

Trade-off analysis

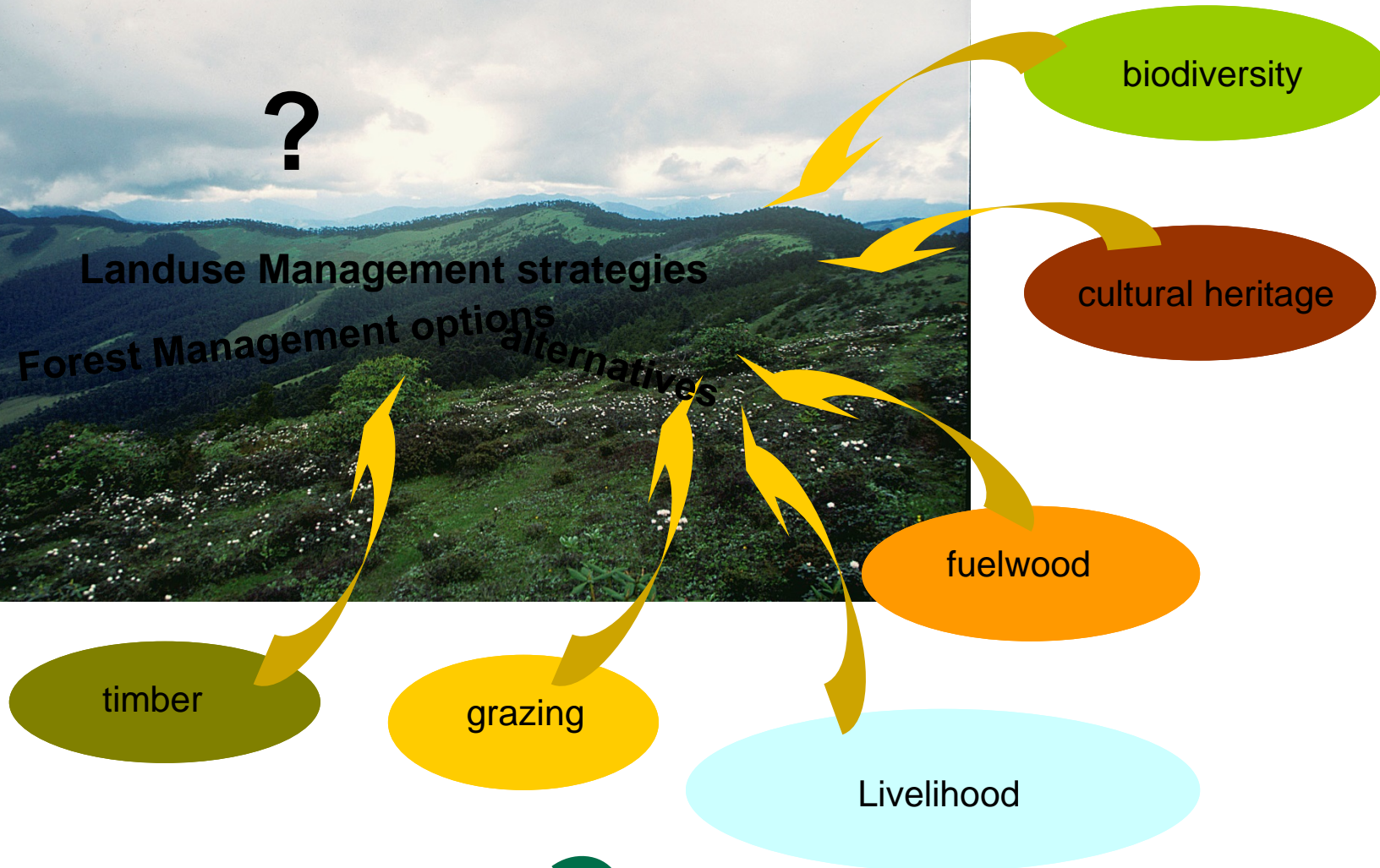
Summer School
Open Seminar
Lesvos 2013

Bernhard Wolfslehner - EFI



trade-offs?

- a situation that involves losing one quality or aspect of something in return for gaining another quality or aspect
- an approach to deliberate “costs” and “benefit” of a choice (real, external, perceived)
- a decision problem in complex environment that implies potential goal conflicts



When do we face a decision problem?

- an individual or a group of individuals has recognised a difference between the actual and the desired conditions of the planning object
- the individual or the group has the option to choose from among alternatives
- the selection of an alternative has significant effects on the current conditions of the planning object
- the individual or the group is *a priori* uncertain about what alternative to choose

(based on JANSSEN 1992)

