Application of Tools MCDA and ABM on the scenario-based workshop results

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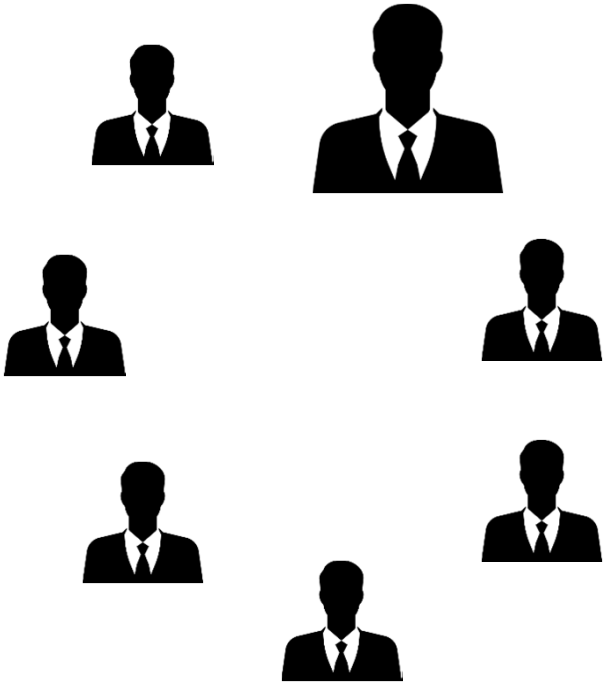
CONFIDENCE Workshop Trnava, May 2019

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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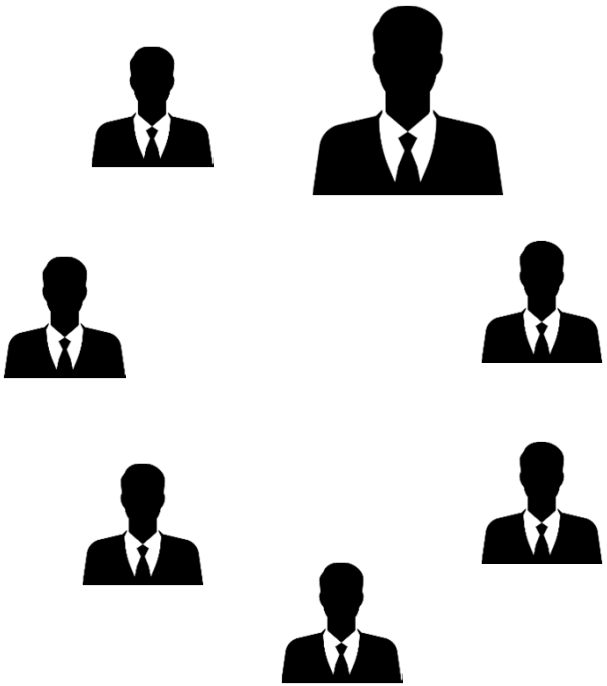

Simplified example

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

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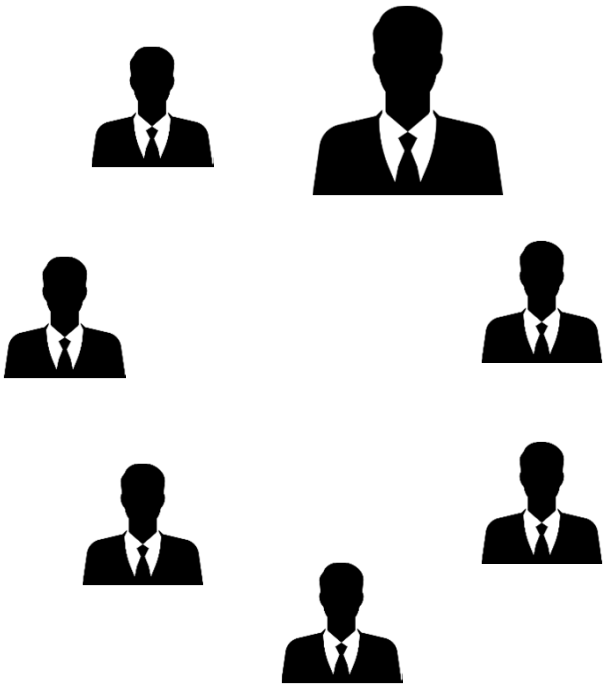

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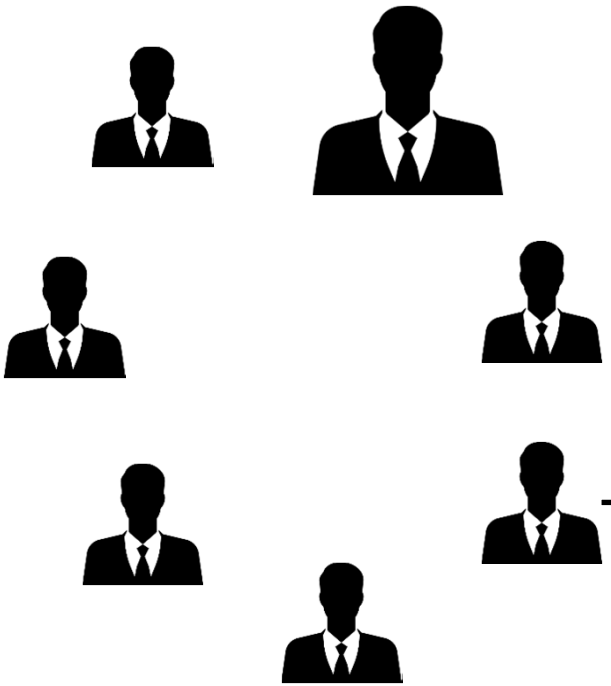

unimportant

important

important

Simplified example

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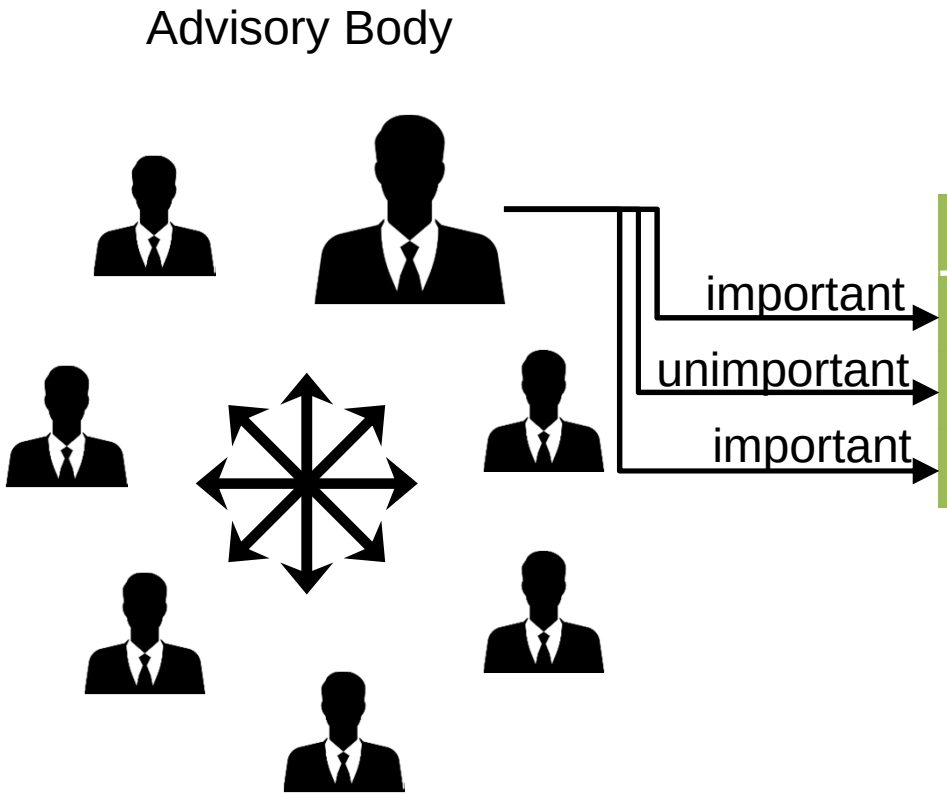

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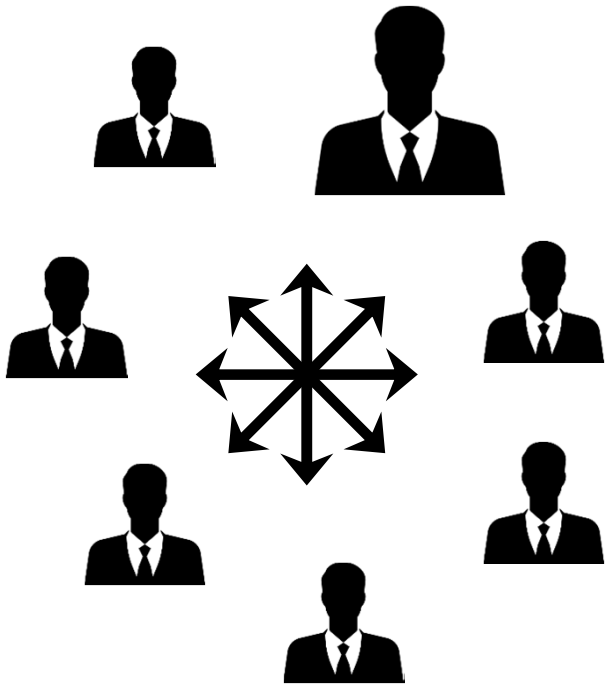

