Karlsruhe Institute of Technology

How can existing MCDA software support sustainability assessment?

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Agenda

Motivation

Objective

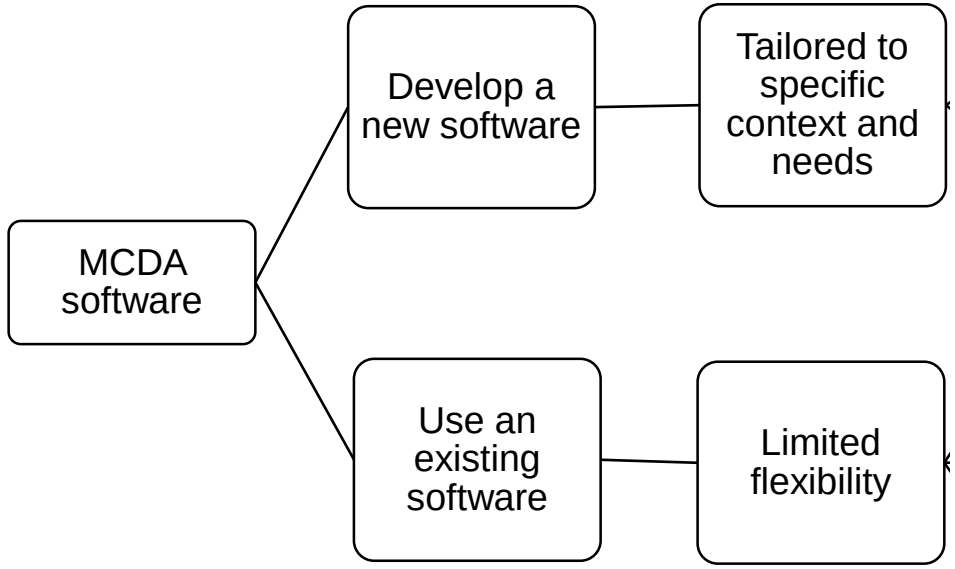
Methodology

Results

Motivation

Sustainability is a complex decision making problem

- Multiple conflicting criteria
- Complex relations
- Many social and political interests
- High level of uncertainty
- Many different decision makers and stakeholders



Operationalization of sustainability assessment using MCDA methods.

Motivation

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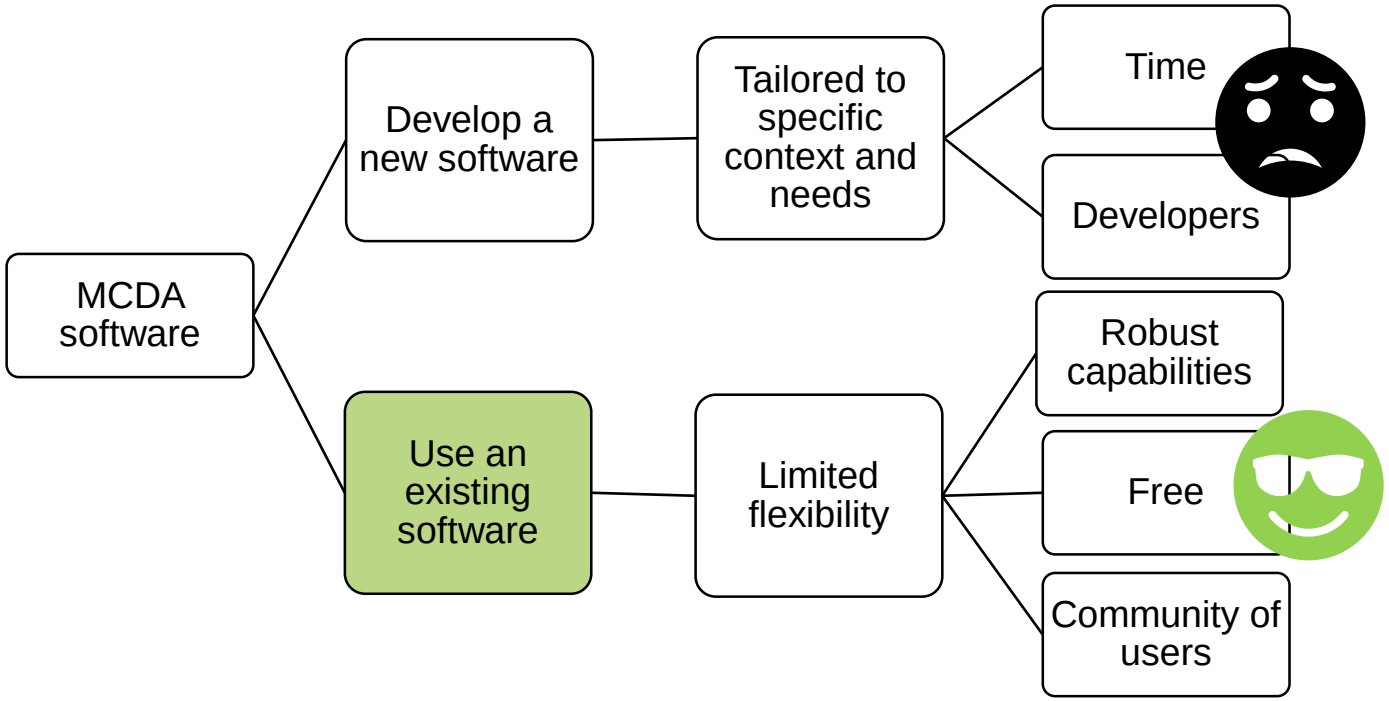


Operationalization of sustainability assessment using MCDA methods.