decision types

- **objective system**

 - single objective

 - multiple objective

 - complementary

 - neutral

 - conflicting

- **consequences of alternatives**

 - certainty

 - risk

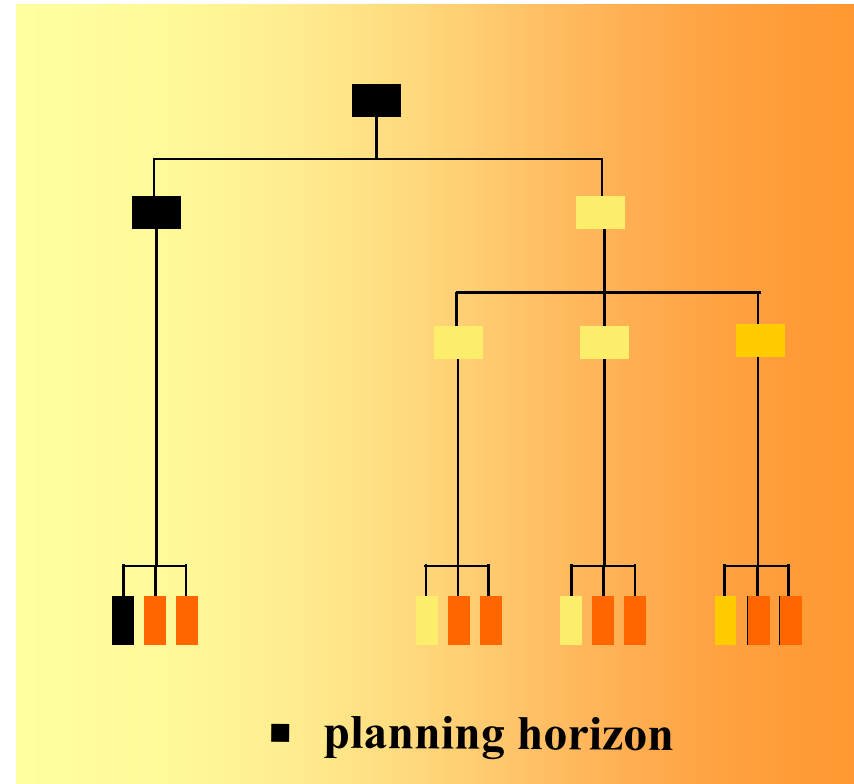
 - uncertainty

- **decision making situation**

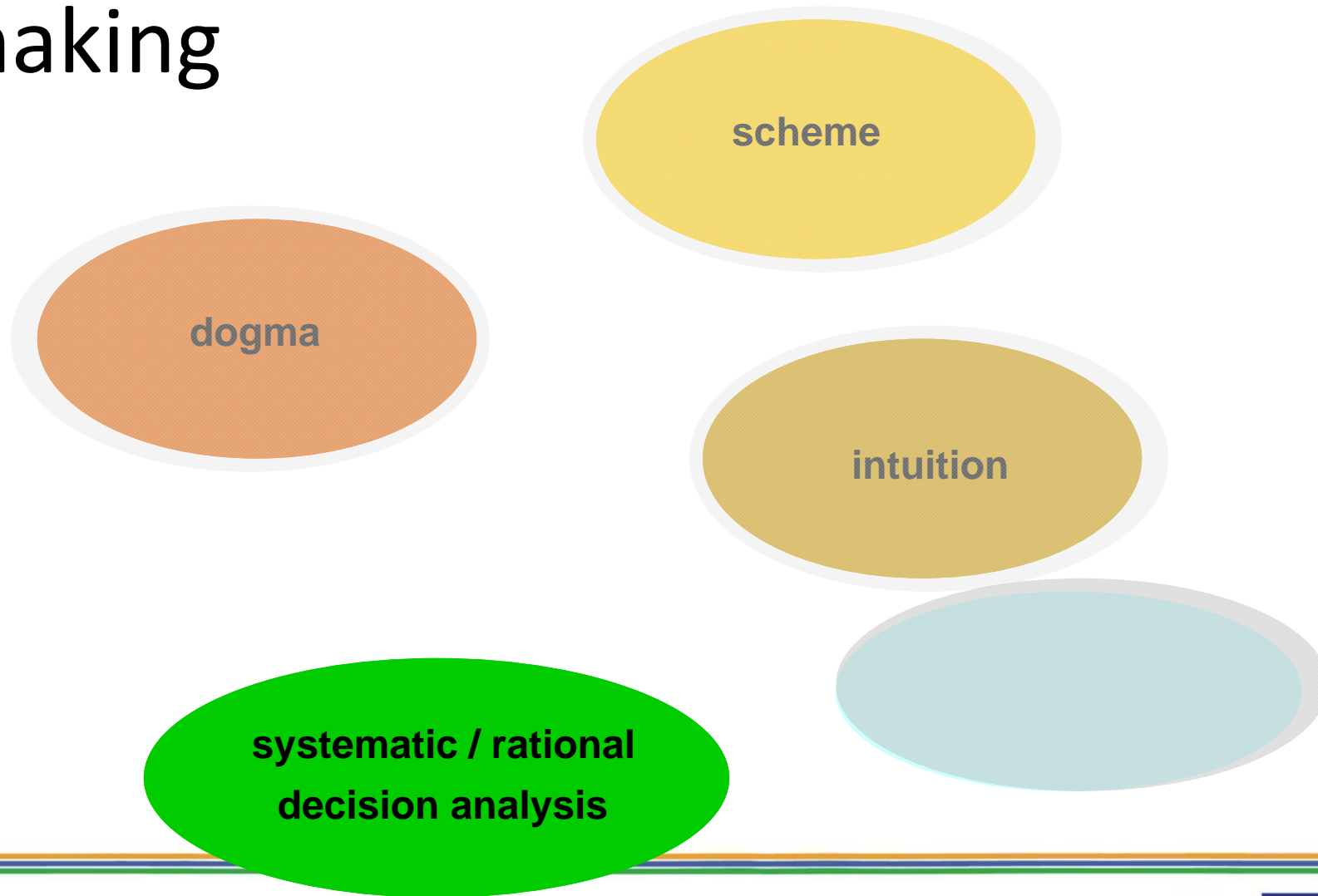
 - unilateral

 - collegial

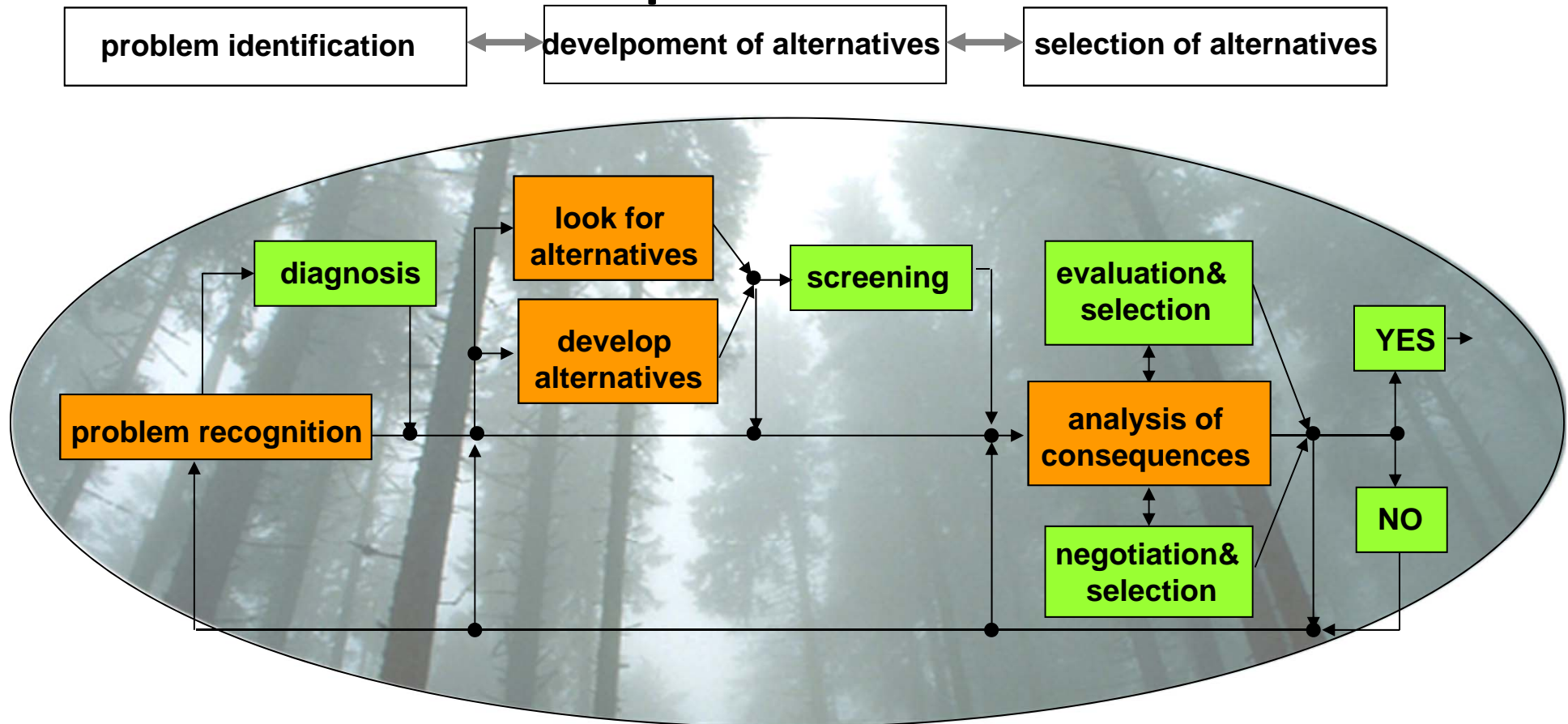
 - bargaining / participative decision making



...possible approaches in decision making



Planning and decision-making process



[modified from Mintzberg et al. 1976, Janssen 1992, Rauscher 1999]

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What makes decisions difficult? (i)

- **decision is not routine**
- **uncertainty**
 - **the outcomes of an alternative are not known with certainty**
 - **risk of surgery**
 - **market introduction of a new product**
- **several objectives/goals**
- **goal conflicts**
 - **hiring new staff: experience, education, leadership, social competence, ...**
- **consequences of alternatives are characterised on different scales/dimensions**

What makes decision making difficult? (ii)

- **number of alternatives**
 - too few or too many alternatives
 - expensive (eventually without success) search for new alternatives
- **complexity**
 - increases with degree of uncertainty (number of uncertain attributes/factors, ...)
 - the higher complexity the greater the importance of systematic analysis and use of relevant information

In Volante we have...