Simplified example

		Sheltering	Evacuation
important	Cost	0.1 M€	10 M€
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⇨ 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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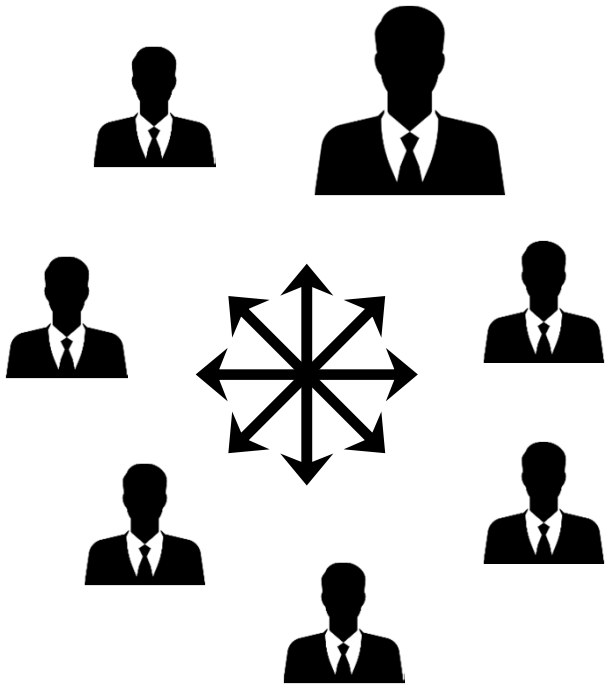
Introduction

ABM

Advisory Body



MCDA

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Motivation and Goal

- In a given scenario and depending on different parameters the “optimal” decision is rarely (or never?) made
- Understand the decision making process
  - What impact do the variations have?
  - What factors may cause variations?
  - Can these factors be influenced, even minimized?
  - How stable is the decision making process?
- Model the decision making process for analysis
  - Evaluate borderline (virtual) scenarios
  - Provide feedback and advice to the decision makers, advisory body, authorities, …

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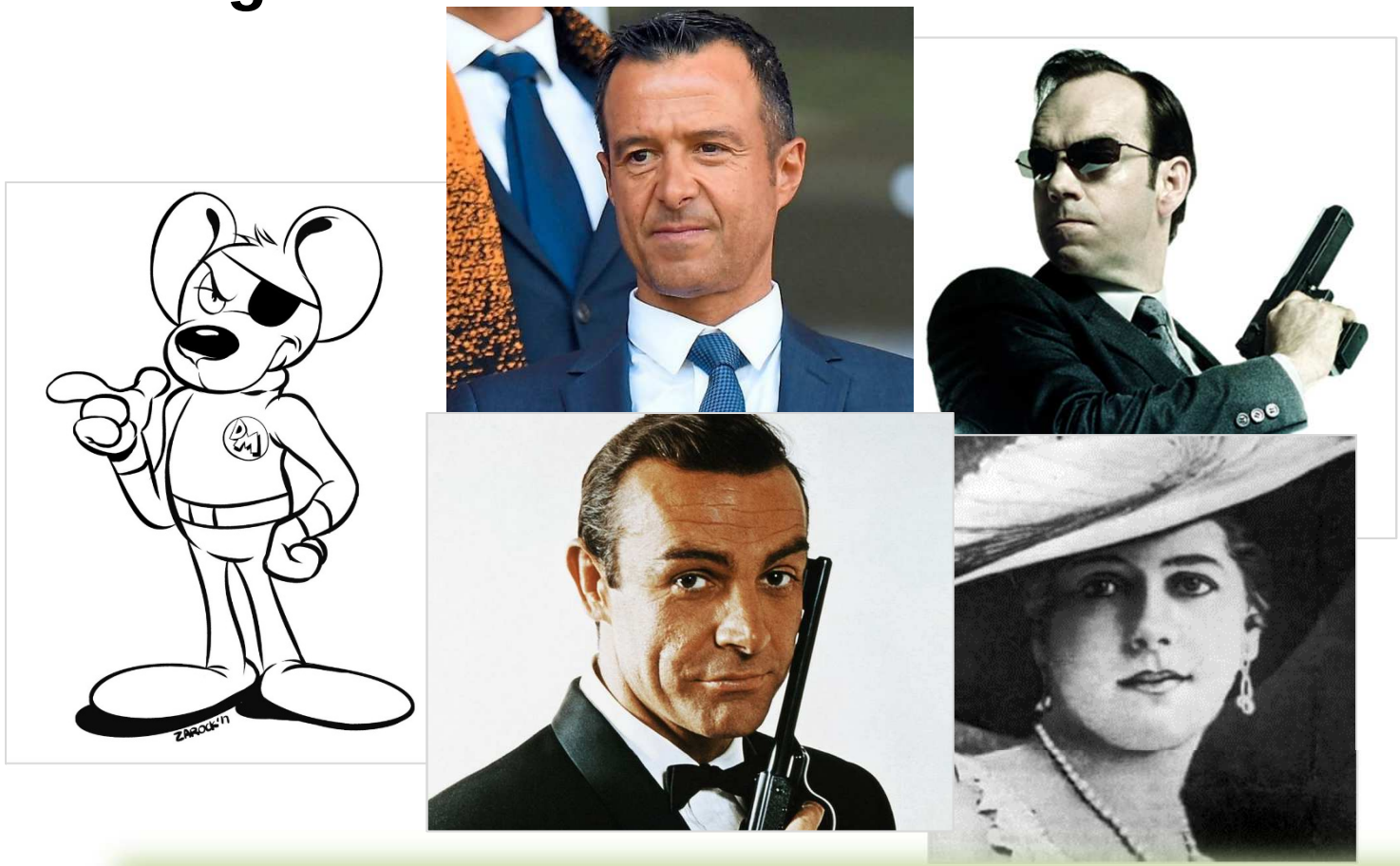
Some Agents…



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

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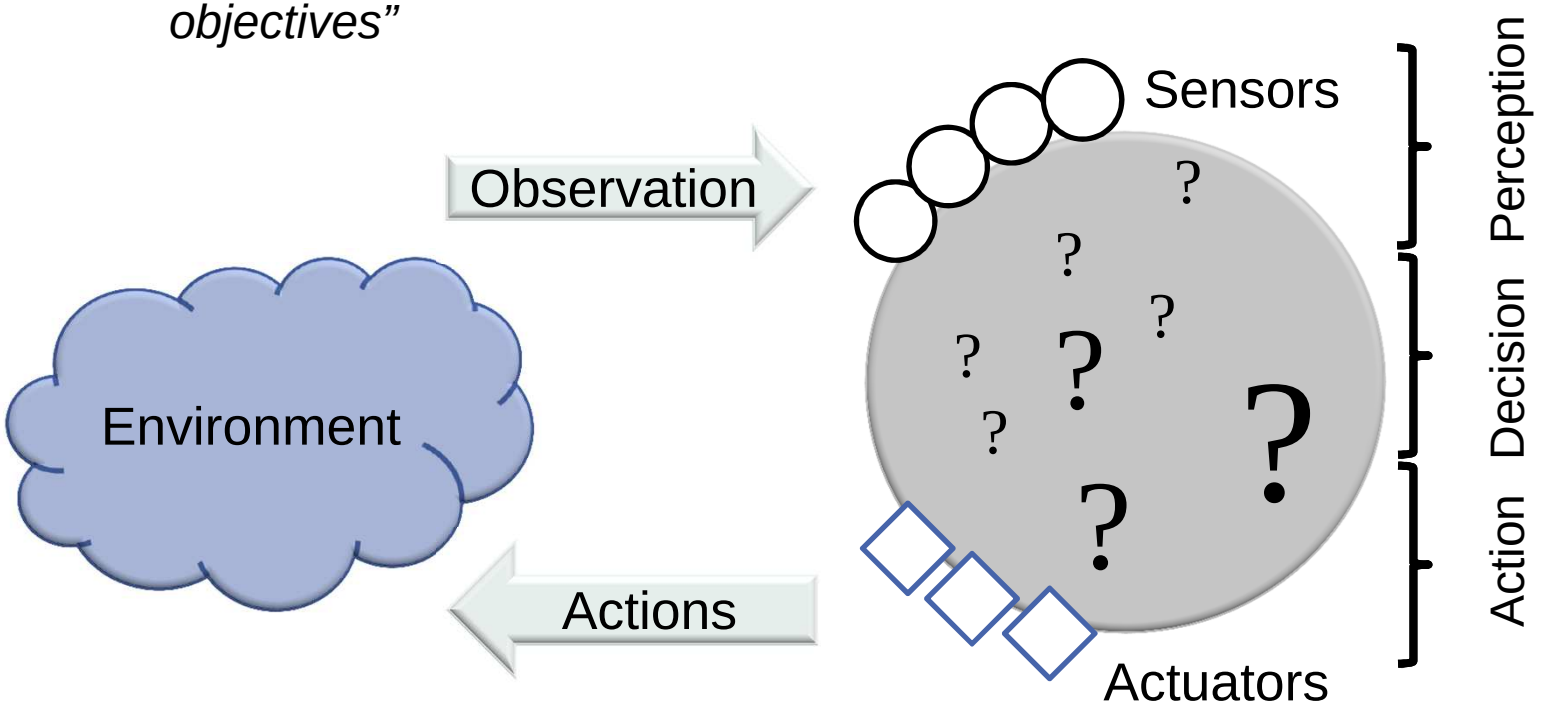
A Software Agent