Which software would be the best choice?

Objective

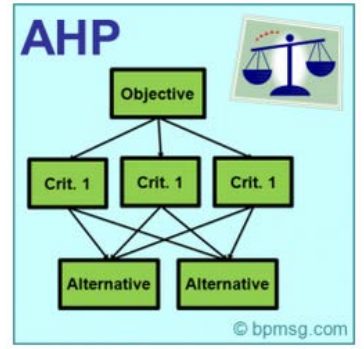
- Identify MCDA software strengths and weaknesses for applications in sustainability assessment (SA).

MCDA-ULaval

Decision radar

SilverDecisions

AHP



DecSpace

ENTSCHEIDUNGSNAVI

PROMETHEE Cloud

A web-based multi-criteria analysis tool.

RuLeStudio

FITradeoff

MCDA

Multi Criteria Decision Analysis

MCDA Calculator

LOGICAL DECISIONS

software for more effective decisions

ValueDecisions

DEX Software

SOCRATES

SOcial Multi-CRiteria AssessmenT of European PolicieS

Methodology

- What are our needs (criteria)?
- What are the options?

A. Applications of MCDA in SA using a software

B. MCDA methods capabilities for SA

C. Free MCDA software

Methodology

	A. Applications of MCDA in SA using a software	B. MCDA methods capabilities for SA	
Stage 1: Development of criteria to assess MCDA-software	**Literature review** Screening/ sorting and grouping of motivations	**MCDA methods capabilities for SA** Screening criteria from selected literature	**Overlap and eligibility analysis** Definition of criteria and domains
Stage 2: Selection of MCDA software sample	Identification and characterization of **MCDA software**	Eligibility of **MCDA software**	C. Free MCDA software
Stage 3: Assessment and recommendations	Assessment of selected MCDA software	Recommendations: road map	

Methodology

Stage 1: Development of criteria to assess MCDA-software	**Literature review** Screening/ sorting and grouping of **motivations**	**MCDA methods capabilities for SA** Screening criteria from selected literature	**Overlap and eligibility analysis** Definition of criteria and domains

	Motivations	Articles	Year	No.	Groups	Frequency (motivations/ group)
1	it was possible to evaluate the performance of criteria/sub-criteria using a range of analytical methods	Iacovidou E., Voulvoulis N.	2018	1	Assessment of alternatives per criterion (performances)	2
2	With the purpose of simplification of the assessment in the initial phase of planning that the tool is designed for, input values between **minima and maxima are determined by linear interpolation, accepting inaccuracies in the scale of values**, at least for some of the criteria proposed.	Wencki K., Thane V., Becker D., Kramer K., Sattig I., Lischeid G., Zimmermann M.	2020			
3	web platform available for stakeholders to introduce the characteristics of the project (share and communicate results)	Riera Perez M.G., Rey E.	2013	2	Communication of results (stakeholders)	1

85
articles

219
statements related to **motivations** for use of software

48
groups of **motivations**

Methodology

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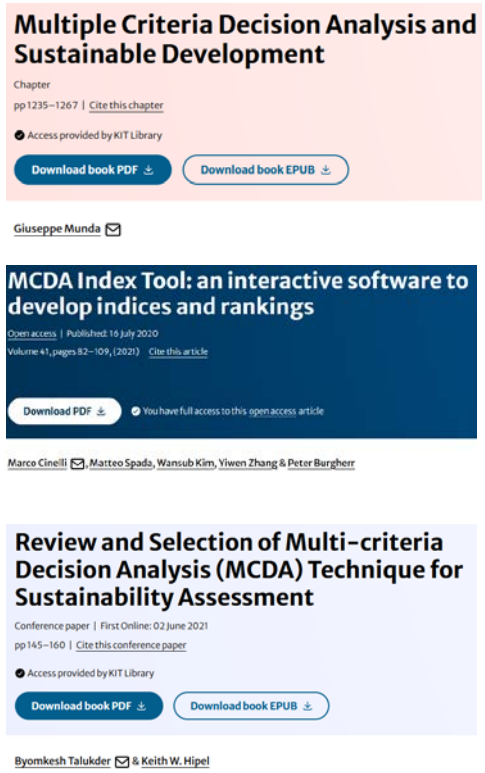
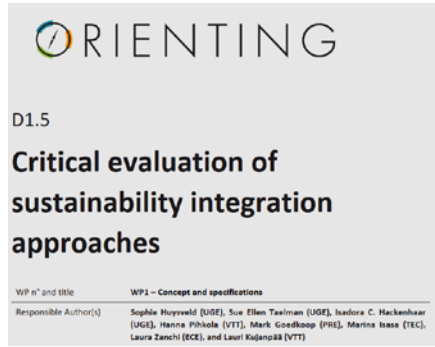
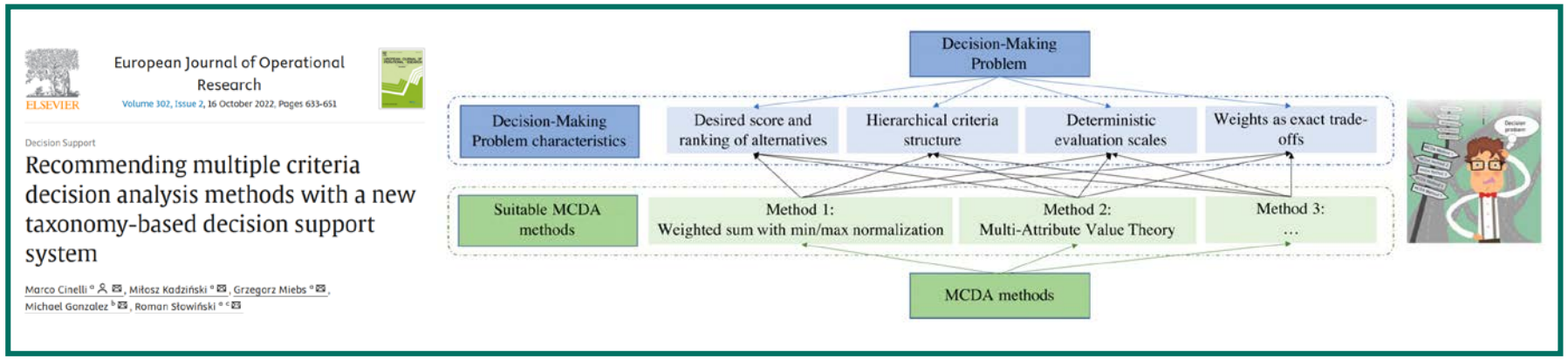






