# Decision making under deep uncertainty

## a tentative taxonomy of approaches

Jan Kwakkel

# Decision-making under deep uncertainty

1. **Decision support** – the aim of decision advise is to facilitate learning about a problem and potential courses of action, not to dictate the right solution. This entails a shift from *a priori* to *a posteriori* decision analysis.

2. **Adaptive plans** – plans should be designed from the outset to be adapted over time in response to how the future is actually unfolding

3. **Exploratory scenario thinking**– the future is uncertain and cannot be probabilistically constrained, we need systematic what-if analysis of the future which serves a s a test bed for candidate strategies

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# Decision Support

Decision aiding can be defined as the activity of one who, in ways we call scientific, helps to obtain elements

of **answers to questions**

helping to **clarify a candidate decision** with the aim to increase coherence of actual decisions and goals and/or systems of values

**Constructive**

co-construct problem and solutions at the same time through joint sense making

The analyst learns about the client's problem, and the client learns about the formal representation of his problem

Consent / consensus

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Tsoukias (2008) 10.1016/j.ejor.2007.02.039

# Decision Support

## Premature aggregation is at the root of all evil

## Aggregations

- Over states of the world → expected value
- Over objectives → MCDA / CBA
- Over actors → social planner, GDP
- Over time → Discounting
- Over space → Risk transfers

- Aggregation is a loss of information → decision myopia
- Aggregations are theoretically problematic (e.g. Arrow's impossibility theorem)
- Aggregations are a source for contestation

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# Adaptive Plans

## Protective adaptivity

Protect a basic plan against vulnerabilities through contingency planning and monitoring

Examples: adaptive policy making, assumption based planning, robust decision making

## Dynamic adaptivity

Transform system functioning through sequencing of actions over time and careful monitoring

Examples: adaptive pathways, adaptive management

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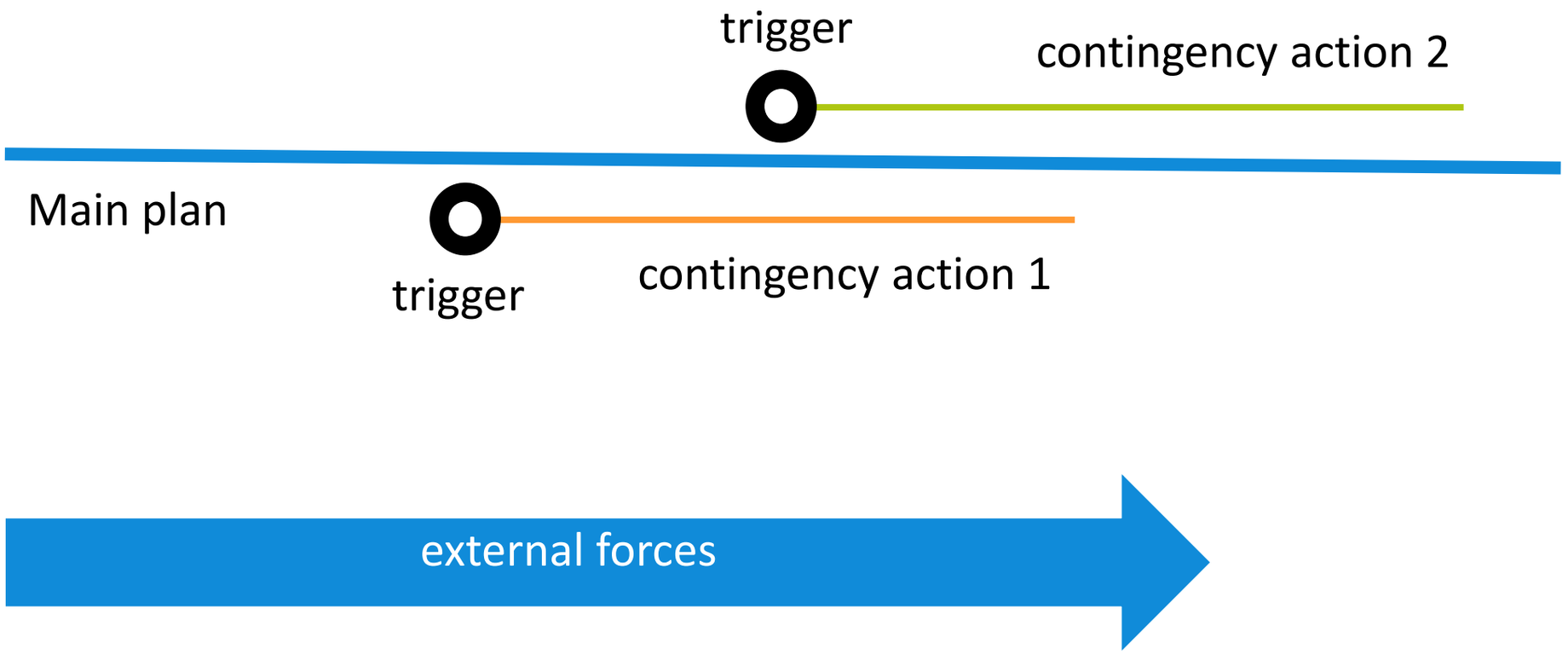
# Protective adaptivity