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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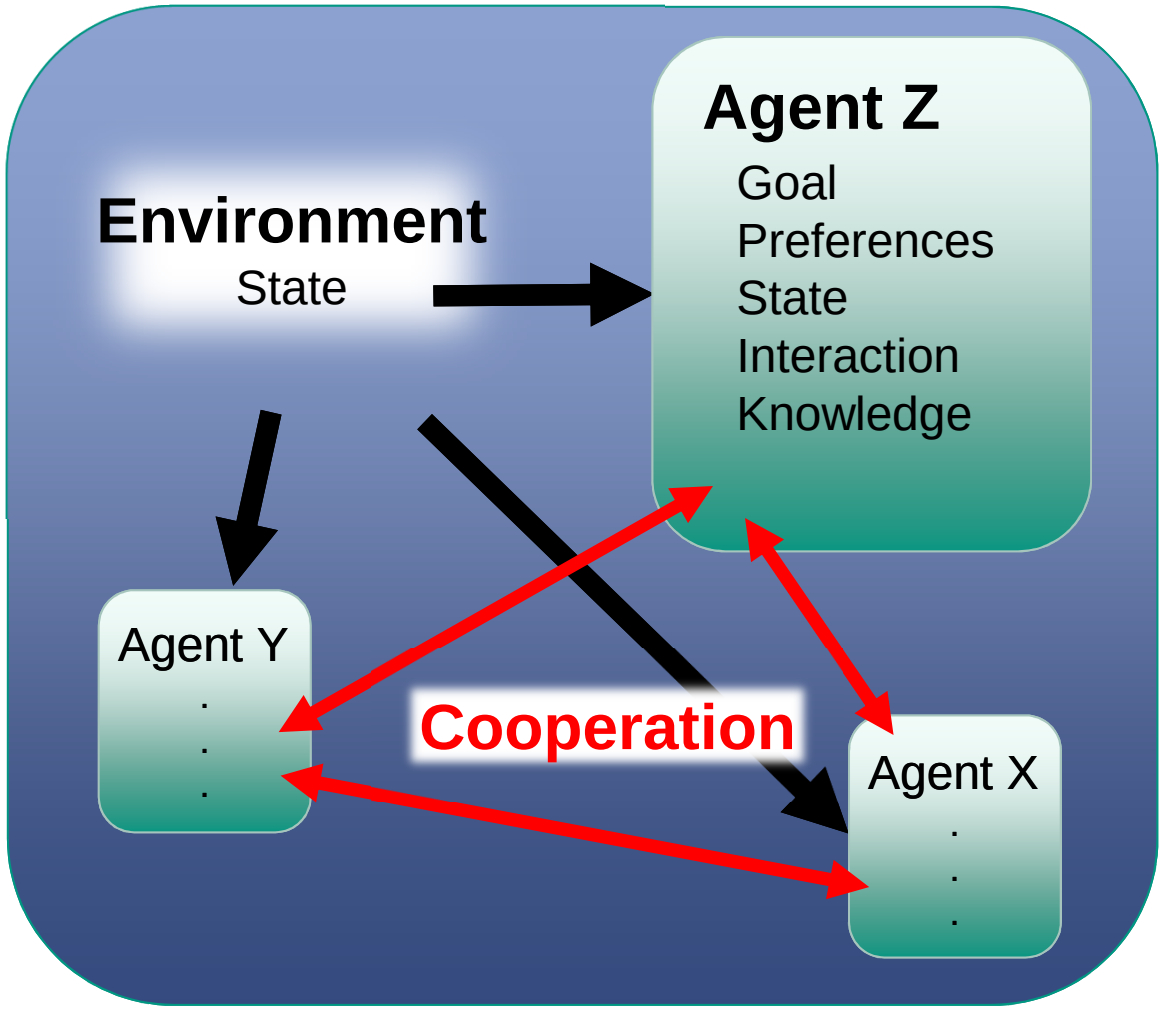
Agent Based Modelling (ABM)



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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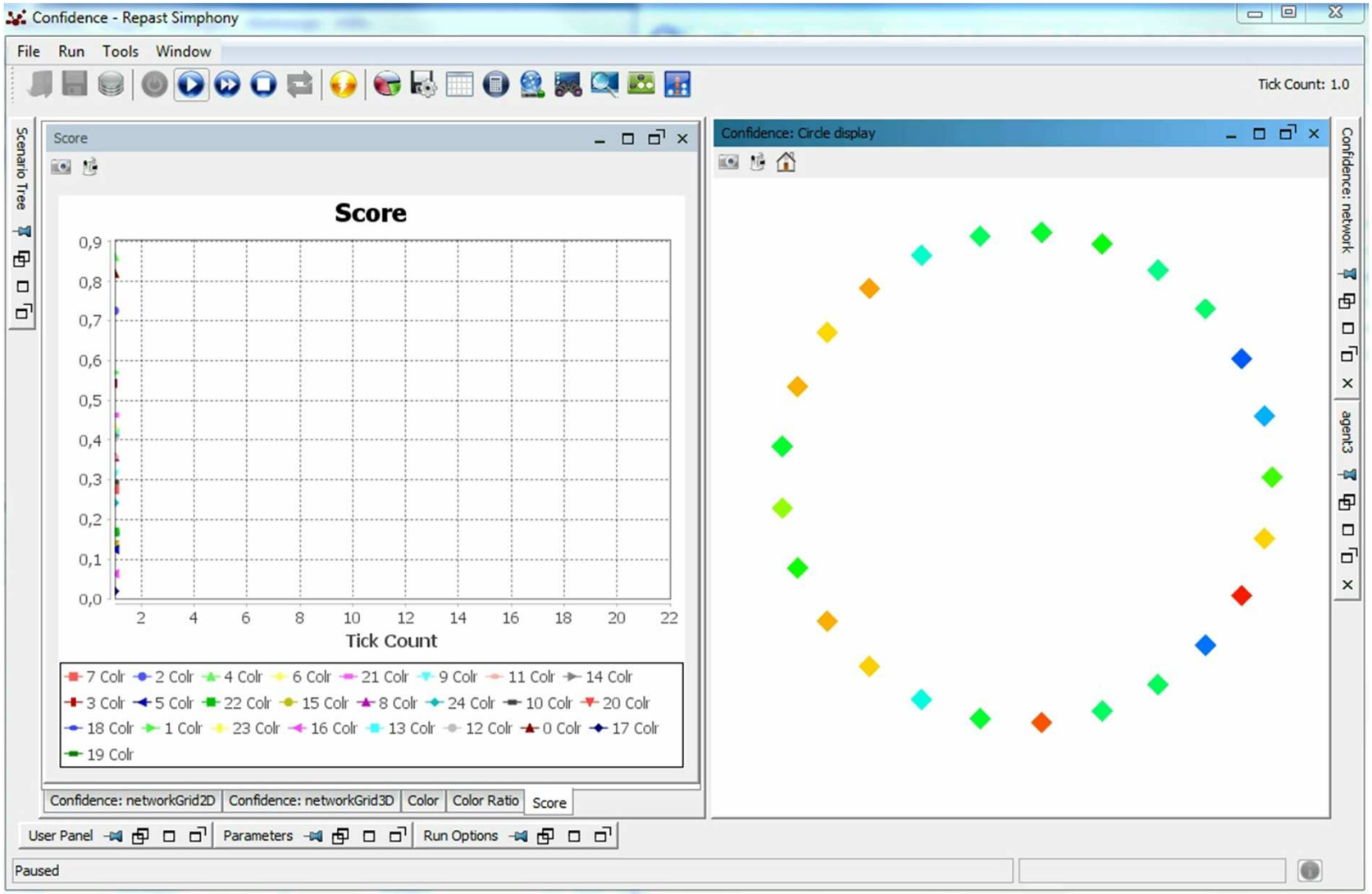
Visualization of Negotiation of a Strategy