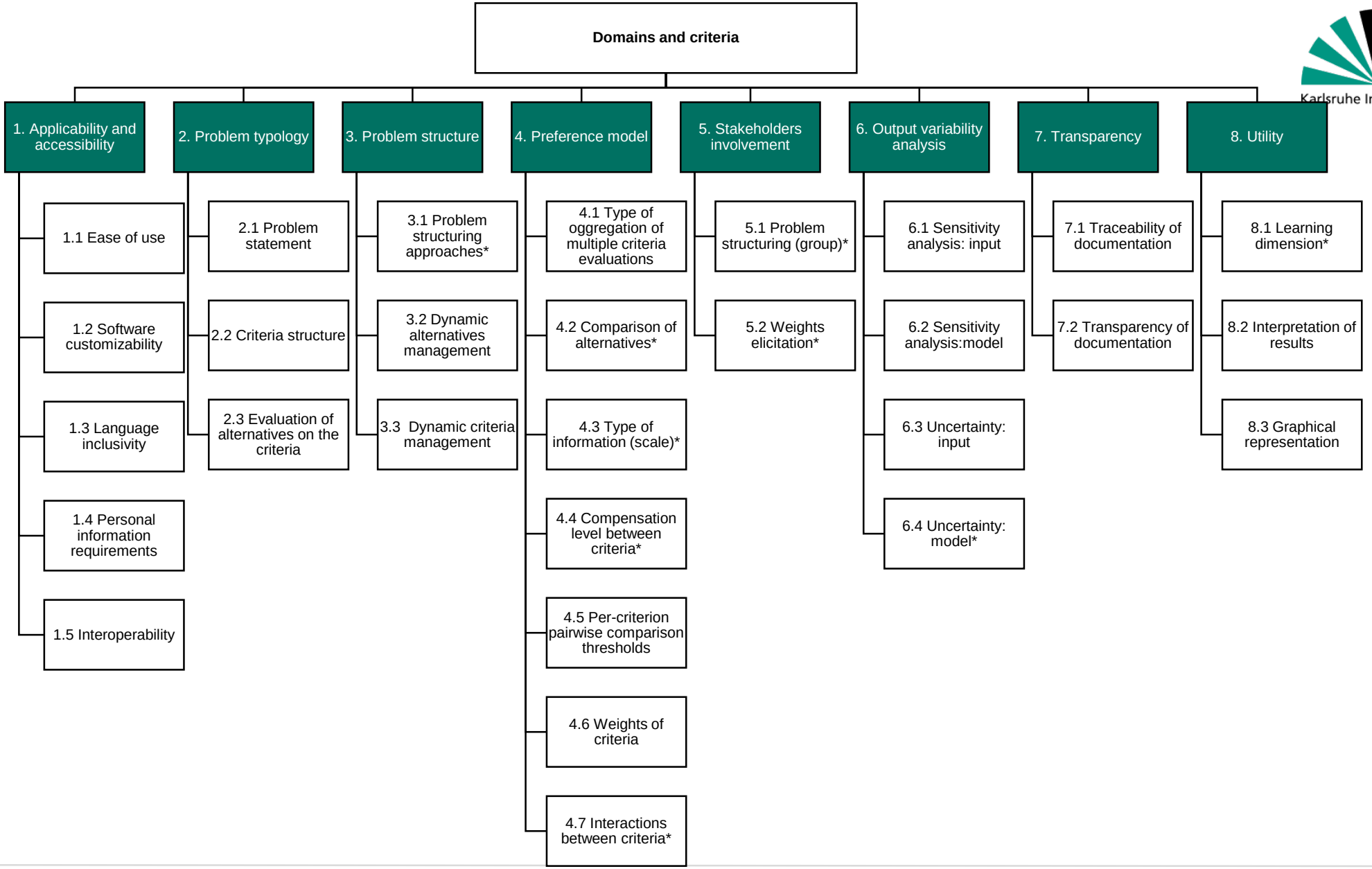
Methodology

Stage 1: Development of criteria to assess MCDA-software	Literature review Screening/ sorting and grouping of **motivations**	MCDA methods capabilities for SA Screening **criteria** from selected literature	Overlap and eligibility analysis Definition of criteria and domains

