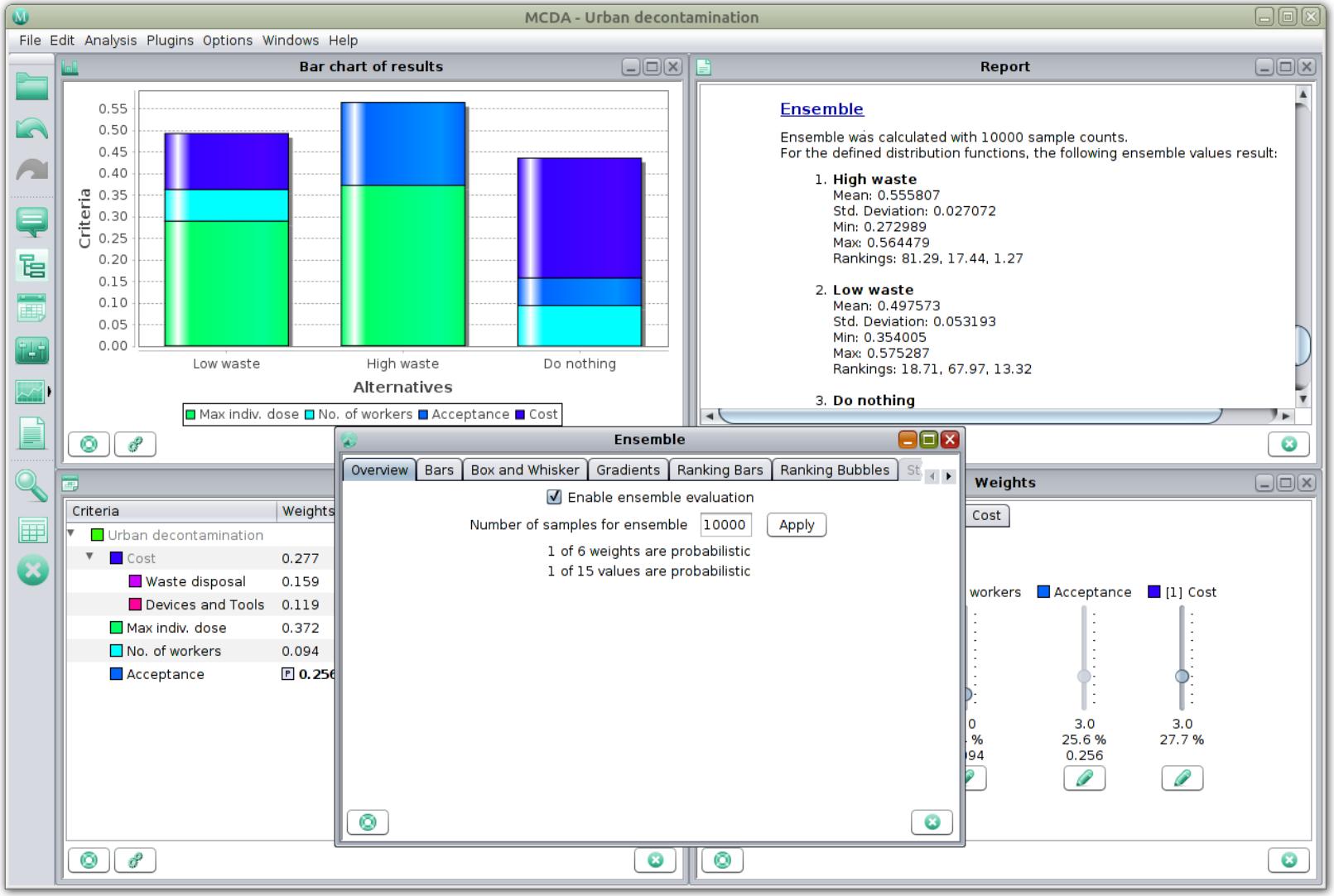
Evaluating Uncertainties



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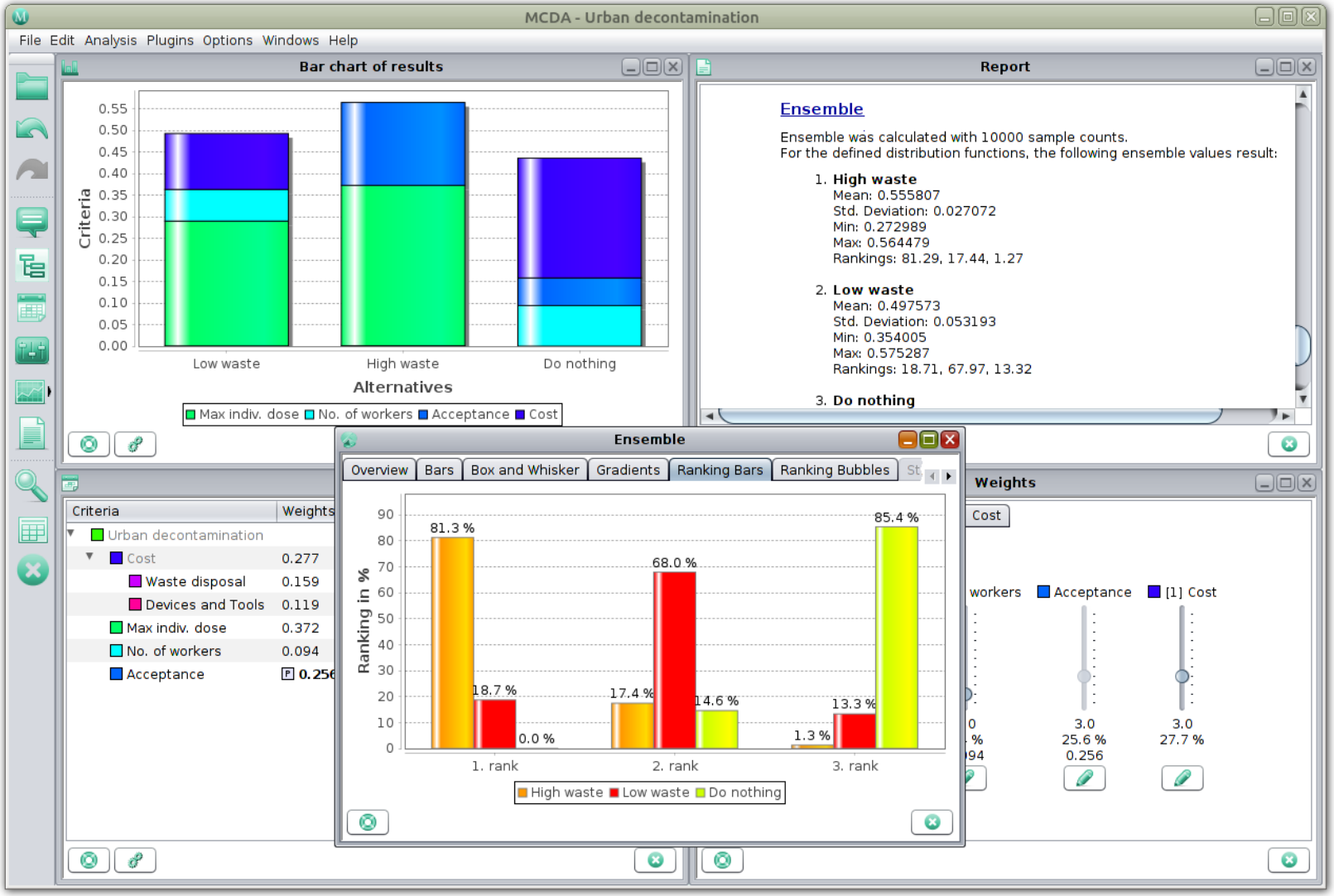