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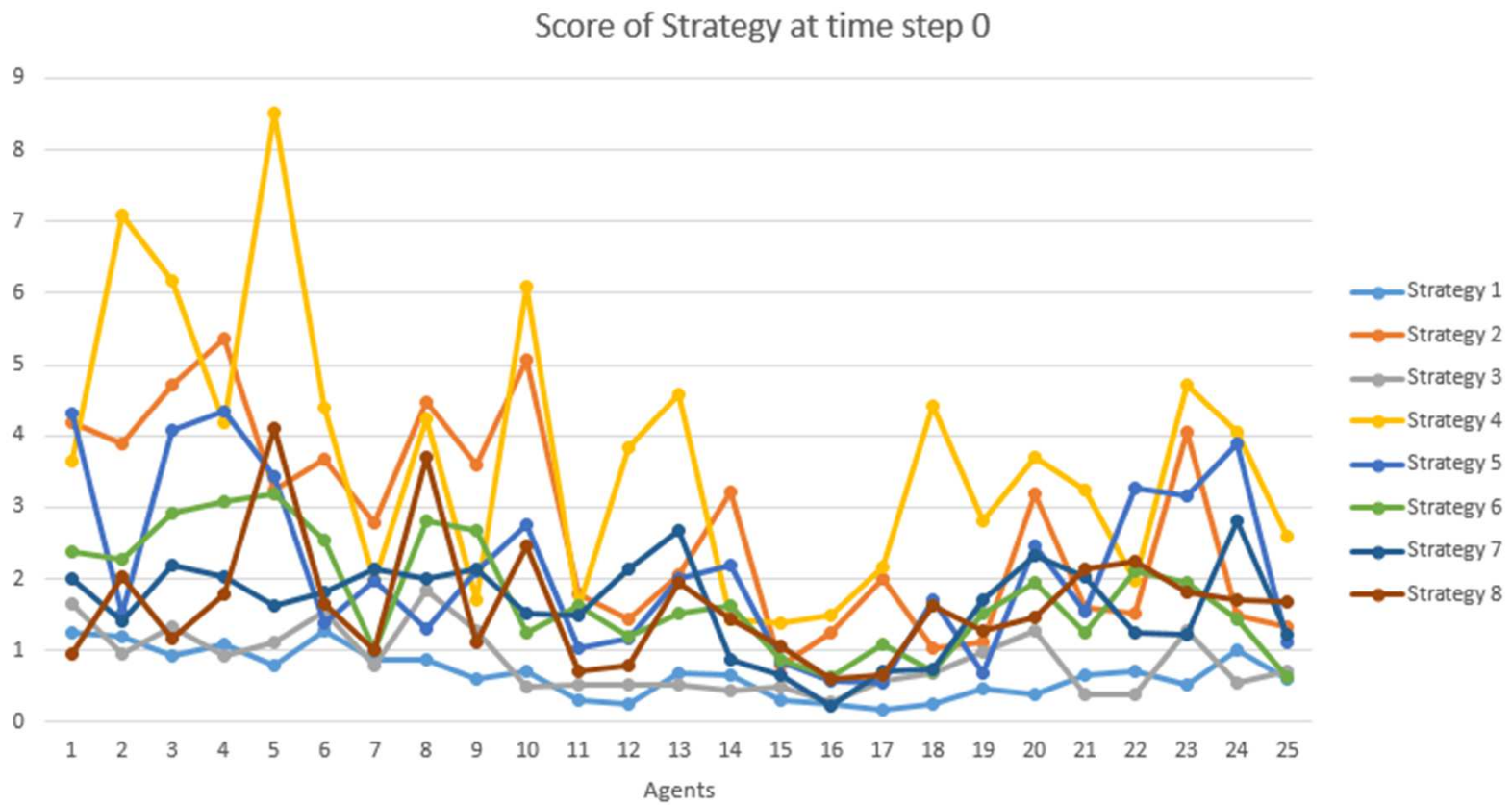
Visualization Test of Negotiation Process



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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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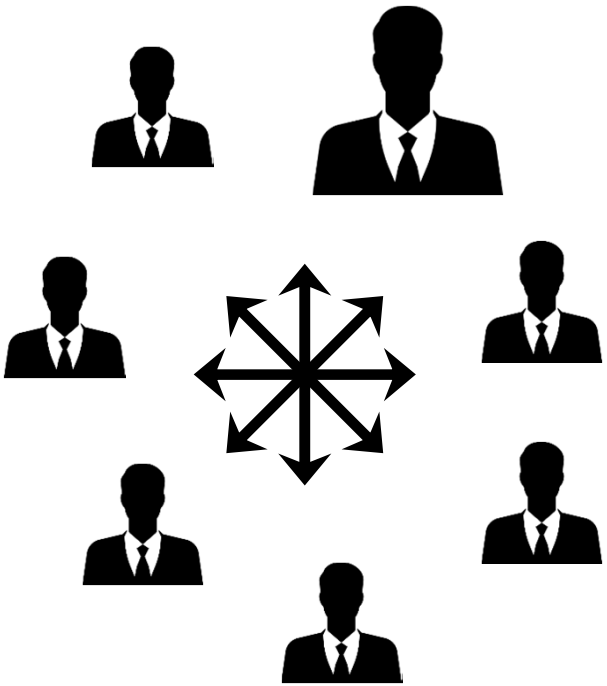
Introduction to MCDA

ABM

Advisory Body



MCDA

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Simplified example

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How MCDA works

a_{ij} Value of Criterion j for Alternative i

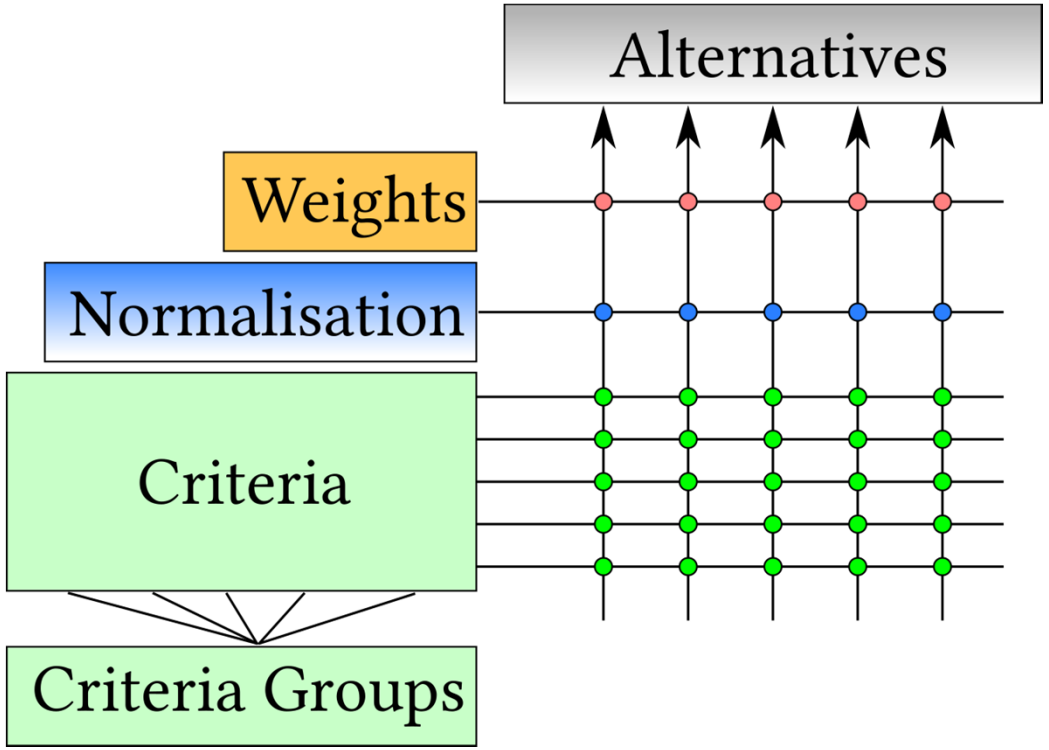
$N_j(\ldots)$ Normalisation of Criterion j

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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How MCDA works