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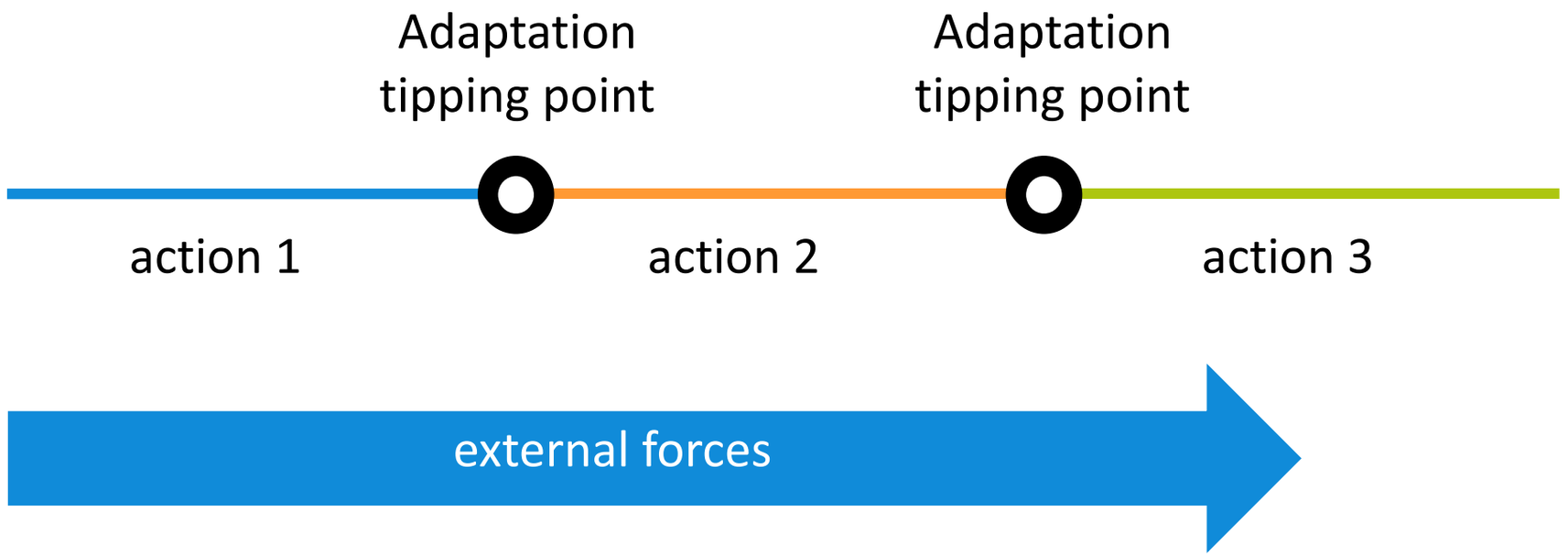
# Dynamic adaptivity

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# Exploratory scenario thinking

*Decision support processes that employ scenarios, as opposed to probabilistic forecasts, to characterize deep uncertainty will help decisionmakers consider a wider range of futures and attributes, and this broader vantage will encourage the choice of more robust options that perform reasonably well in a wide range of futures.*

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Gong et al (2017) 10.1016/j.envsoft.2017.02.002
Holtz et al (2015) 10.1016/j.eist.2015.05.006

# Why use models?

## Argument from complexity

Because the system of interest is often complex, there is a need supplement human reasoning

Complex systems are sensitivity to initial conditions (both parameters and structure)

## Argument from uncertainty

When confronted with uncertainty, instead of making an assumption, explore systematically the consequences of alternative assumptions in order to identify differences that make a difference

