Tutorial: Multi-Criteria Decision Analysis (MCDA)

The tutorial is freely available at the SEAwise Github page of WP6 Taks 6.6 and at the quarto link

This tutorial showcases the R script *mcda.R* developed within the Seawise project under WP6 (see Garcia et al. 2025) and applies a fictional dataset to demonstrate its use. The tutorial illustrates how MCDA can be integrated to evaluate the effectiveness of climate and management scenarios with respect to different stakeholder objectives.

1.1 Intro Multi-Criteria Decision Analysis (MCDA)

In decision-making processes, we are often confronted with multiple options or scenarios, each carrying different values with respect to the criteria or attributes that we consider important. By comparing these criteria to reference thresholds, we can define our level of satisfaction with the different options.

However, decision-making is rarely straightforward: stakeholders usually have diverse interests, which generate conflicts and unresolved trade-offs among alternatives.

Multi-Criteria Decision Analysis, or MCDA, provide a structured framework to address this complexity. It allows decision-makers to recognise possible trade-offs, to account for conflicting viewpoints, and to evaluate objectives that cannot be reduced to a single monetary dimension. This is particularly relevant in natural resource management, as shown in previous studies by Mardle and Pascoe (1999), Andalecio (2010), and Melià and colleagues (2017).

Fisheries management is a clear example. Here, the challenge is to reconcile objectives such as maximising fishing yields and profits while minimising ecological and social impacts. The transition towards an ecosystem-based fisheries management approach complicates this even further because of the growing number of indicators used to describe the system. These indicators give us a holistic view of the ecosystem, but they also increase the number of conflicts and trade-offs that must be addressed.

1.2 Multi-Attribute Utility Theory

Among the different MCDA approaches, Multi-Attribute Utility Theory, or MAUT (Keeney and Raiffa 1993), has gained particular relevance in resource and environmental management (Rossetto et al. 2015). MAUT is based on the idea that decision-makers aim to maximise their overall satisfaction, or expected utility, across multiple independent attributes — each representing a decision objective. The performance of each objective is translated into a utility score, and these partial utilities are then aggregated into a single measure of overall performance. This facilitates clear comparisons among management scenarios, promotes stakeholder engagement, and supports transparent, evidence-based policies.

The main steps of MAUT are the following:

- identifying decision objectives and relevant indicators (attributes) to measure performance with respect to each of them;
- developing utility functions that express the desirability, or satisfaction, associated with a given indicator value;
- assigning weights to attributes reflecting their importance in the decision;
- aggregating weighted utilities into a composite score representing the overall performance of a scenario;
- comparing scenarios in terms of overall performance.

1.3 Seawise MCDA example

In Seawise, we identified six macro-criteria, each corresponding to a management criterion: conserving stocks, conserving biodiversity, conserving habitats, mitigating climate change, sustaining communities, and ensuring economic viability.

Macro Criterion	Attribute	Unit
Conserving Stocks	Spawning stock biomass (SSB)	Tonnes (t)
	Fishing mortality (F)	Fishing mortality * yr–1

Conserving Biodiversity	Mean maximum length across trophic guilds (MML)	cm
	Apex vertebrate predator biomass (AVPB)	Tonnes (t)
Conserving habitats	Relative benthic state (RBS)	% of area with RBS>0.8
Mitigating climate change	CO2 emissions per unit catch (CO2)	Tonnes of CO2 / kg landings
Sustaining communities	Wage (WAGE)	€
	Employment (EMPL)	Full-time equivalent (FTE)
	Ratio between small and large scale fishery landing value	%
Ensuring economic viability	Gross value added (GVA)	€

For every criterion, we defined one or more attributes, each associated with a utility function that maps its value to a range between zero — representing minimum satisfaction — and one — representing maximum satisfaction. Utility functions incorporated reference points whenever available; otherwise, the current value of the indicator served as a baseline. The utility scores of the attributes are aggregated into macro-criteria scores, summarising the utility of each macro-category.

We then set up three weighting scenarios, simulating a potential combination of different management objectives:

- Equal weightings, all criteria are equally important when evaluating the performance of an alternative;
- Environment first, the criteria leaning towards the protection of the environment are weighted more than the economic criteria (ratio 5:1);
- Economic first, the criteria pointing towards economic benefits are favoured (5:1 ratio).

The results of the MCDA applied to the Seawise case studies are presented in the deliverable D6.12 (Garcia et al. 2025)