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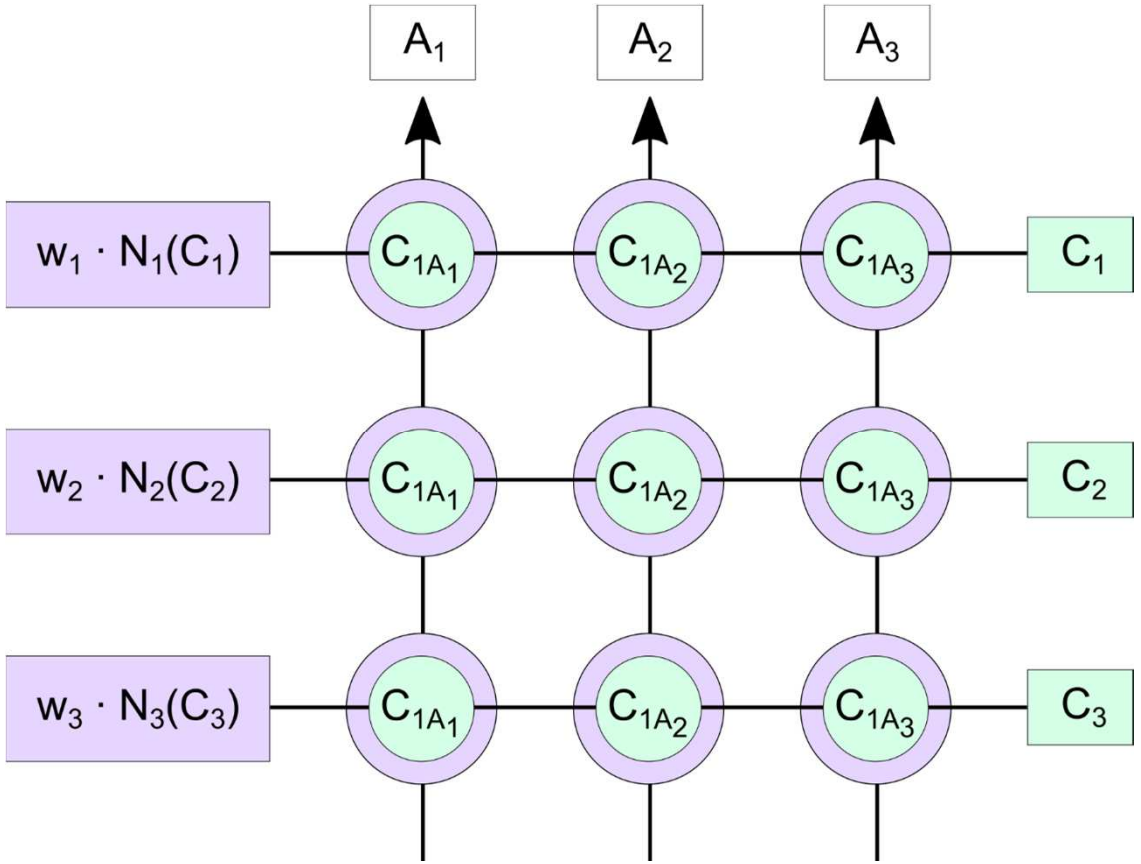

Implemented as MCDA tool with graphical user interface

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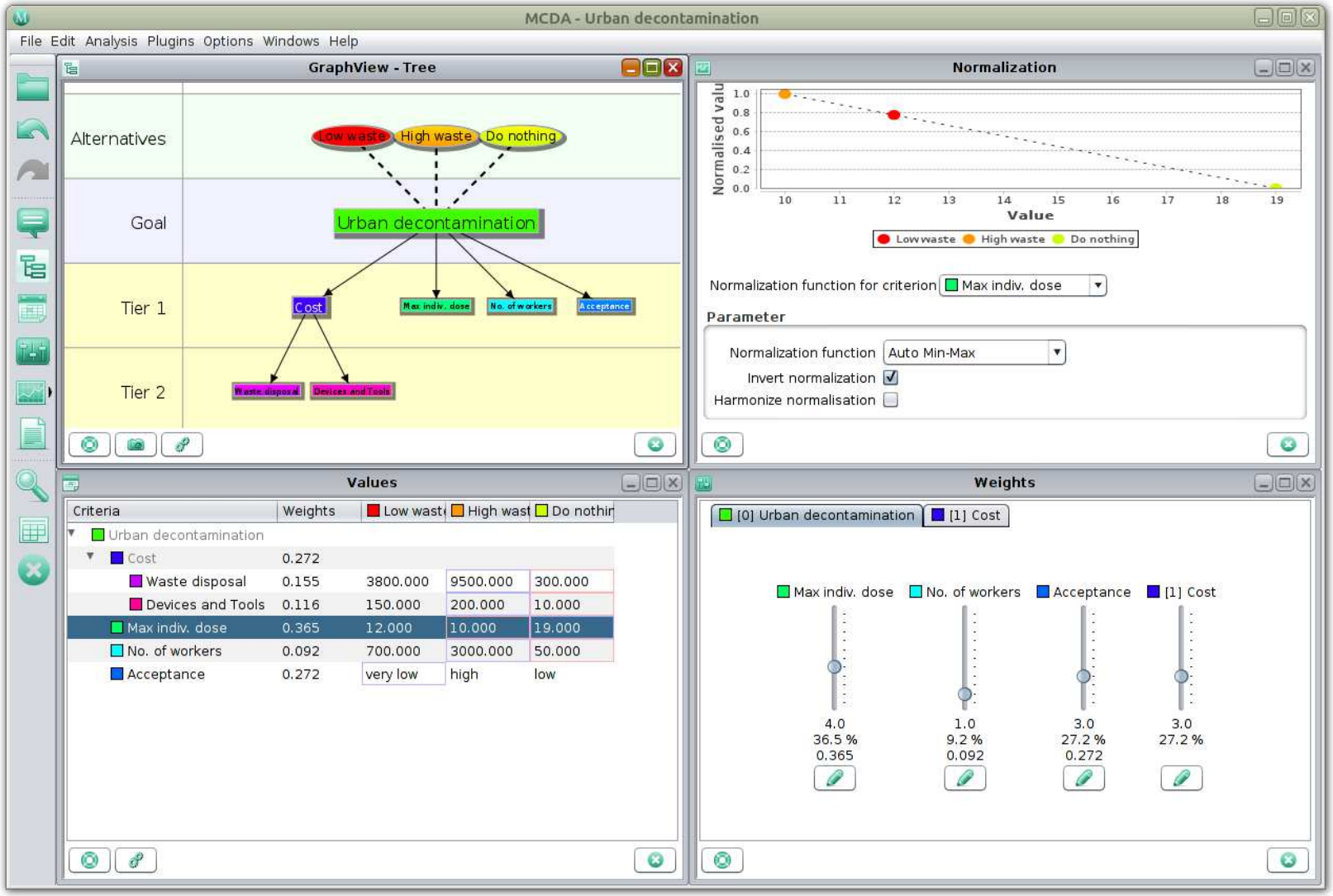
The MCDA Tool



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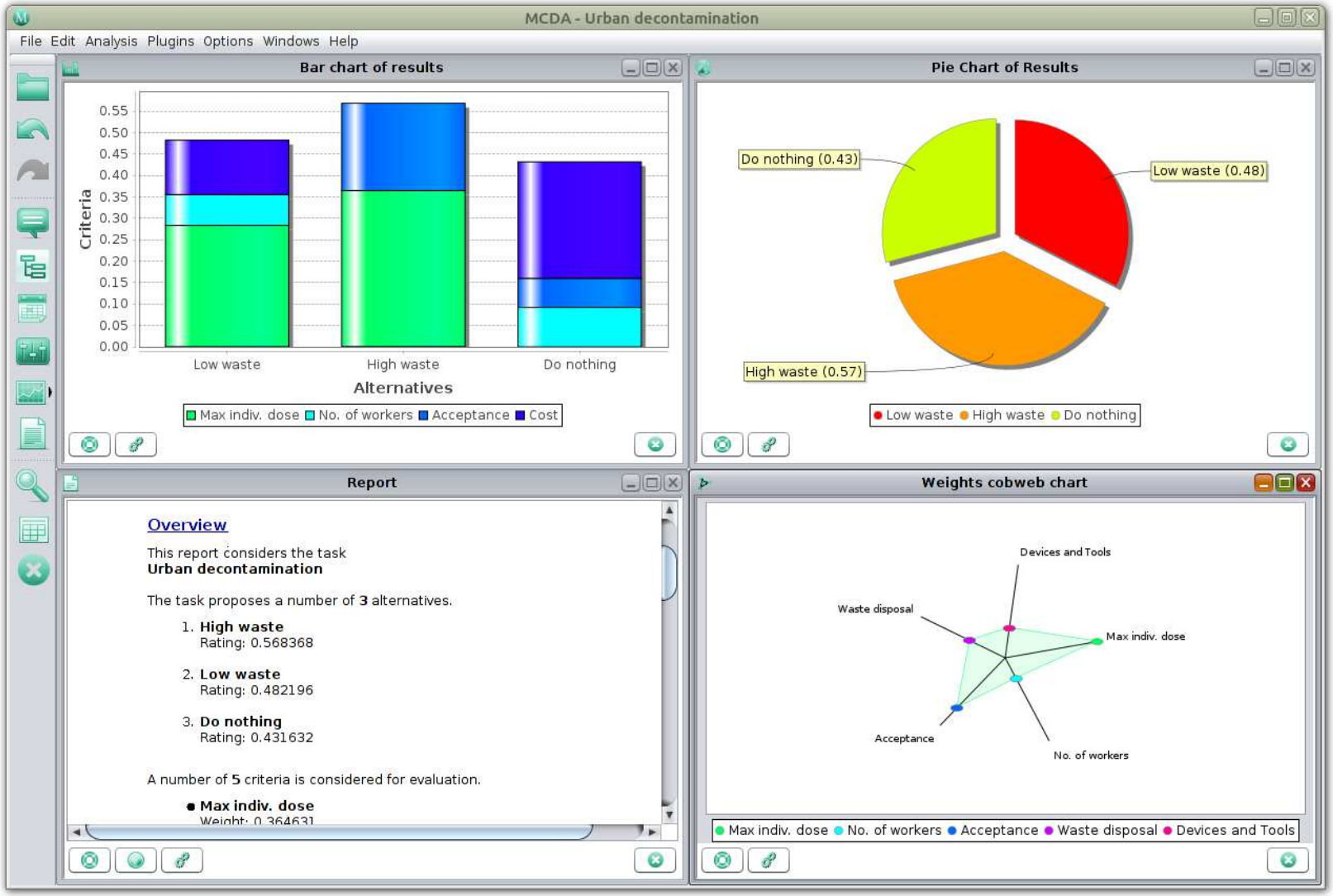
Visualisation of Results