Visualising Uncertainties



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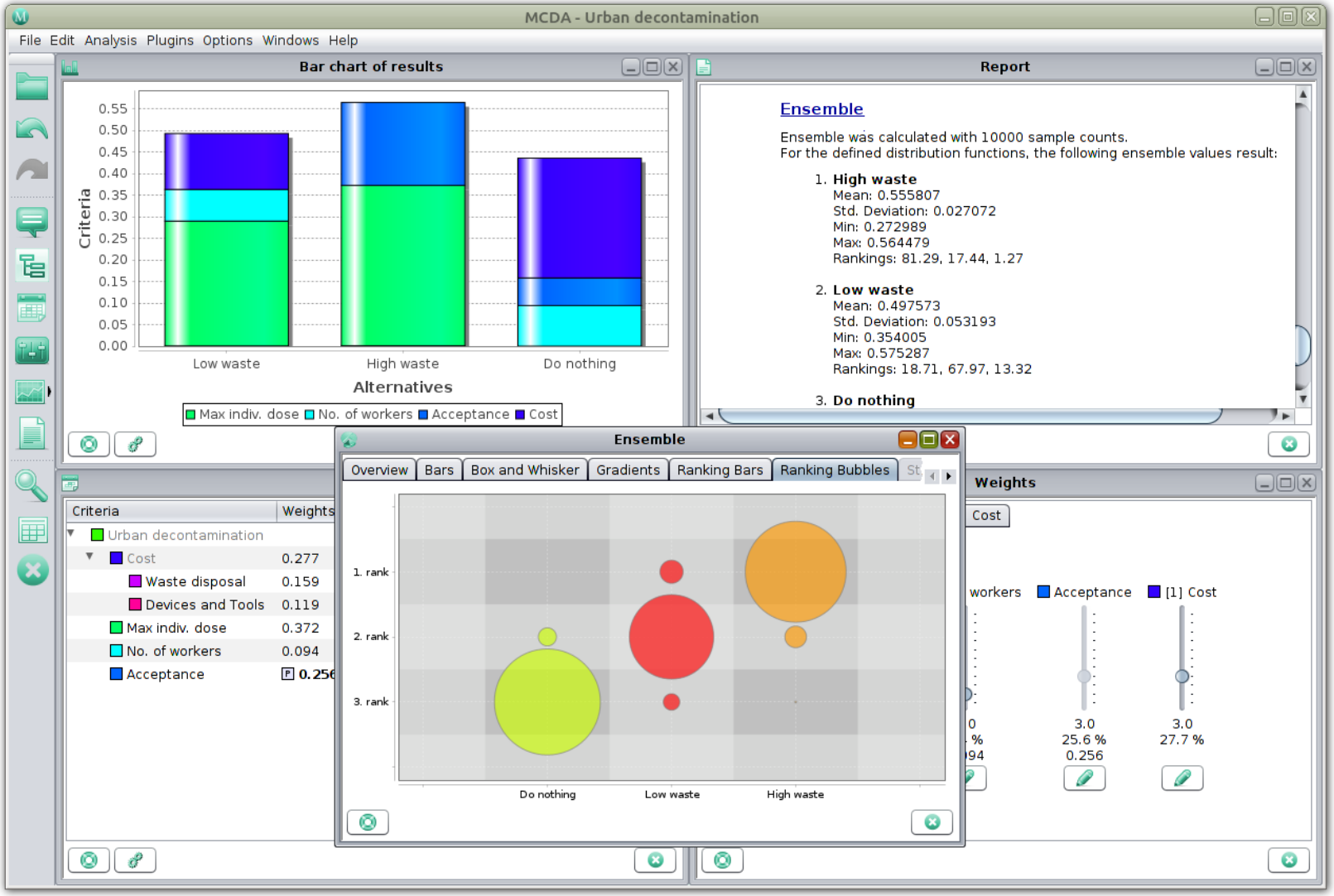
Visualising Uncertainties