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# from **Predict** and **Act**
# to **Explore** and **Adapt**

from **predict** to **explore**

- Scenario discovery (Bryant & Lempert 2010)
- Robust multi-objective optimization (Kwakkel et al. 2015)
- Info-Gap decision theory (Ben Haim, 2001; Hall et al. 2012)
- Adaptation tipping points (Kwadijk et al 2010)
- Decision scaling (Brown et al. 2012; LeRoy Poff et al. 2015)

from **act** to **adapt**

- Assumption-Based Planning (Dewar  et al.1993)
- Adaptive Policymaking (Kwakkel et al 2010)
- Dynamic Adaptive Policy Pathways (Haasnoot et al. 2013)
- Robust Decision Making (Lempert & Collins 2007)

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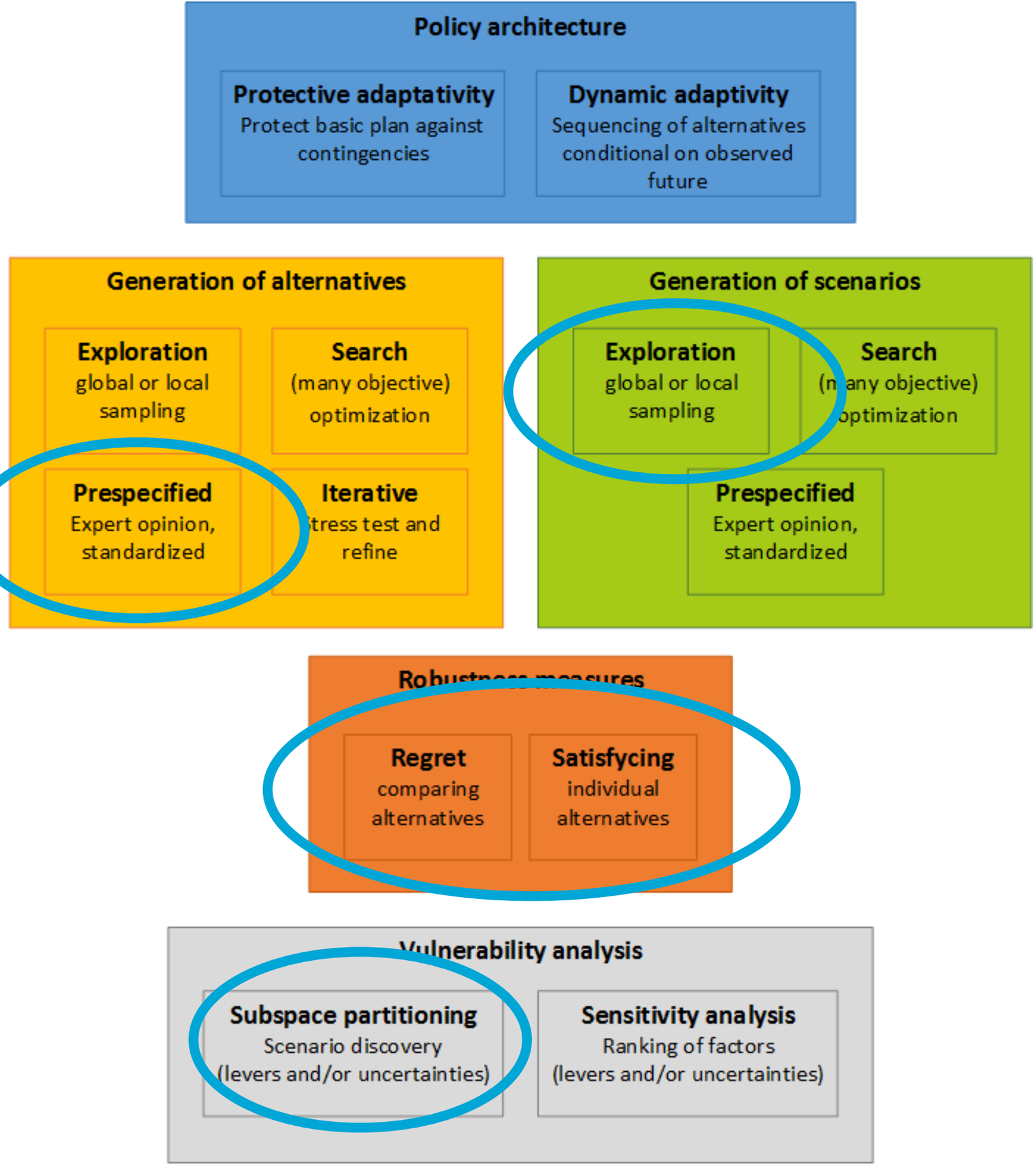
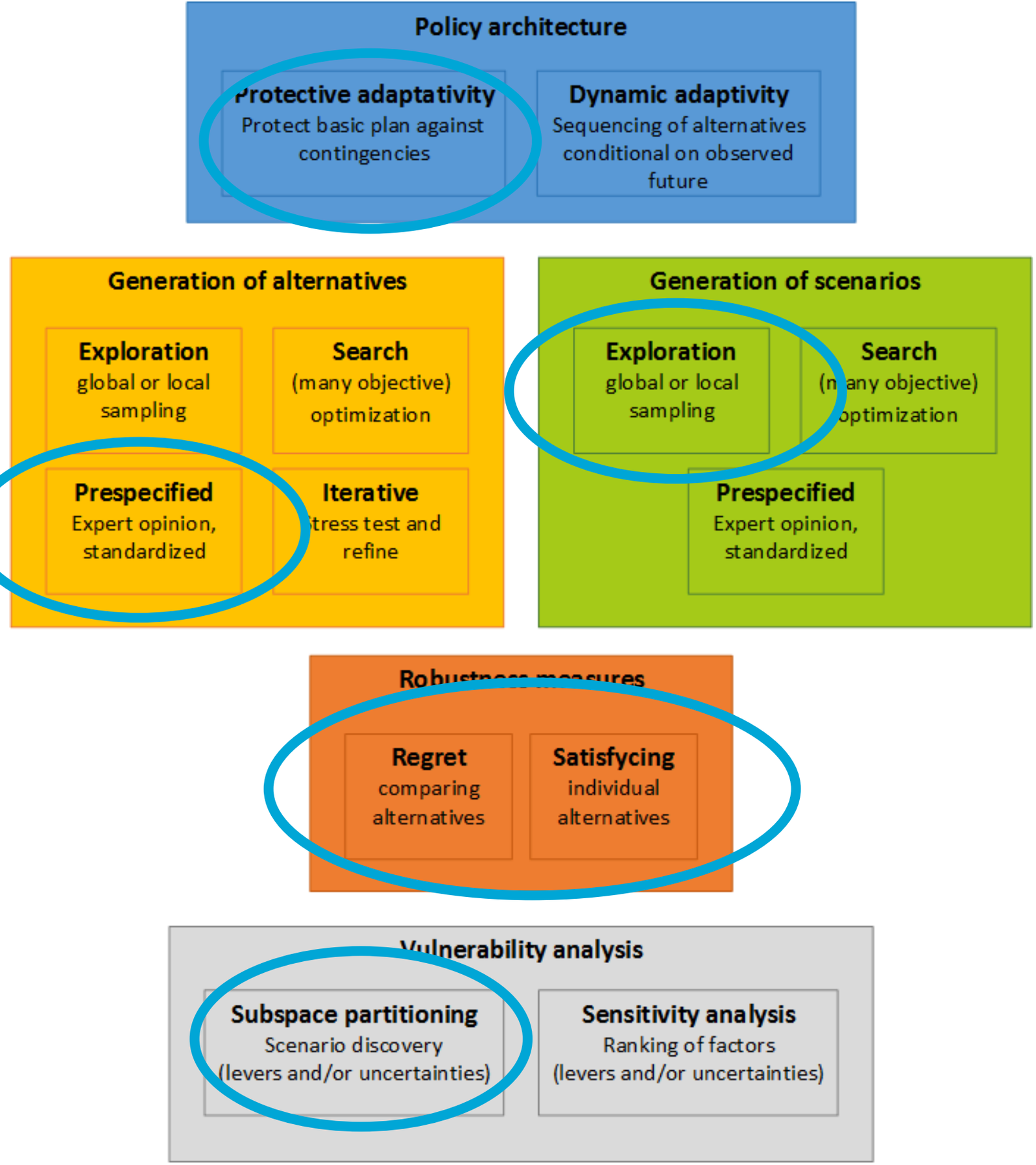
Walker, W.E., M. Haasnoot, and J.H. Kwakkel (2013) https://dx.doi.org/10.3390/su5030955




Inspired by Herman *et al*.(2015) How should robustness be defined for water systems planning under change. doi: 10.1061/(ASCE)WR.1943-5452.0000509