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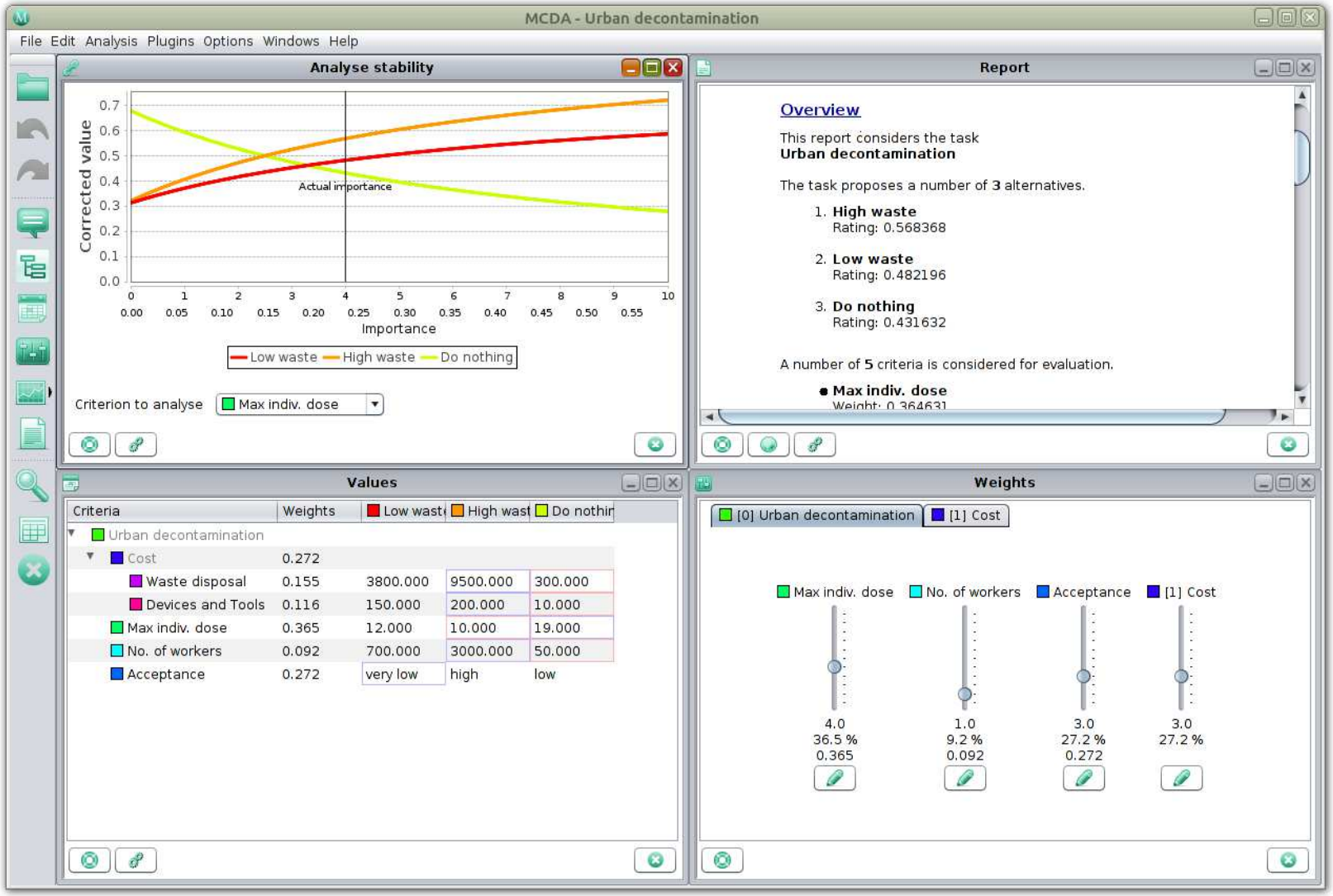
Robustness and Stability



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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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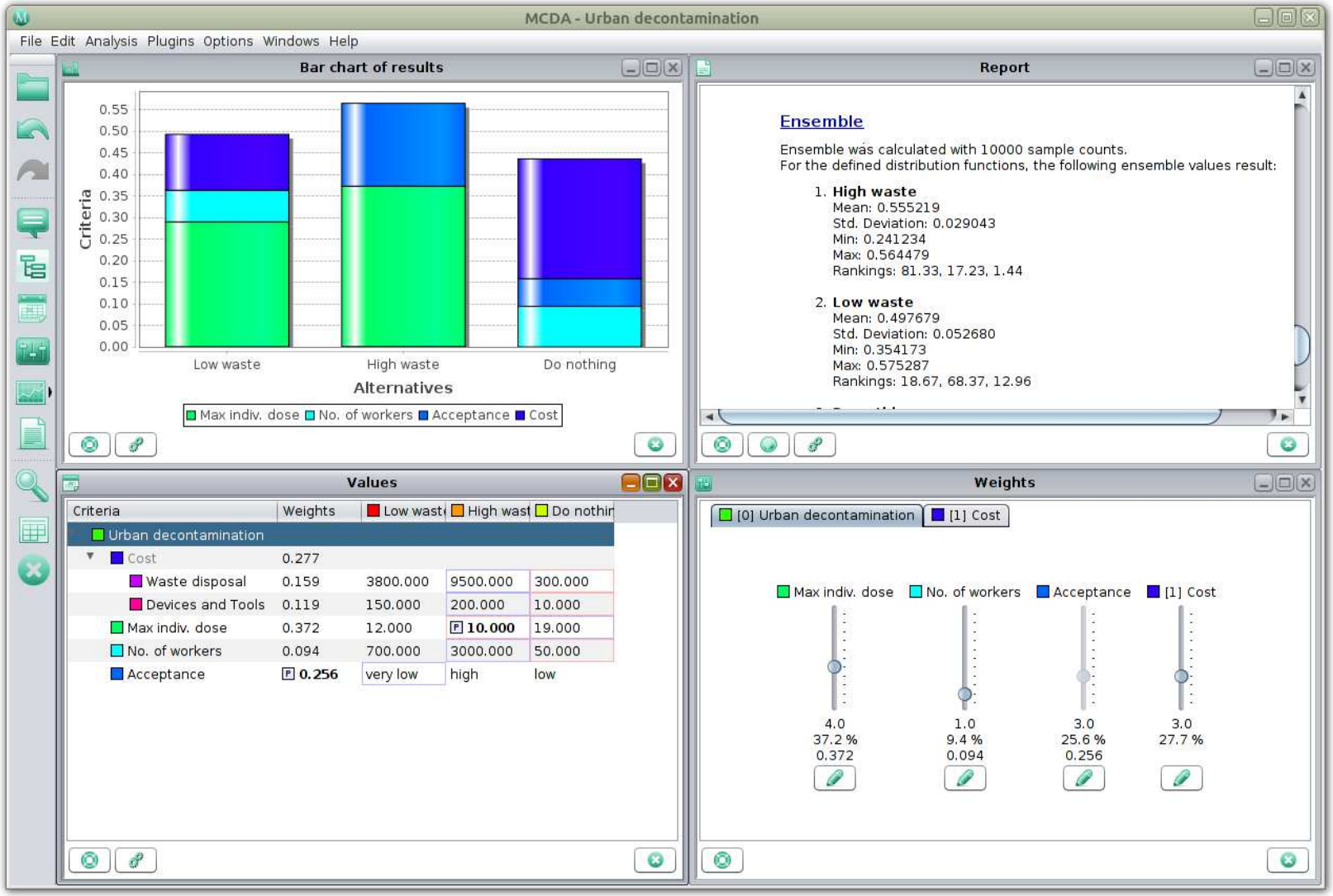
Defining Uncertainties