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Summary of MCDA in CONFIDENCE

- The existing MCDA tool was enhanced to work with uncertainty in input parameters. Several means to define uncertainties as probabilities are implemented
- Ensemble evaluation has been implemented. Appropriate user interfaces were designed to control ensemble management
- Methods for visualizing the results of the ensemble evaluation results have been implemented
- The MCDA tool was and is presented in stakeholder workshops. Suggestions for improvement were taken into account (e.g. colour blindness). Evaluation is still going on.

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Next: evaluate the scenario with MCDA

- Split into groups
- Scenario outline, alternatives and (most) criteria are predefined
- Discuss some criteria and values
- Discuss and change preferences of criteria
- Evaluate and discuss the results in each group
- Compare and discuss results together
- Provide feedback
  - Usefulness
  - Usability
  - Suggestions and improvements, missing features, …

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Thank you for your attention

Questions?

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References

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- Jiang-Jiang Wang You-Yin Jing, Chun-Fa Zhang, Jun-HongZhao: Review on multi-criteria decision analysis aid in sustainable energy decision-making, 2009
- https://en.wikipedia.org/wiki/Multiple-criteria_decision_analysis
- https://en.wikipedia.org/wiki/Software_agent
- https://en.wikipedia.org/wiki/Multi-agent_system
- Agent image by Setyo Ari Wibowo from the Noun Project

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Objectives WP6

- **Task 6.1**: *Robust decision making (KIT lead, NMBU, NRPA, PHE, DTU, RIVM, SCK*CEN, UMIL, VUJE, UK Met Office, RIKILT)*
- This task will deal with formal **decision aiding tools such as MCDA** and how they can be adapted for **uncertainty handling and "robust" decision making** for radiological emergencies. **Indicators** will be developed to define a **"robust" solution** and introduced into the **MCDA** tool. Preferences collected within WP4 and WP5 will serve as inputs. To widen the information provided by stakeholder panels, an **agent based model (ABM)** will be developed with intelligent agents that allow **investigation of additional combinations of strategy and preference uncertainty**. Both the MCDA and ABM will be applied and tested in national and international stakeholder panels. The **role of ethics in decision making** will also be assessed based on input from WP4 and WP5.

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Objectives WP6

- **Task 6.2**: *Visualisation of uncertainties (Lead KIT, NMBU, NRPA, PHE, SCK*CEN, STUK, UMIL, VUJE, UK Met Office)*
- This task will investigate the appropriate means of **visualisation in terms of maps and graphs of uncertainties in model results** and information for **decision making when based on an MCDA tool**. In addition, **indicators** will be developed to **categorise results of simulation models** in decision support systems (JRodos will be used as example) **as appropriate, or not, for decision making** in an evolving exposure situation. For instance, dose assessments based on source term estimations in the very early phase are very uncertain but they become more reliable after days/weeks. **Workshops with decision makers will be used for testing the newly-developed approaches**.

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Deliverables

- D6.1 Indicators for robust decision making (M16; KIT)
- D6.2 Improved MCDA tool for decision making under uncertainty for panels (M18; KIT)
- D6.3 ABM tool with artificial intelligence to compare decision strategies for panels (M24; KIT)
- D6.4 Report from stakeholder panels and workshops related to the application of the methods and tools developed in WP6 (M35; NRPA)
- D6.5 Visualisation approaches developed and tested in workshops and panels (M35; KIT)

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