8
domains

29
criteria

Domain	Criteria	Description	Strong (S)	Moderate (M)	Weak (W)
1. Applicability and accessibility	**1.1 Ease of use**	Degree of MCDA knowledge required to use the software.	The help system is integrated as Contextual Help: This type of help provides information relevant to the task or feature the user is currently using.	Help systems are integrated into the software's user interface (UI). They can be accessed through menus, buttons, or shortcuts within the software.	Help systems are NOT integrated into the software's user interface (UI). They can be accessed through menus, buttons, or shortcuts within the software.
	1.2 Software customizability	Type of permissions given to the user of the software, i.e. view, modify, and distribute.	free-software licence: The source code is freely available to the public	Options for extending the software are available e.g. creation of plug-ins	Non-free software licence: no options available for extending/ customizing software capabilities
	1.3 Language inclusivity	Capability to support several languages	Multilingual support (including English)	**Only** English	Only other language (no English included)
	1.4 Personal information requirements	Type of personal data required to get access to the software.	Software is free and publicly available online without restrictions	Software is free and publicly available online with registration for full functionality	Software not available online
	1.5 Interoperability	Ability of the software to exchange infromation with e.g. external libraries, frameworks, or data sources.	Import **AND** export formats available including Excel	Only import **OR** only export formats	Not possible


Domains and criteria
1. Applicability and accessibility
1.1 Ease of use
1.2 Software customizability
1.3 Language inclusivity
1.4 Personal information requirements
1.5 Interoperability
2. Problem typology
2.1 Problem statement
2.2 Criteria structure
2.3 Evaluation of alternatives on the criteria
3. Problem structure
3.1 Problem structuring approaches*
3.2 Dynamic alternatives management
3.3 Dynamic criteria management
4. Preference model
4.1 Type of oggregation of multiple criteria evaluations
4.2 Comparison of alternatives*
4.3 Type of information (scale)*
4.4 Compensation level between criteria*
4.5 Per-criterion pairwise comparison thresholds
4.6 Weights of criteria
4.7 Interactions between criteria*
5. Stakeholders involvement
5.1 Problem structuring (group)*
5.2 Weights elicitation*
6. Output variability analysis
6.1 Sensitivity analysis: input
6.2 Sensitivity analysis:model
6.3 Uncertainty: input
6.4 Uncertainty: model*
7. Transparency
7.1 Traceability of documentation
7.2 Transparency of documentation
8. Utility
8.1 Learning dimension*
8.2 Interpretation of results
8.3 Graphical representation

Methodology

Stage 2: Selection of MCDA software sample	Identification and characterization of **MCDA software**	Eligibility of **MCDA software**

List of software 1 — Literature review (Stage 1) (n= 53)

List of software 2 — Selected inventories/reviews on MCDA software (n=40)

List of software 3 — Google search (n= 18)

111
MCDA software

Source No	Author	Title
1	Weistroffer and Li (2016)	Multiple Criteria Decision Analysis Software
2	Mustajoki and Marttunen (2013)	Comparison of Multi-Criteria Decision Analytical Software-Searching for ideas for developing a new EIA-specific multi-criteria software.
3	Beekman (2020)	Decision Analysis Software Survey (OR/MS Today)
4	International Society on MCDM (2024)	Software related to MCDM
5	Mohamad and Selamat (2018)	An analysis of rough set-based application tools in the decision-making process.
6	Moreno-Calderón, Tong, and Thokala (2020)	Multi-criteria Decision Analysis Software in Healthcare Priority Setting: A Systematic Review.
7	Cinelli, Spada, et al. (2021)	MCDA Index Tool: an interactive software to develop indices and rankings.
8	Huang 2024	MCDA Calculator: A Streamlined Decision Support System for Multi Criteria Decision Analysis

Methodology

Stage 2: Selection of MCDA software sample	Identification and characterization of **MCDA software**	Eligibility of **MCDA software**
List of software 1	Literature review (Stage 1) (n= 53)	Literature review (Stage 1) (n= 3)
List of software 2	Selected inventories/reviews on MCDA software (n=40)	Selected inventories/reviews on MCDA software (n=8)
List of software 3	Google search (n= 18)	Google search (n= 7)

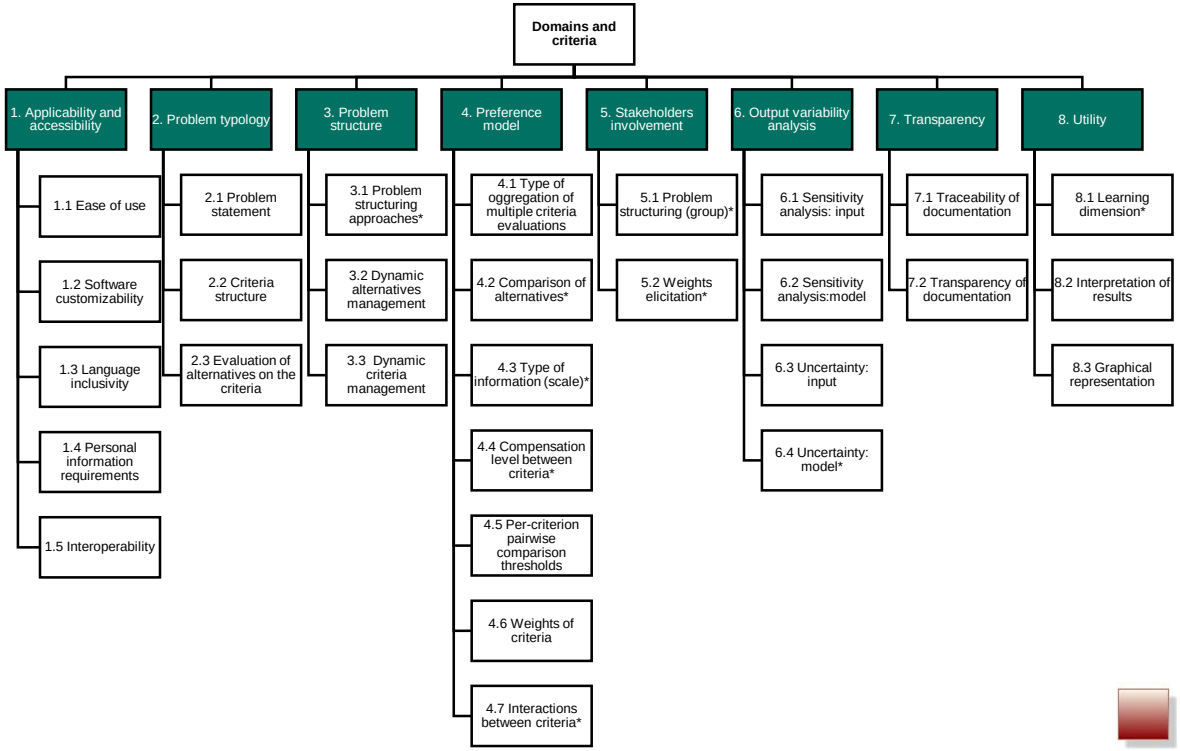
- Free
- Active version released after 2019
- With user interface and executable file