- Cross-sectoral approaches
- Multi-modelling
- Different spatial scales across Europe
- Scenarios and visions
- Socio-ecological diversity
- ...

which trade-offs?

- Between ecosystem services (provision), bundles, clusters, etc.
- Between land-use options (Visions), bundles, clusters, etc.
- Between sectors
- Between targets
- Between values
- Long-term / Short-term impacts (Scenarios)
- Spatial trade-offs: regional, national, European and global dimension

Mechanisms and analysis

- public interest
- Markets
- democratic negotiation processes
- power relations
- pressure/impact
- new land use index
- Conflicts
- Consensus
- Diversity
- Dominance
- Synergies
- Targets
- Warning, e.g. flag system
- Etc.

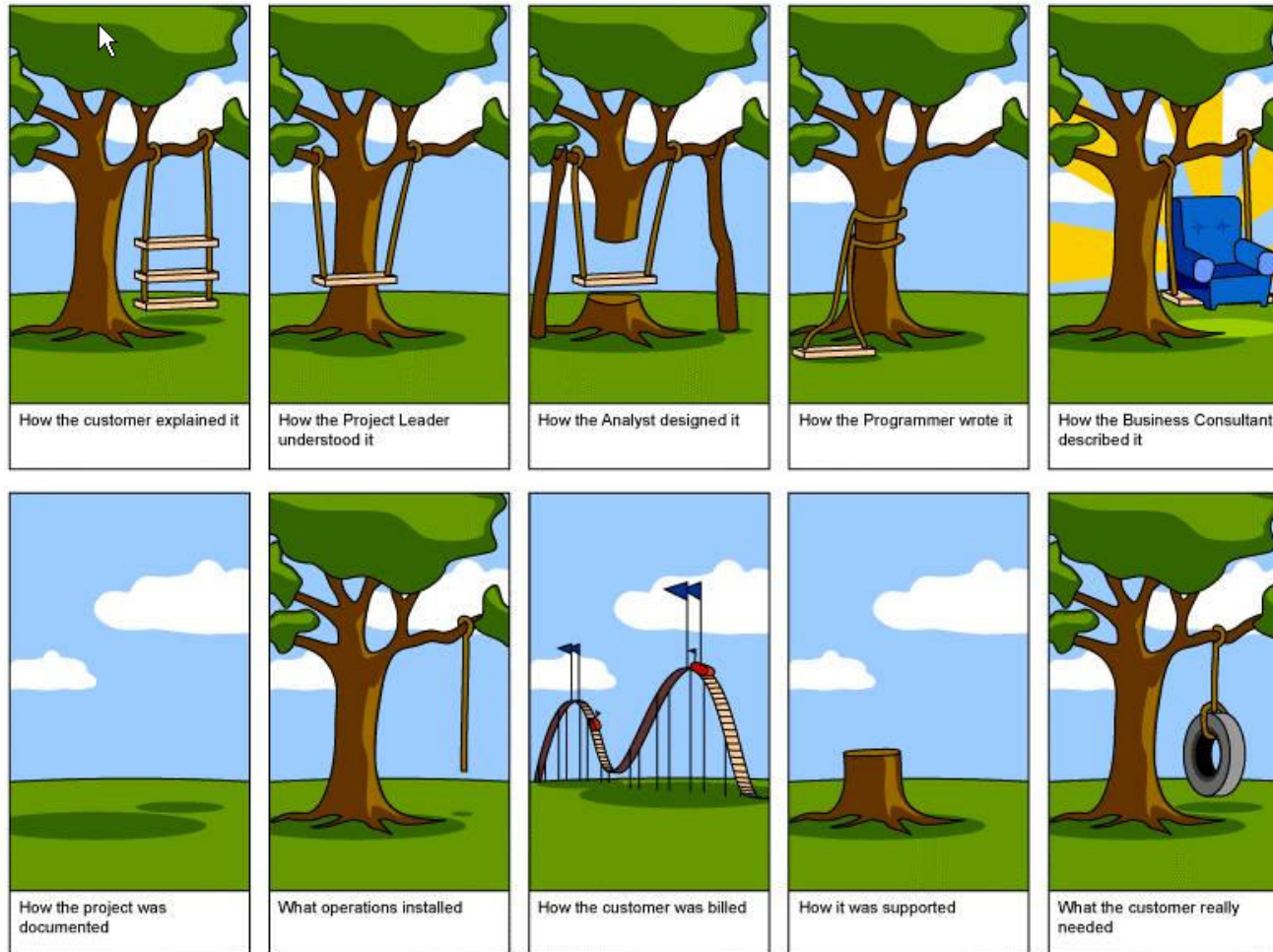
Stakeholders

- principal use of stakeholders input in trade-off analysis?
 - use SH for **elicitation of explicit preference information** and extrapolation thereof -> how much can we cover?
 - use SH for **verifying/falsifying** stochastic preference concepts (e.g., spatially differentiated preference probabilities) in terms of robustness of choices
 - use SH for testing a ready-made trade-off system (**social learning**)
 - use SH for gathering levels of acceptance for certain trade-offs (**legitimacy**)

...and further....

- How to communicate thresholds and constraints in contrast to Visions and Scenarios
 - Multi-threshold system with different implementation of (1): restrictions to the decision space, ecological constraints to land use options, non-compensatory features
 - how to deal with the normative aspects of (1) (i.e., reduction of options) in TOA?
- Meta-information and uncertainty management has to be clarified and coordinated at early stage
 - Communication, knowledge transfer and learning concepts to be linked to TOA (main concept: informed decision making)

Complexity of use



Different kinds of trade-offs in Volante

- Science-based trade-offs analysis relies on ecosystem service indicator and perform statistical analyses on their appearance, bundling, and synergies/trade-offs (as from WP8)
- Value-based trade-off analysis operate in the field of decision sciences and integrates the component of interests and preferences into indicator-based assessments
- Trade-offs as applied in the Visions workshops add the informative and explanatory character to the overall trade-off concept (as from WP10)

Trade-off methods

Approach	Method	Input	Output	Scale	Mechanism
Science-based trade-off analysis	Pairwise correlations (Pearson's coefficient) between ES	Stratified sampling of pixels from ES maps, standardized and normalized	Maps of ES hotspots and cold spots	Europe Resolution: 1 km ² , (NUTS 2)	Informs on multifunctionality vs. segregation – depending on scale
	Factorial Analysis for Mixed Data (FAMD) and/or Cluster Analysis for sets of multiple ES	As above	List of positively (synergies) and negatively (trade-offs) correlated ES	As above	Description on groups of ES (bundles) positively associated (synergies) or ES that are exclusive of each other (trade-offs).
	Redundancy Analysis - RDA)	As above	Ranking of a list of potential drivers according to their relative importance	As above	Identification of drivers of ES bundles
Value-based trade-off analysis	Spatial MCA	ES service indicators, model-based land-use indicators, scenario results	Land-use evaluation index on different spatial and thematic aggregation levels, maps of regional and spatial trade-offs	As above + NUTS 3, LAU1, LAU2	Evaluating, weighting and aggregating indicators (and subsets thereof) to compare land-use scenarios, their impacts, and their potential prioritisation
	Preference modelling	As above + Monte Carlo distribution of preference patterns	Maps of robust/conflicting land use scenarios,	As above	Preference patterns inform about a combined evaluation of empirical information and value systems in the context of decision analysis
	Uncertainty analysis	As above	Uncertainty index for trade-off results	As above	Provides a measure of confidence to draw recommendations made based on trade-off analyses

Science-based trade-off analysis

- Data transformation – normalisation
- Spatial auto-correlation
- ES (non)-weighing
- ES associations via PCA
- ES bundles: spatially explicit