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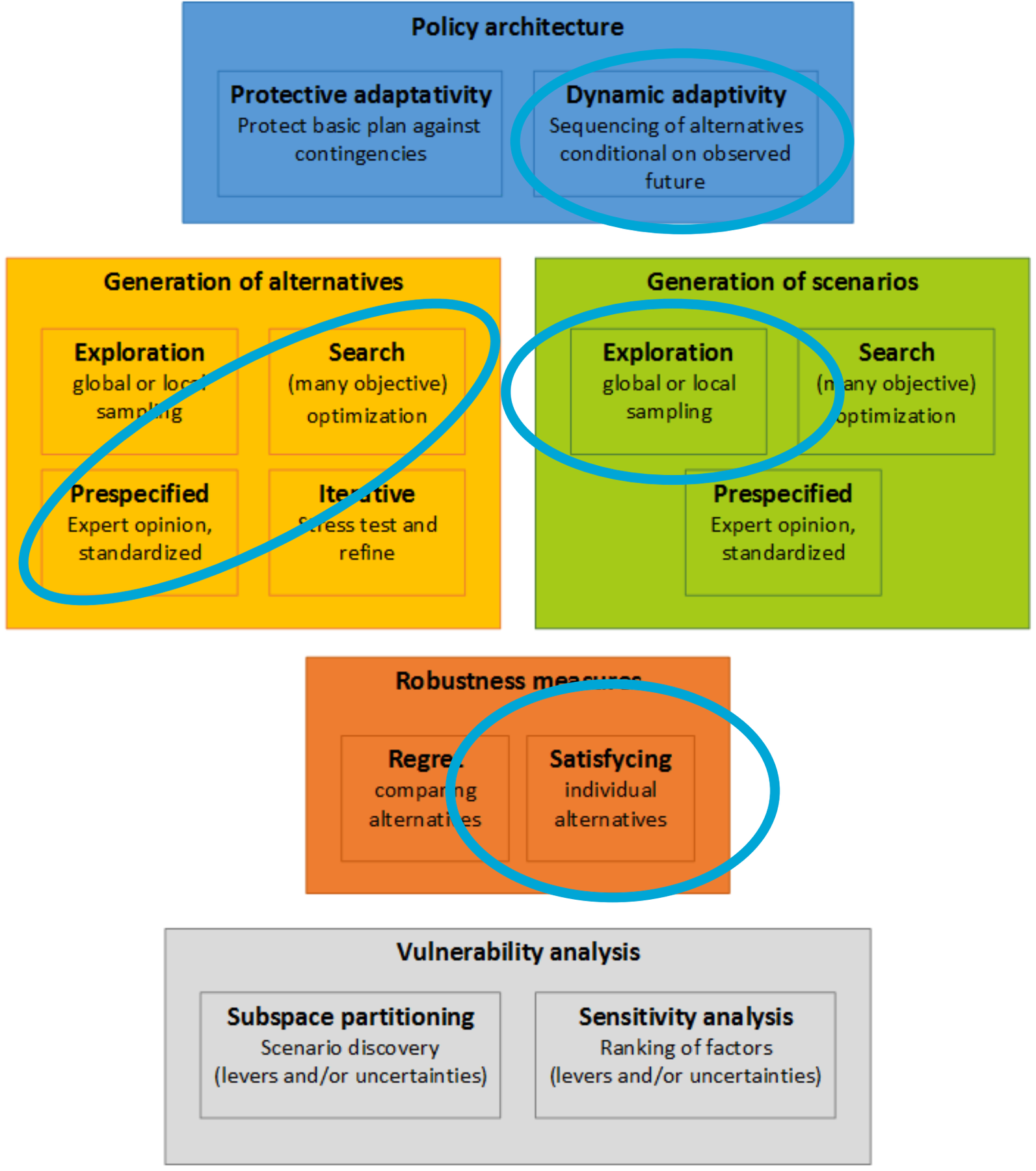