111
MCDA software

Sample = **18** MCDA software

Results

Stage 3: Assessment and recommendations	Assessment of selected MCDA software	Recommendations: road map



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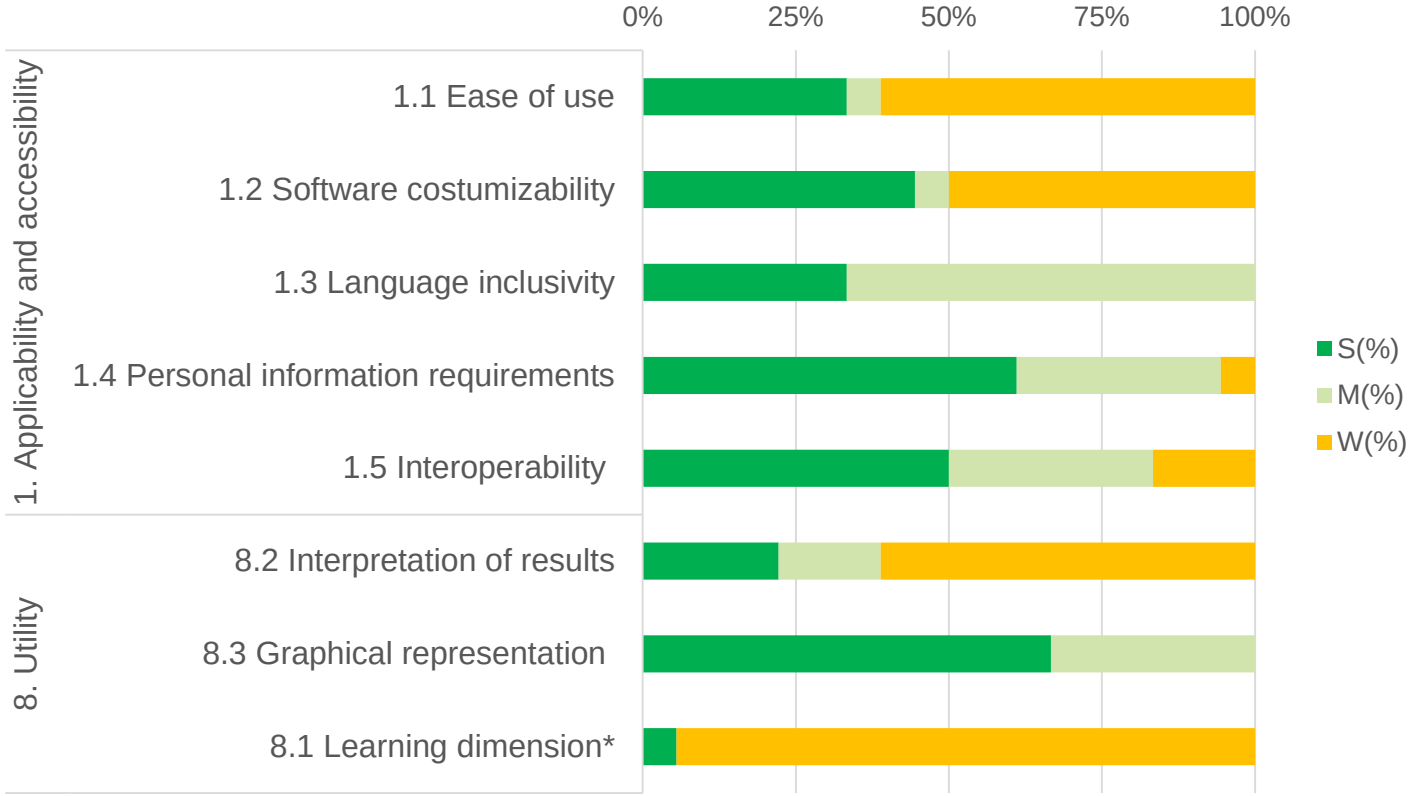
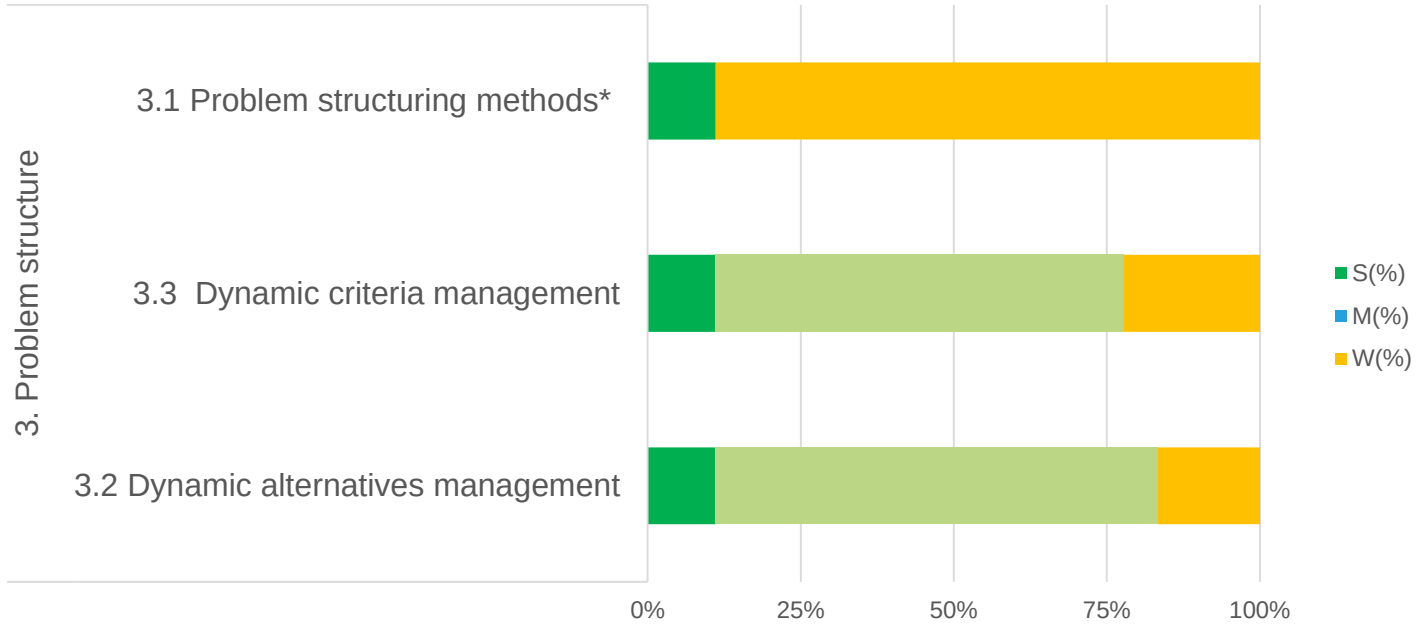