ES indicators

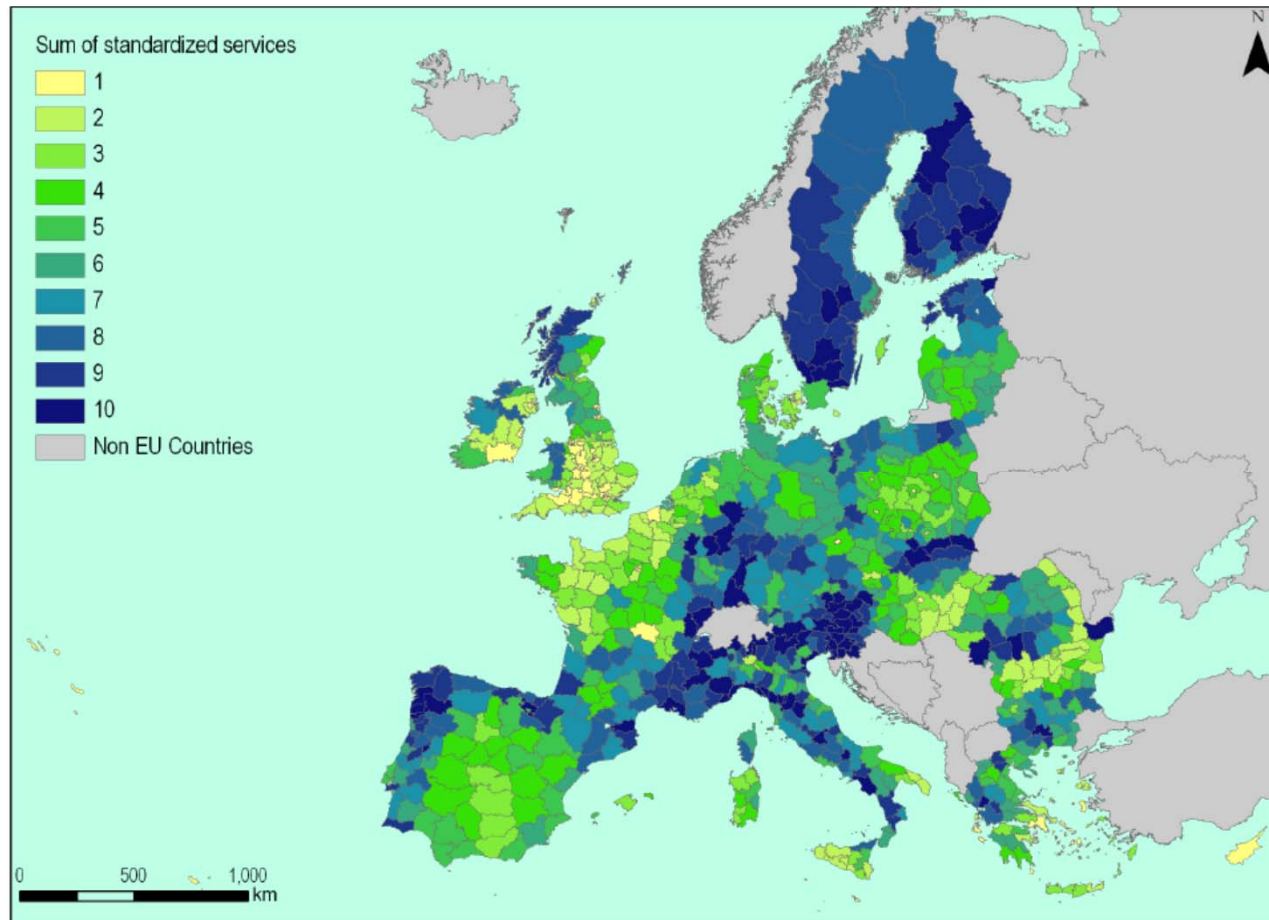
ES indicator	Description
Territorial capital of rural tourism	Potential for 'rural tourism' incorporating the supply of 'beach tourism,' of attractions for winter tourism, of attractions for nature tourism and assets of symbolic capital
Recreation potential index	Potential provided by ecosystems related to the presence of certain ecosystems (i.e. forest, coastline), certain ecosystem characteristics (i.e. naturalness) and their accessibility
Food-feed-fiber production	Crop yields
Wood supply	Round wood and harvest residues from thinning and final felling
Carbon sequestration	Amount of carbon that is sequestered from land use, land use change and forestry
Nitrogen retention capacity	Amount of nitrogen retained in water bodies (proportion of potential input)
Fire risk index	Estimated on the vegetation vulnerability to wildfires, climatic conditions and topography
Relative water retention	Related to flood regulation. Based on the variability of the peak discharge at the outlet of a catchment in dependence of land use and soil distribution
Species richness of species providing natural pest control	Based on the overlaid distributions of species providing pest control
Relative pollinators abundance	Related to the availability of floral resources, bee flight ranges and the availability of nesting sites
Dead wood	Indicator for biodiversity in forests. Related to the resource availability and species richness
Alien threat score	Based on the ecological impact and the invasive potential of species
Human appropriation of NPP	Amount of energy in form of biomass used by society by anthropogenic alteration of land cover
NPP of the actual vegetation	Actual available energy in terms of biomass assuming anthropogenic alteration of land cover
NPP difference due to land conversion	Amount of NPPact due to land conversion www.volante-project.eu
harvested NPP	Amount of NPPact due to harvest



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Example: mapping ES hotspots