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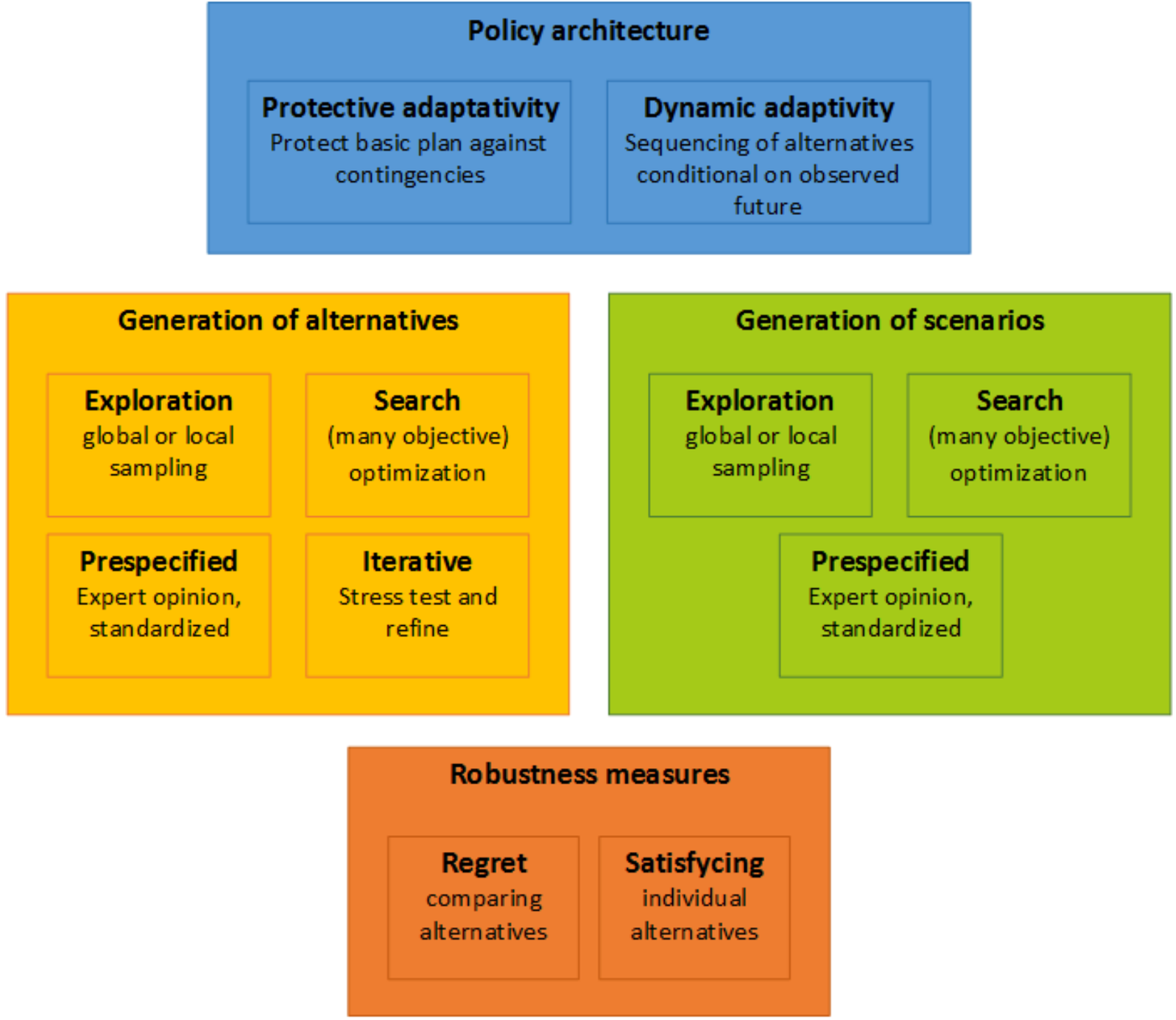
Policy architecture
Protective adaptativity
Protect basic plan against contingencies
Dynamic adaptivity
Sequencing of alternatives conditional on observed future
Generation of alternatives
Exploration
global or local sampling
Search
(many objective) optimization
Prespecified
Expert opinion, standardized
Iterative
Stress test and refine
Generation of scenarios
Exploration
global or local sampling
Search
(many objective) optimization
Prespecified
Expert opinion, standardized
Robustness measures
Regret
comparing alternatives
Satisfycing
individual alternatives
Vulnerability analysis
Subspace partitioning
Scenario discovery (levers and/or uncertainties)
Sensitivity analysis
Ranking of factors (levers and/or uncertainties)

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# Looking forward

Canonical approaches (e.g. RDM, MORDM, DAPP) are recipes. Recipes are great if you are learning to cook, but once mastered you can creatively recombine them as well as adapt them to your taste, skill, and what is available.

Research is needed to understand better what ingredients are used in the various recipes, which ingredients go well together, and how ingredients align with the specific context.

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