- Most of software is designed for users with a level of expertise in MCDA.
- Important amount of open-source software (customizable)
- Only one software allows simultaneous comparison of results with different configurations (learning dimension)

Results

Stage 3: Assessment and recommendations	Assessment of selected MCDA software	Recommendations: road map



- Very few software options to support problem structuring methods (PSM)
- More efforts needed towards flexibility of the problem structuring

Results

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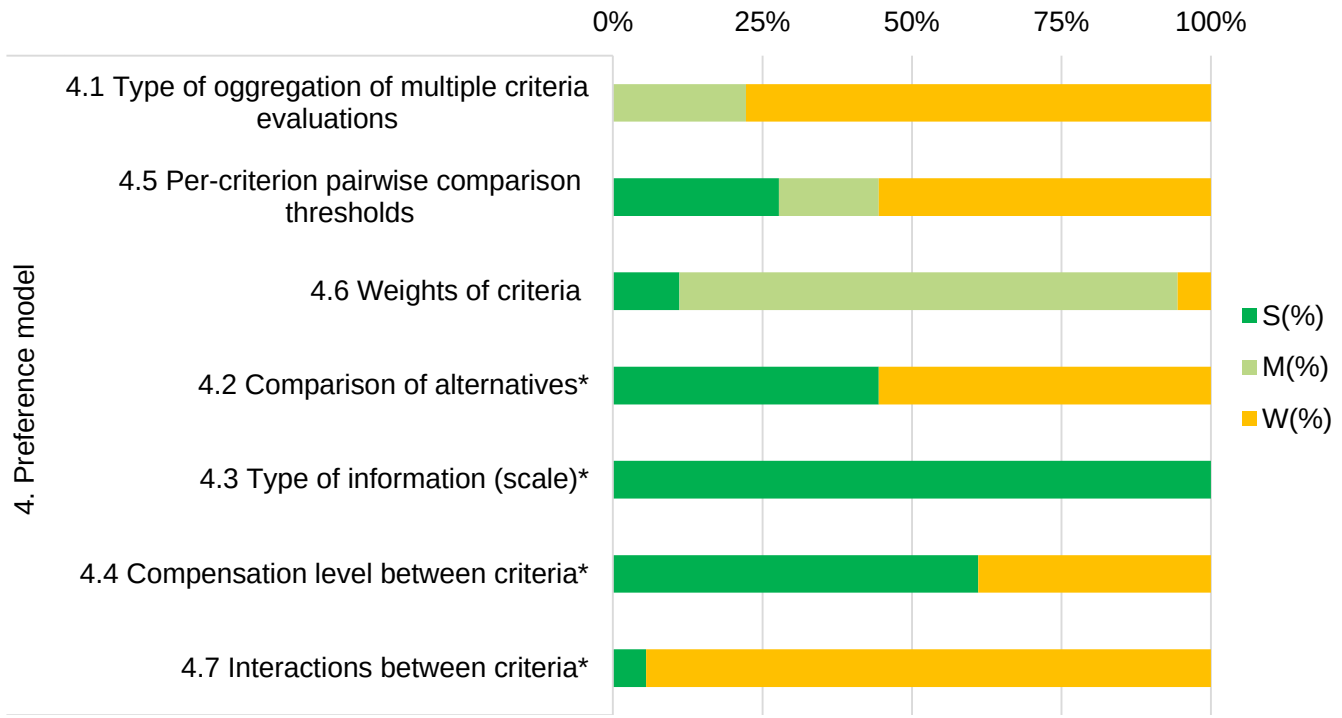