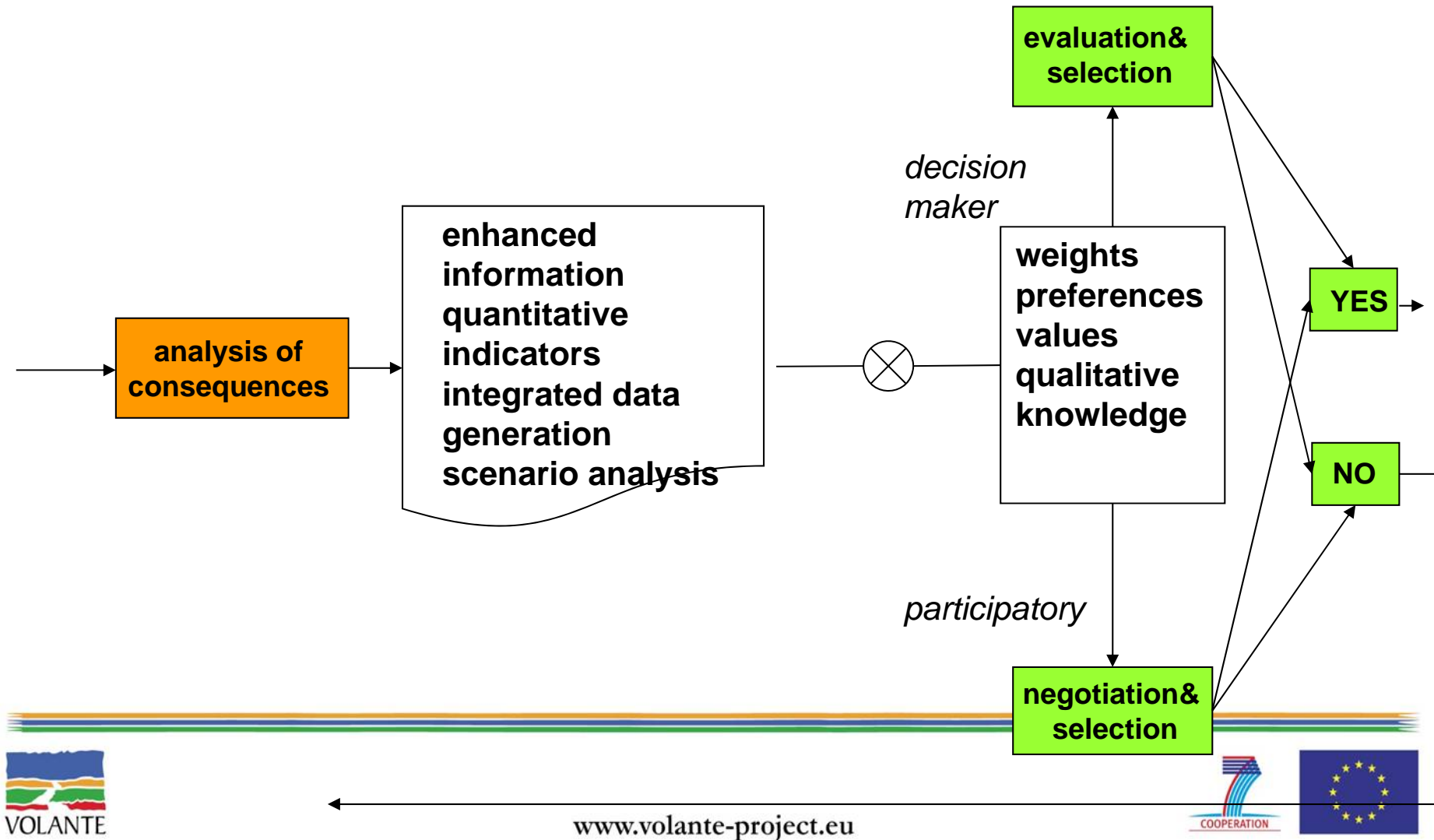


Maes et al.,
2011

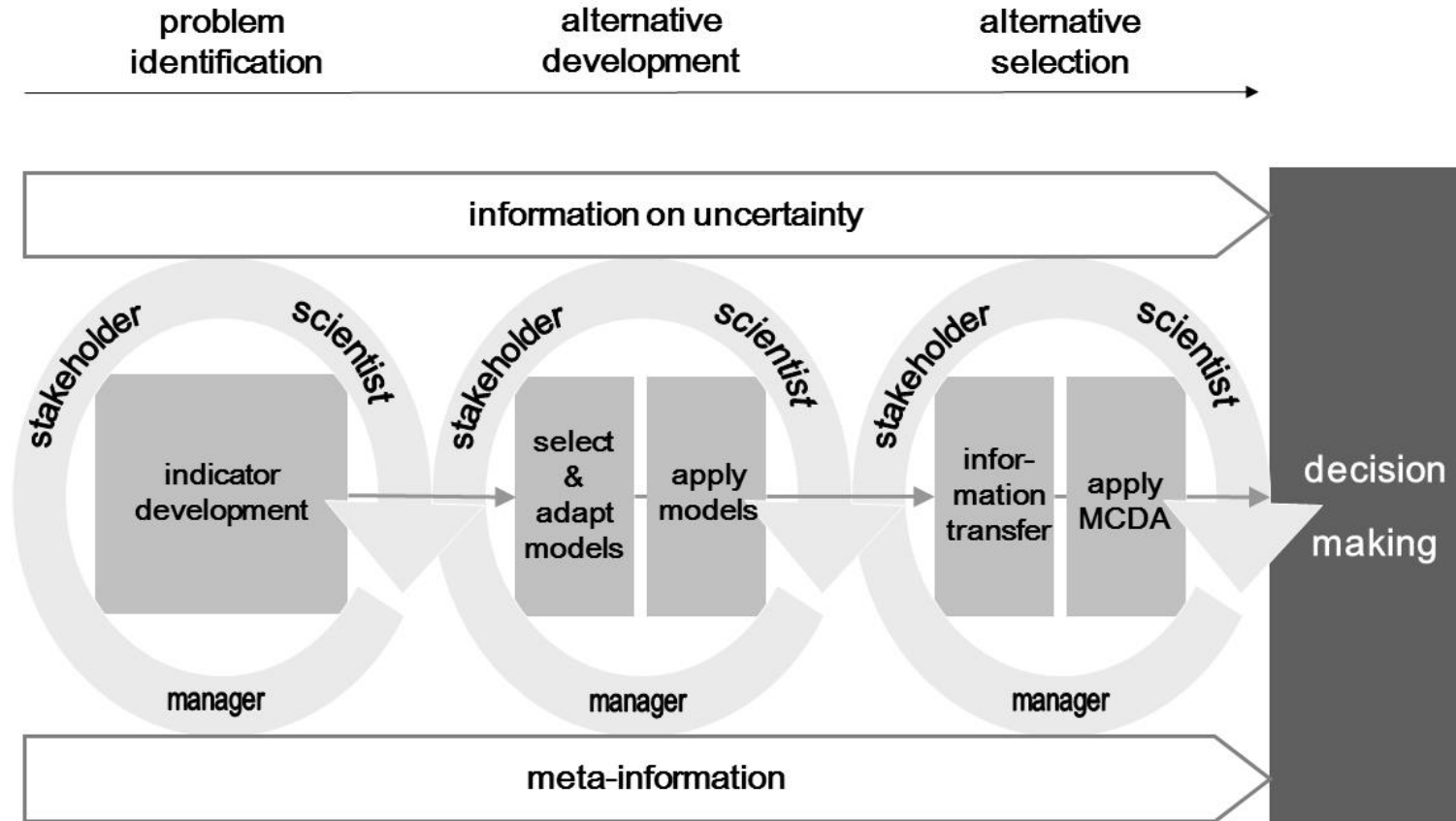
Value-based trade-off analysis

- synthesize both the available scientific-empirical evidence and value information
- Elicit and develop stakeholder preference patterns
- Comparing alternative pathways and their robustness in preference
- implementing a spatially explicit multi-criteria analysis tool

selection of alternatives



From data to information to decision-making



Wolfslehner & Seidl, 2010

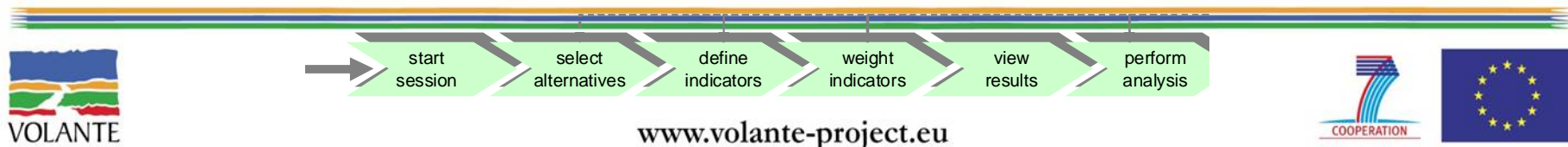
Multi-criteria analysis -MCA

MCA has gained increasing legitimacy on governmental decision-making level and explicit recognition as decision- support tool in public processes and is designed to:

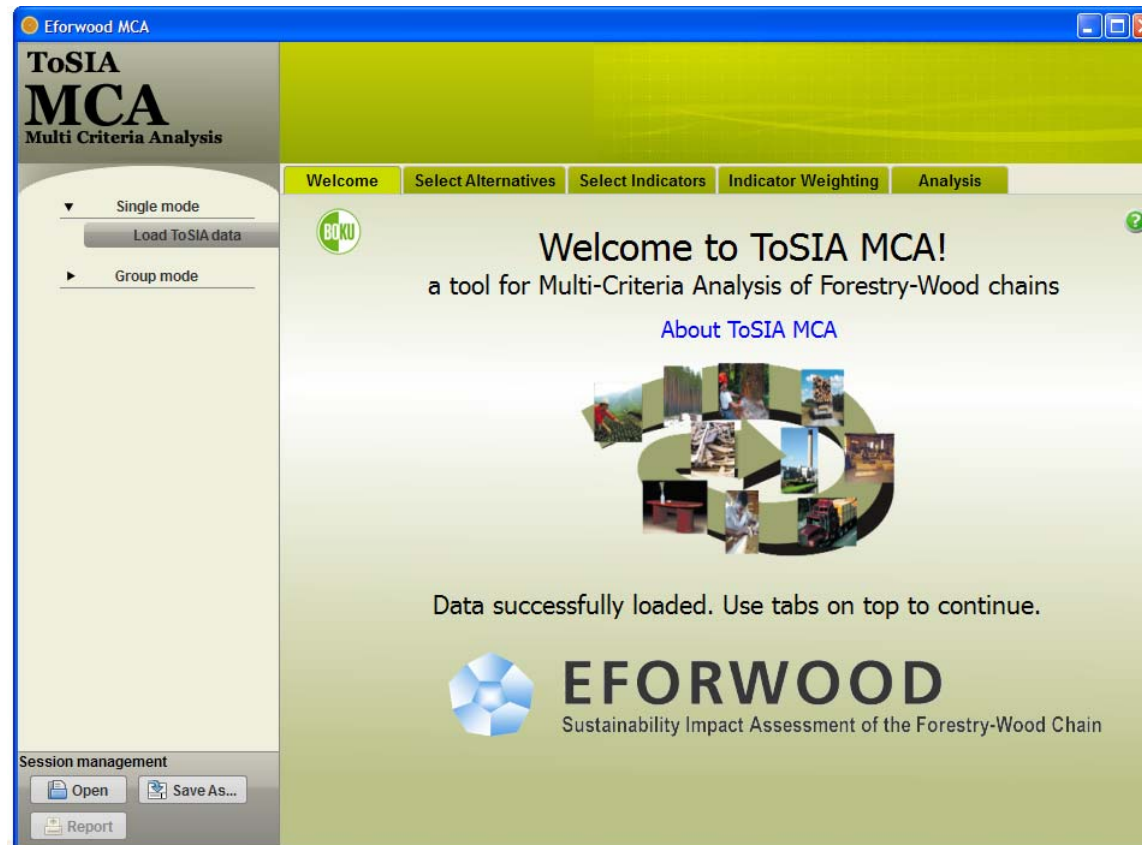
- *take account of multiple, conflicting indicators, criteria or objectives*
- *to structure a decision problem*
- *to identify the most preferable option among alternatives/strategies*
- *to provide a formal quantitative model for such problems as a focus for discussion*
- *to support rational, justifiable, and explainable decisions*

MCA - procedure

- Choose alternatives for evaluation (e.g. different pathways)
- Select assessment indicators/parameters (e.g. ecosystem services, land use)
- Involve actors & their preferences (e.g. weights)
- Assess & Aggregate indicator values of alternatives on a uni-dimensional scale (e.g. preference scale)
- Evaluate & Compare impacts and trade-offs of alternative options



ToSIA-MCA as basis for Volante



Selection of alternatives

Eforwood MCA

ToSIA
MCA
Multi Criteria Analysis

Alternatives

- 2005
- 2015**
- 2025

Session management

Open Save As... Report

Welcome Select Alternatives Select Indicators Indicator Weighting

2015

Alternative **2015**
of chain Scandinavian General Structure Case Study.

Details:

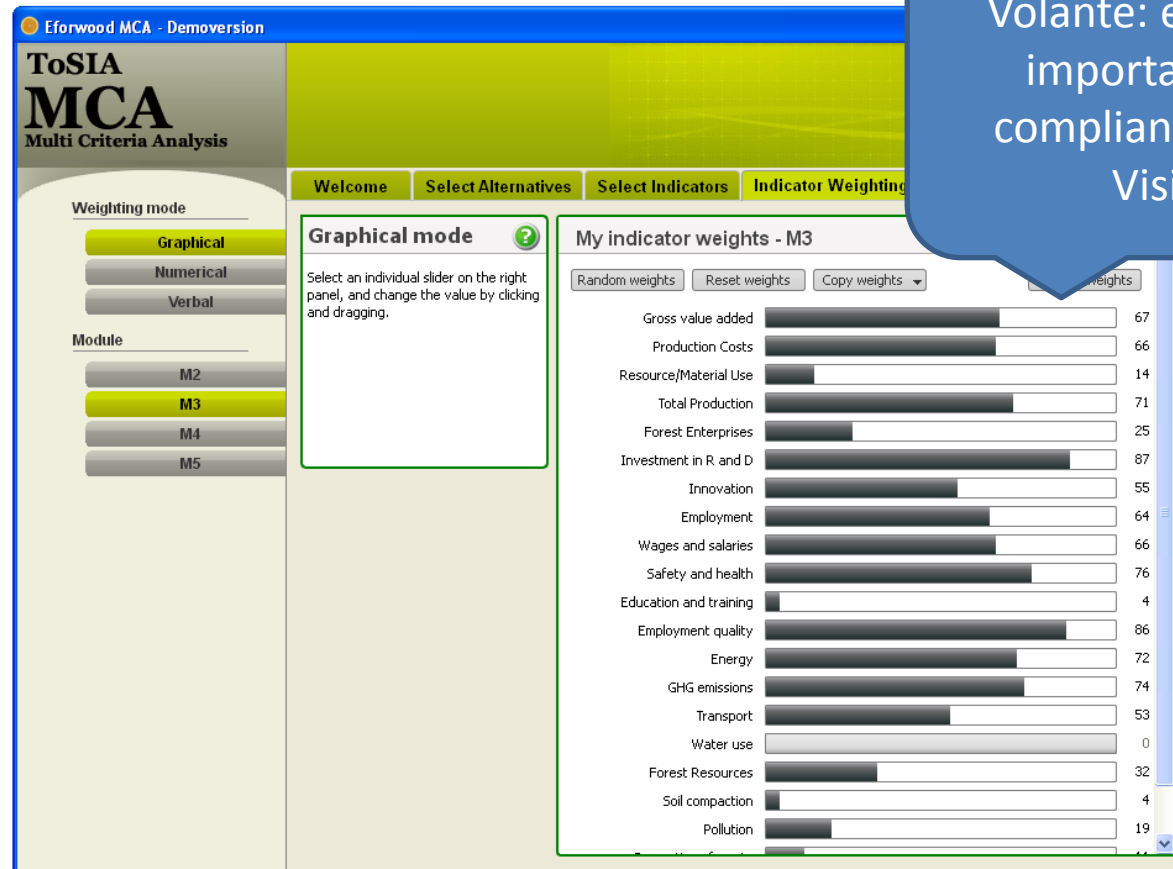
- Year: **2015**
- Reference Future: A1
- Scenario: --
- Id: **10000003**

Description:

Volante: A set of Pathways within/among Visions

Indicator weighting

Volante: estimated importance for compliance with a Vision



Comparison of alternatives



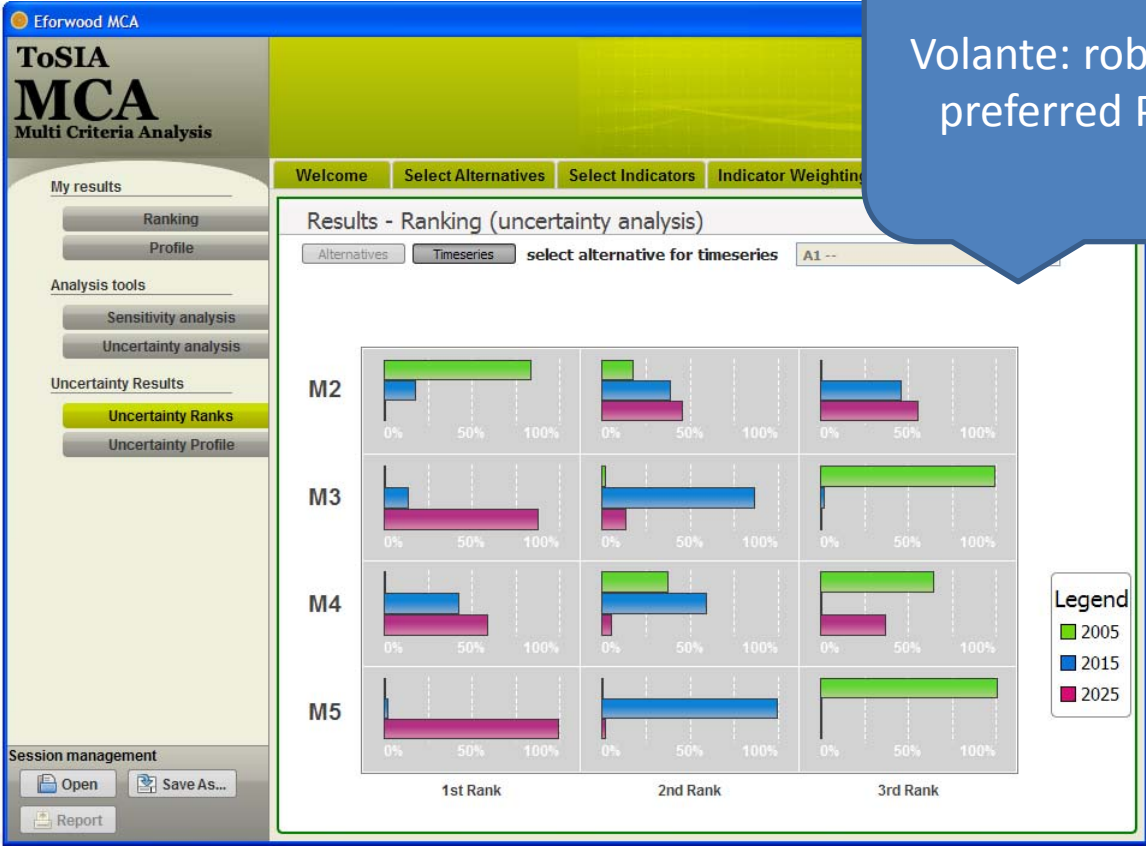
Volante: impact of estimated data uncertainty on robustness of choices

Indicator selection

The screenshot displays the 'Eforwood MCA' software interface. The main window is titled 'ToSIA MCA Multi Criteria Analysis'. The left sidebar contains a tree view of indicators: Economic indicators, Environmental indicators (with 'Energy' selected), and Social indicators. The 'Energy' indicator is expanded, showing a list of subindicators: Onsite generation, Heat from residues, Heat from other wood, Heat non-wood, Electricity from residues, Electricity from other wood, Electricity non-wood, Fuel from residues, Fuel from other wood, Fuel non-wood, Energy use, and Heat renewable. The 'Onsite generation' subindicator is selected, and its details are shown in the main panel. The details include the description: 'On-site energy generation (from renewables) and energy use classified by origin including the share of self-sufficiency', the unit 'MJ', and the selection of subindicators M2, M3, M4, and M5. The interface also includes a 'Session management' section with 'Open', 'Save As...', and 'Report' buttons.

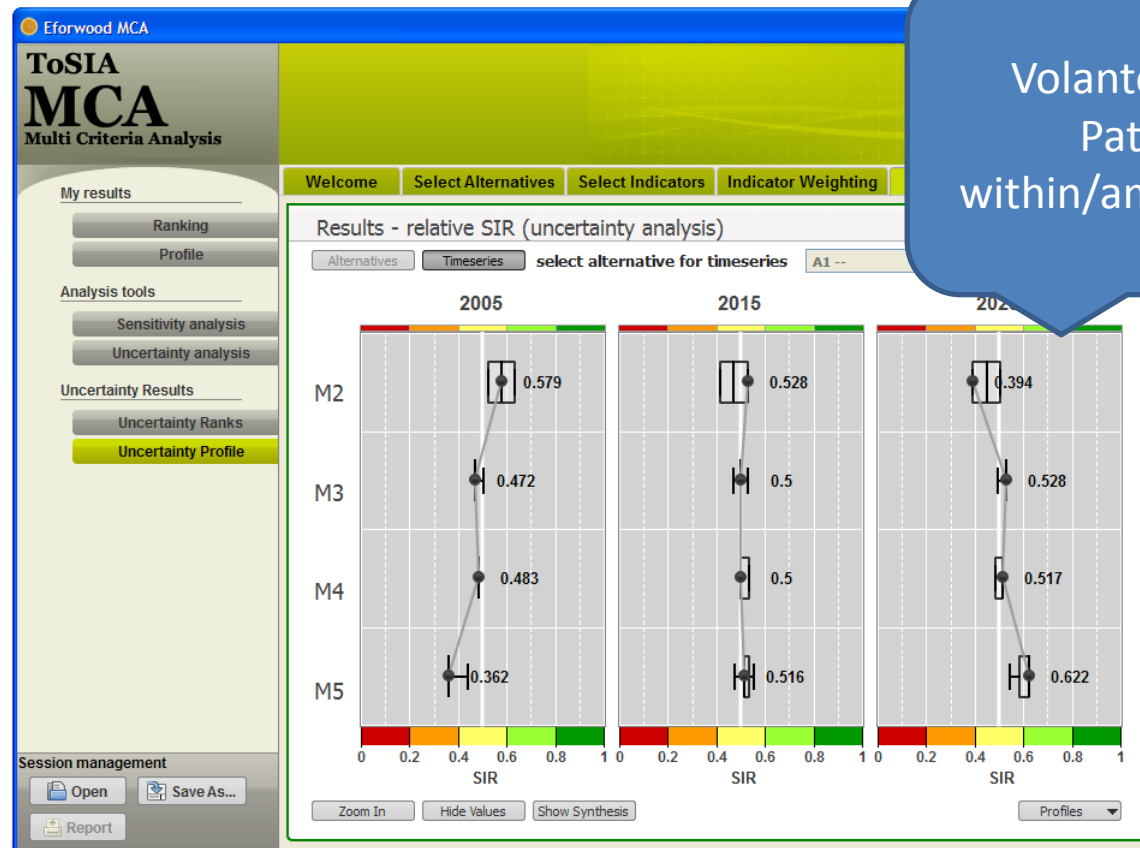
Volante: Ecosystem service and land use indicators