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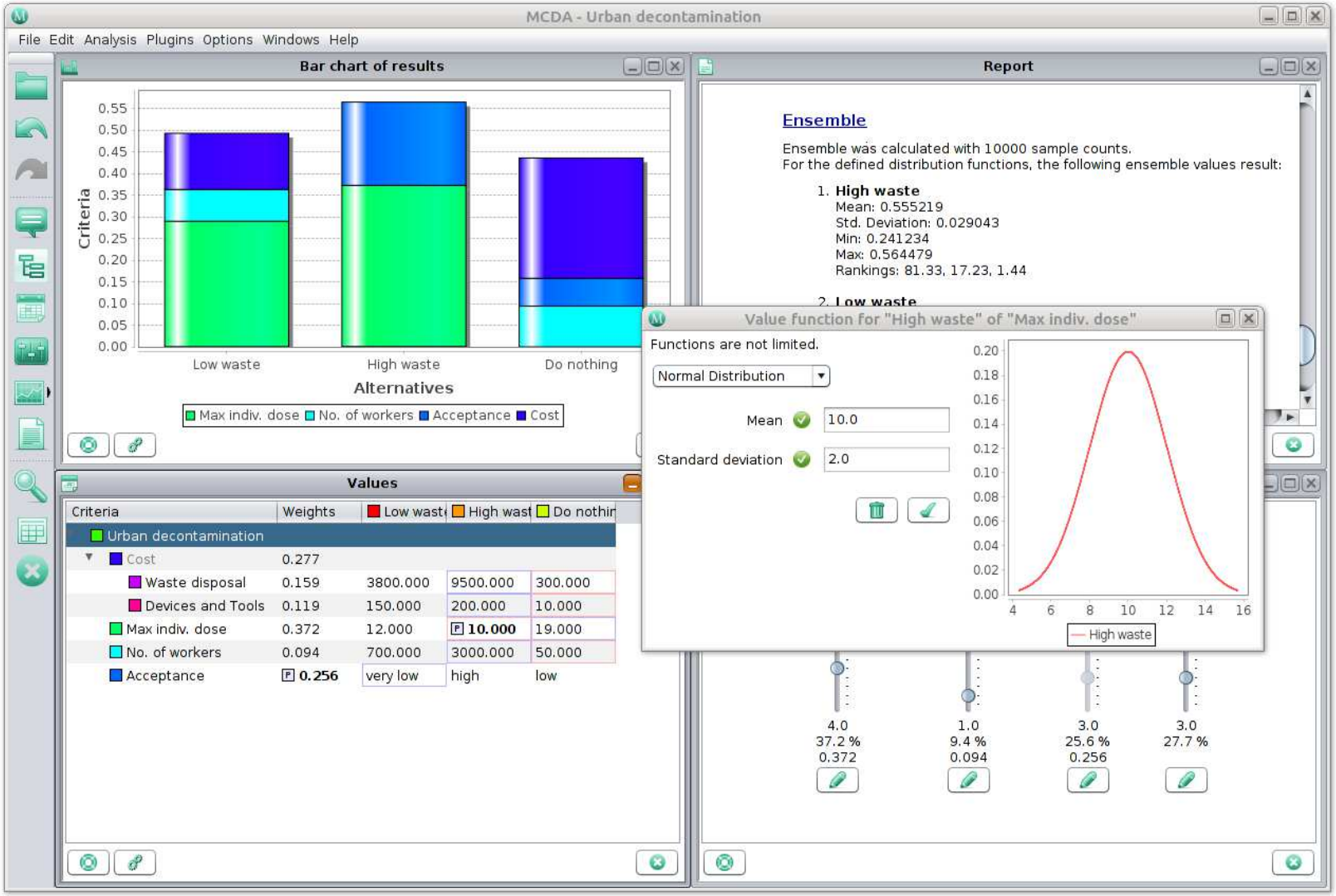

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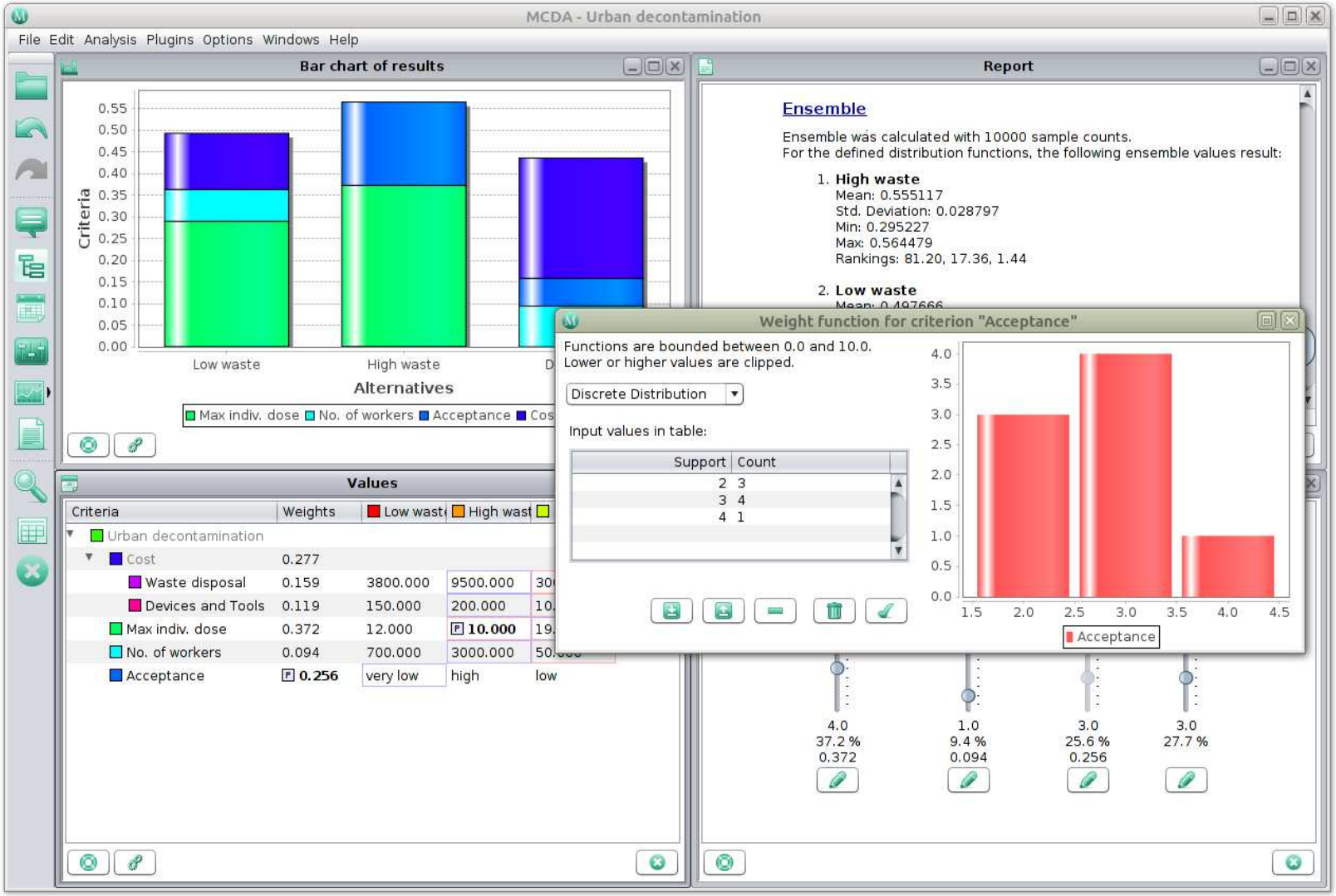

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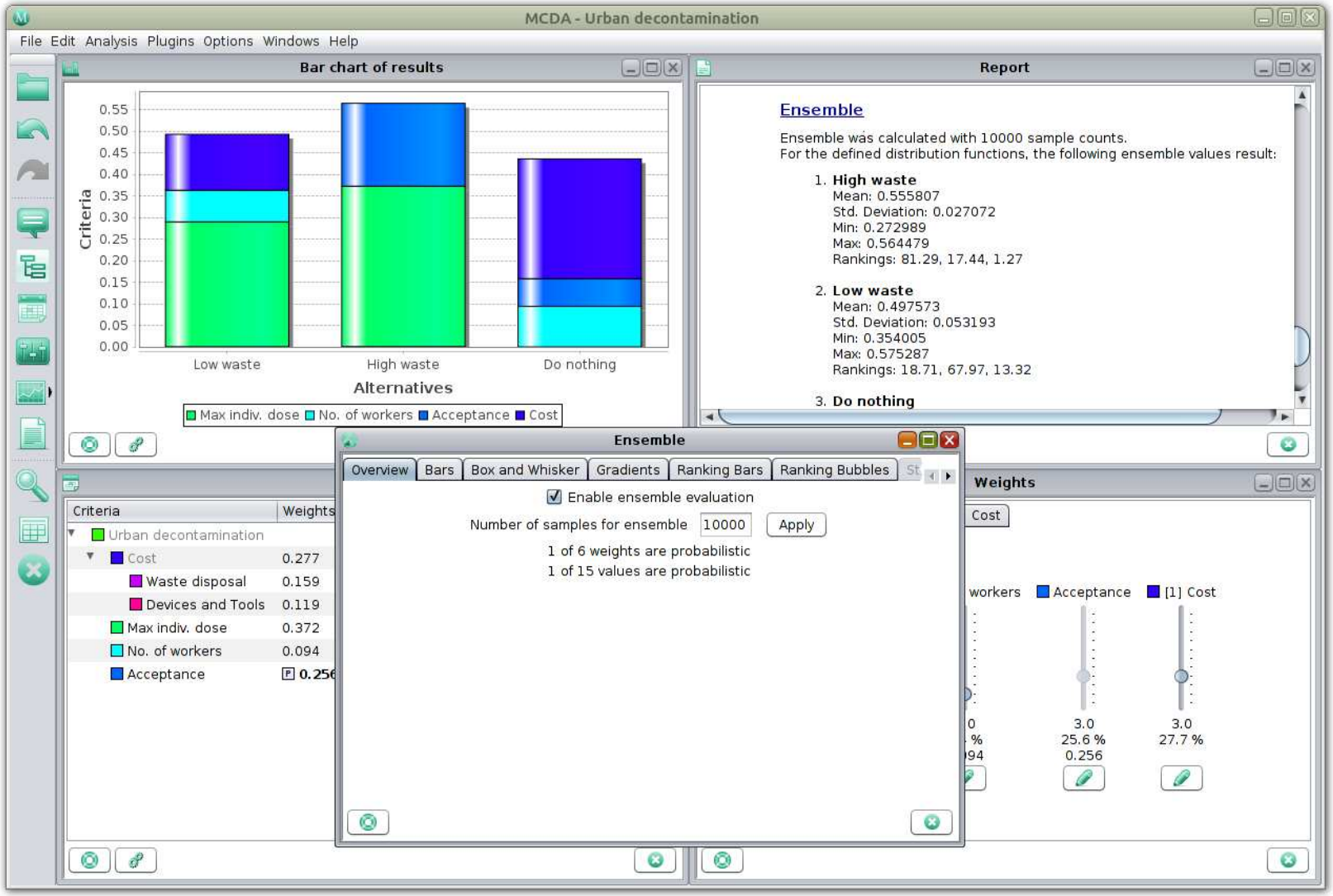
Evaluating Uncertainties