- Most of the software are specialized in only **one type of aggregation**.
- Most of the software support **precise weights**.
- Only one software could model **interactions between criteria**

Results

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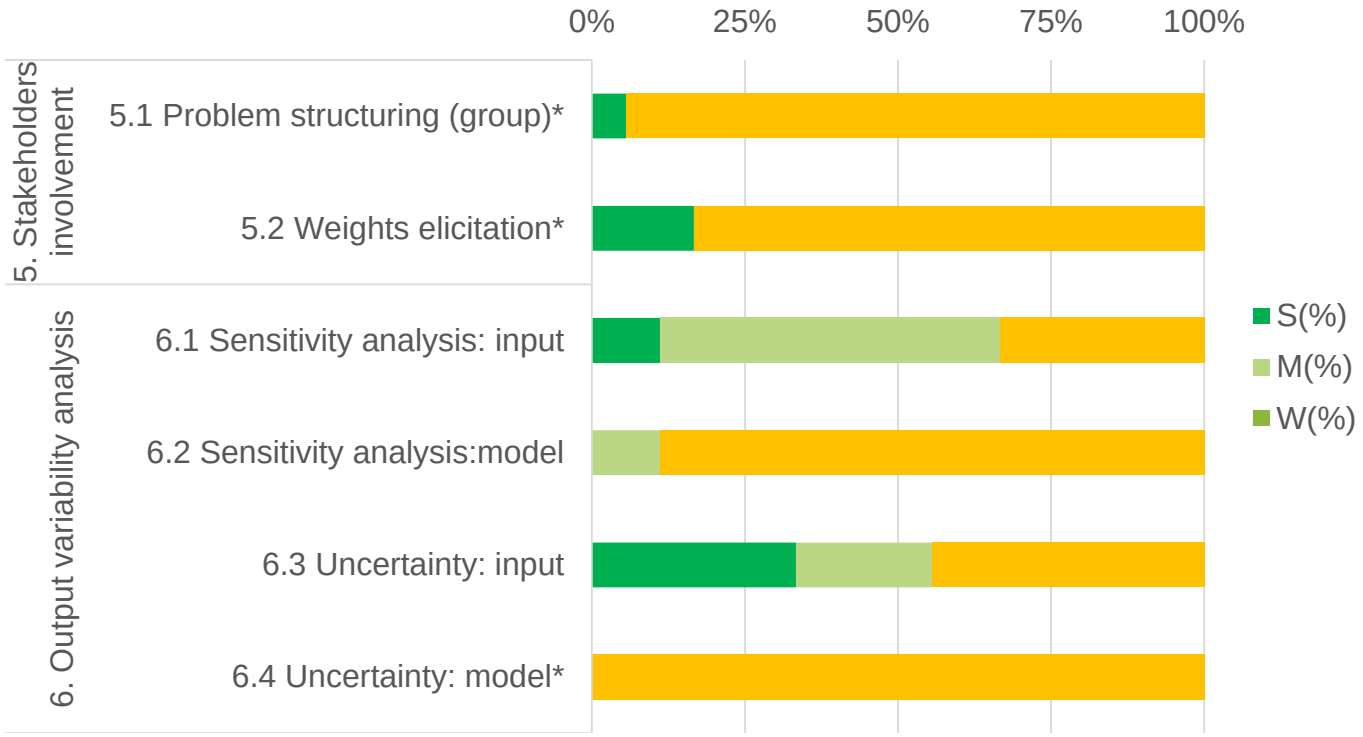

- Limited capability of the software to support stakeholder integration and output variability analysis (OVA)
- Only a few software could support **stakeholders integration,** mostly **weighting.**
- Most of software handle **OVA of input data**, mostly weights.
- None of the software can support uncertainty analysis of the model.