Ranking probability



Volante: robustness of preferred Pathways

Uncertainty analysis

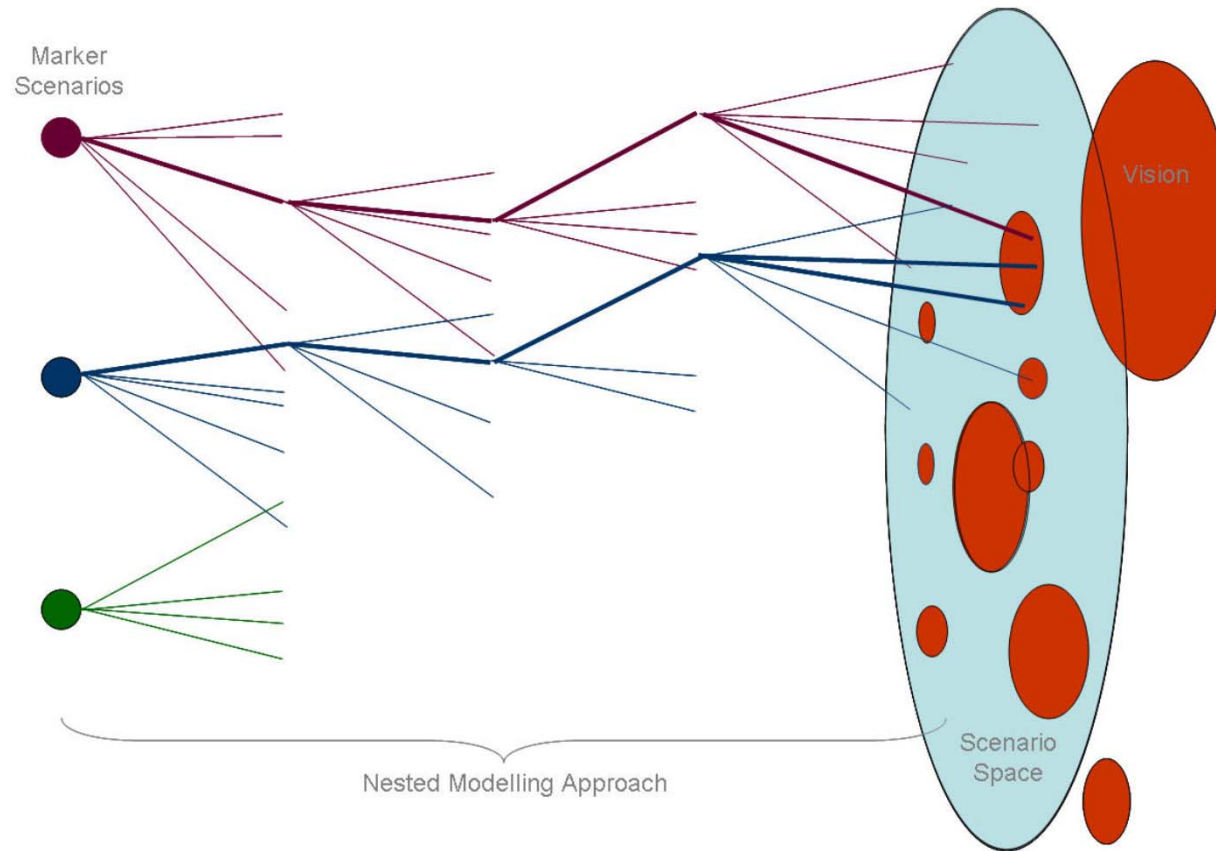


Volante: A set of Pathways within/among Visions

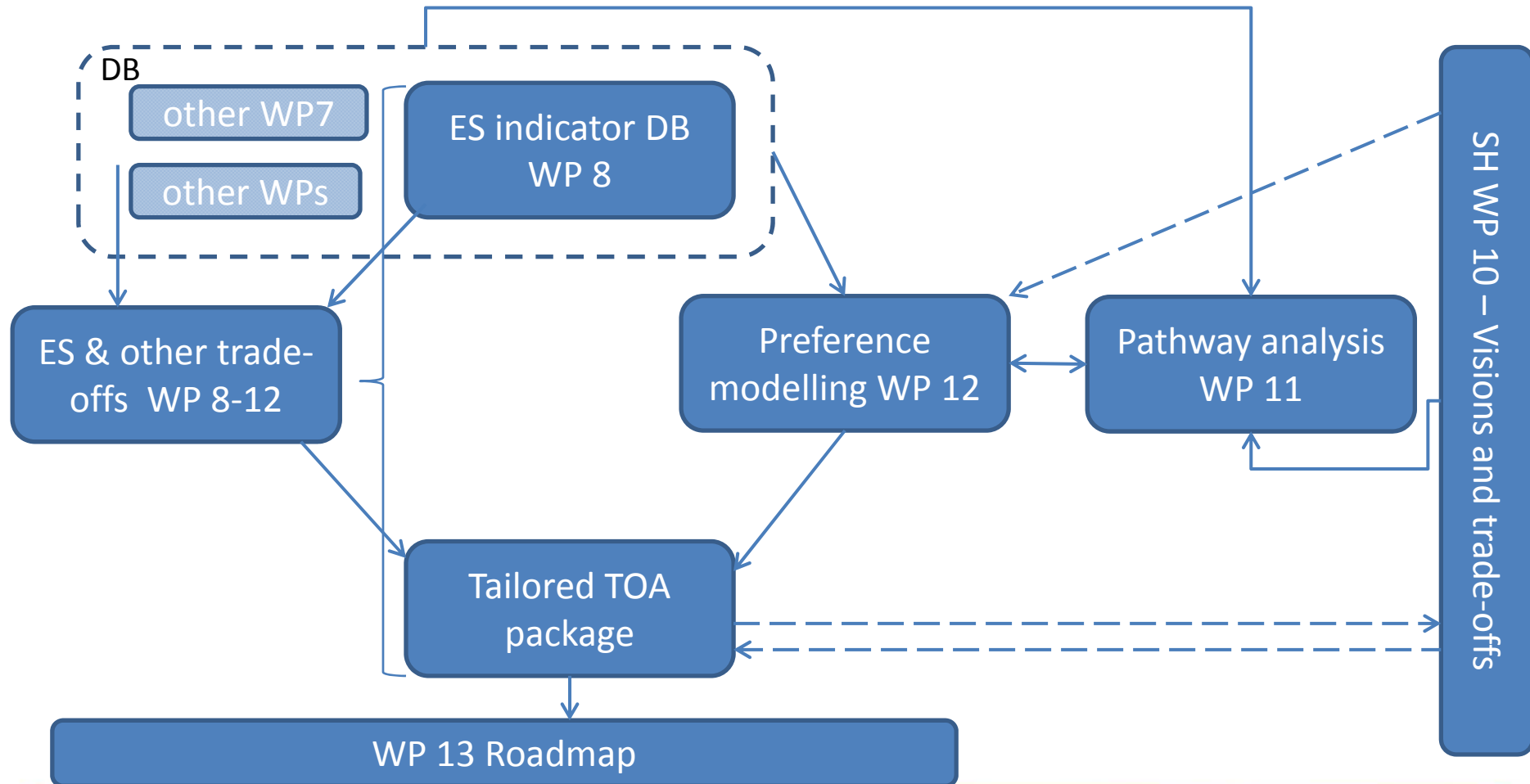
In Volante this means

- Comparisons of potential pathways within/among Visions
- Development of preference patterns (SH workshop and Monte Carlo modelling)
- Robustness analysis by rank correlation
- Uncertainty analysis (input data)
- Spatially explicit implementation on European, NUTS1, NUTS 2 level

A choice in the maze of pathways?



Trade-off analysis framework



Trade-offs analysis outputs

- Ecosystem services trade-off maps
- Single indicator analysis, partially aggregated systems (indicator subsets), or full land use indices
- Indicator-wise analysis of responses to scenarios (temporal and spatial)-> thematic maps
- Integrated preference/conflict maps
- Regionalised analysis (urban, peri-urban, rural) of hot-spots, trade-off patterns

„Roadmap“

- Consolidation of MCA methodology until June 2013
- Clarify database links and data availability
- Finalise conceptual linkage to Pathways
- Start implementation of MCA and preference modelling by June 2013
- Exemplatory output for demonstration in autumn workshops

Open issues

- Scaling
- Choice of indicators for final analysis
- Module P input
- Design of final trade-off package