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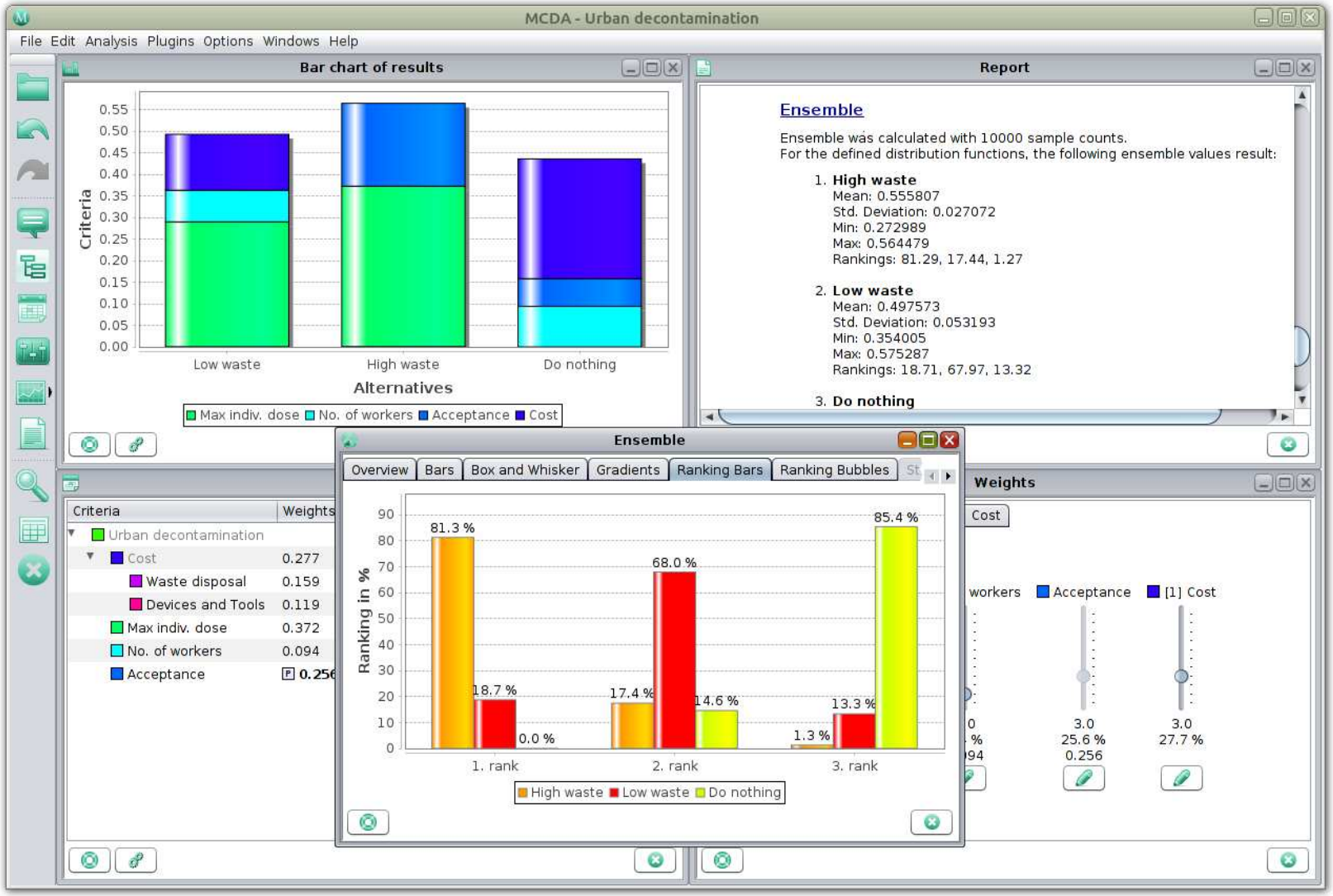
Visualising Uncertainties



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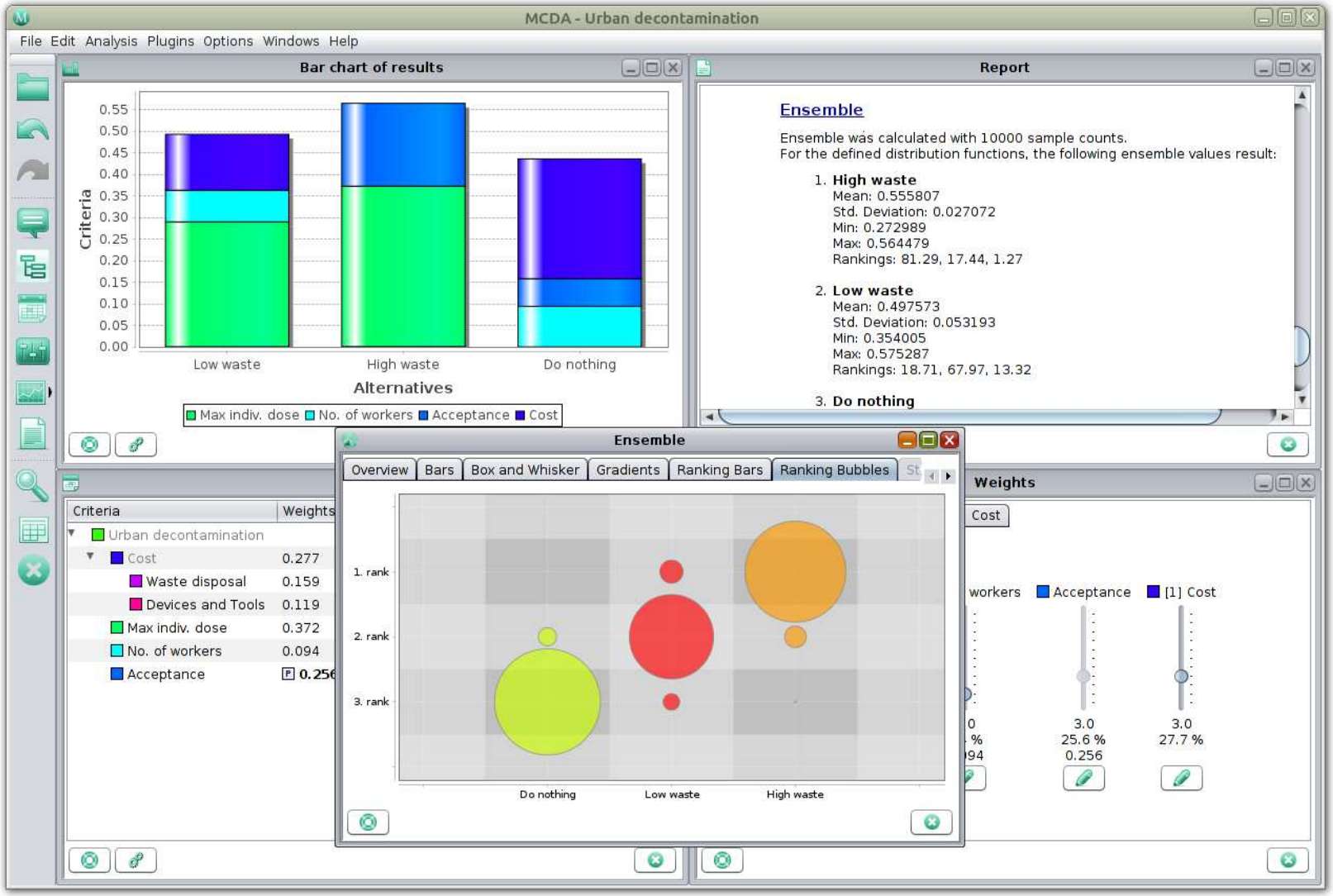
Visualising Uncertainties



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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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- Jiang-Jiang Wang You-Yin Jing, Chun-Fa Zhang, Jun-HongZhao: Review on multi-criteria decision analysis aid in sustainable energy decision-making, 2009
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- 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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