Results

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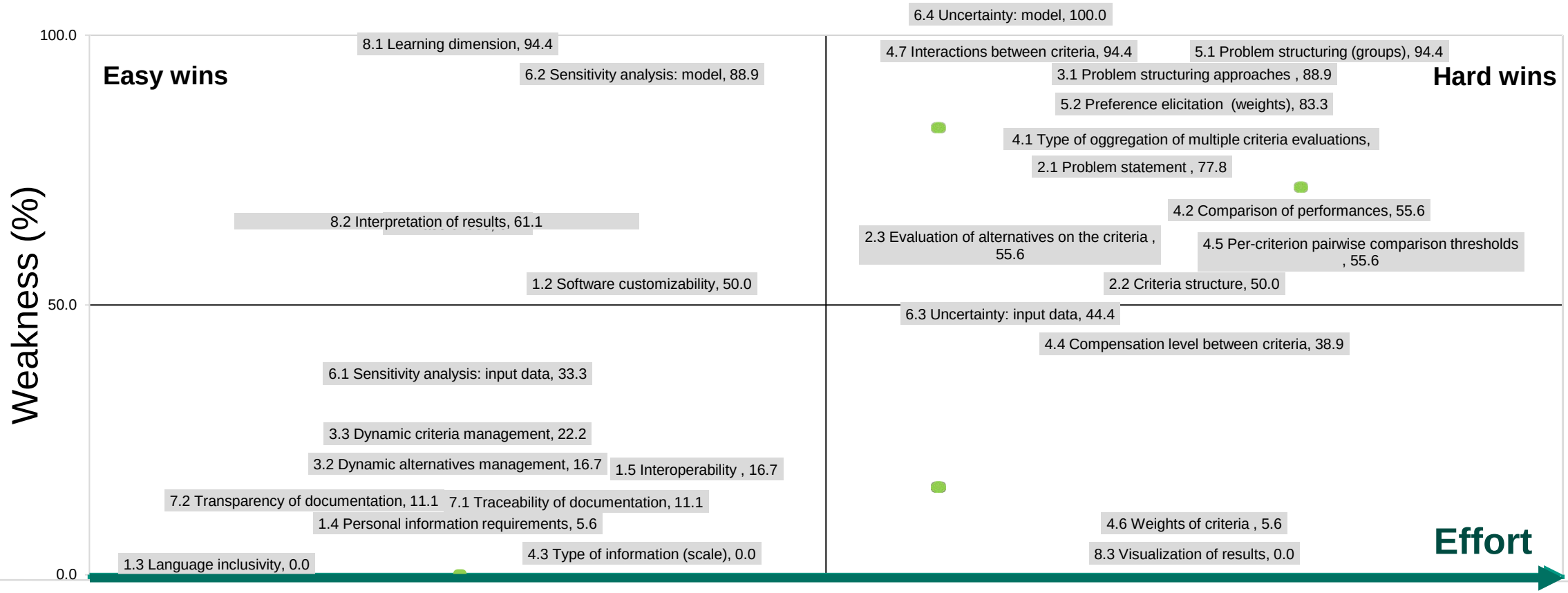

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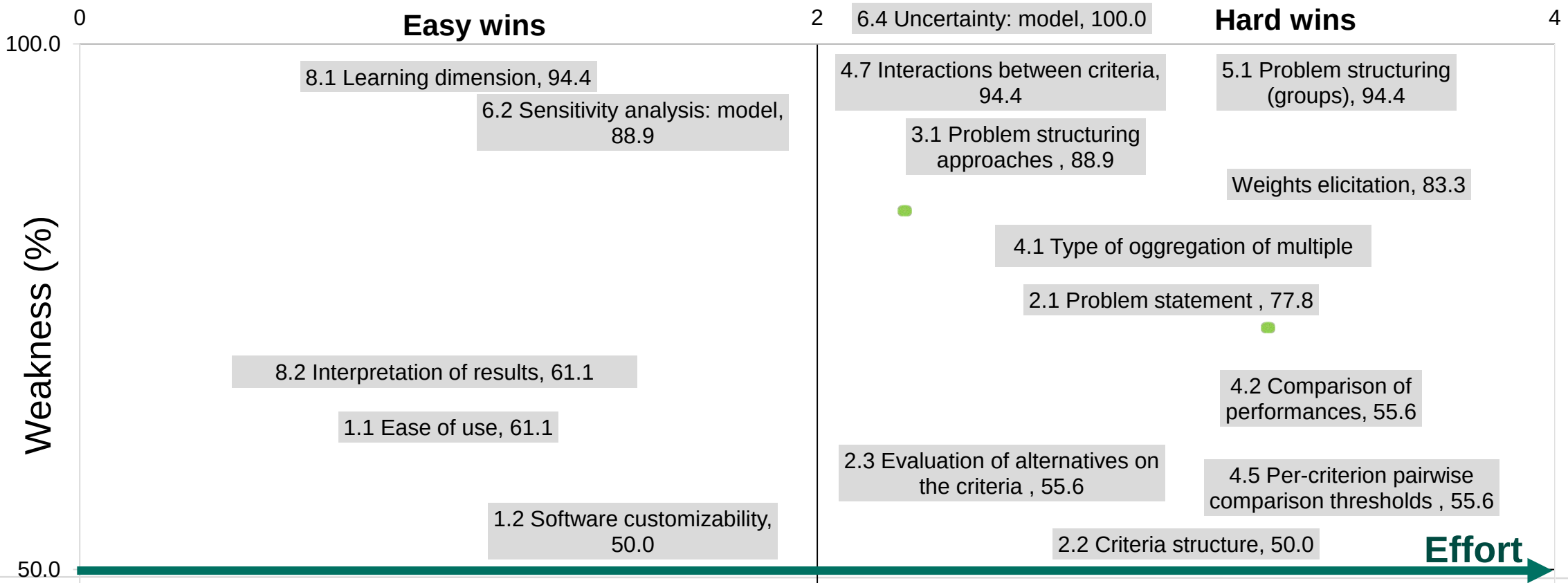

Conclusions

- There is no single free MCDA software that fullfills all the capabilities needed for SA.

Strengths:

- Free, accessible and robust MCDA software developed by members of the MCDA community.
- Different types of problem statements and aggregations can be modeled with free MCDA software.

Weaknesses:

- Only few software support problem structuring, stakeholders integration and output variability analysis.
- Low flexibility in some features e.g. most of the software can model only one type of problem statement.

Recommendations

- Interoperability: Each MCDA software brings unique features that could complement each other.
- Connecting software users (researchers) and software developers as a strategy for strengthening software capabilities and accesibility.