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TOOL for CONSEQUENCES MAPPING

CONTEXT

A risk-benefit *assessment* (RBA) is a key component of a comprehensive analysis that includes the assessment, management, and communication of risks and benefits for specific use cases, often using the steps of a multi-criteria decision analysis (MCDA). This MCDA method provides a structured and iterative framework that facilitates complex decision-making e.g. related to food safety (EFSA). Its multiple-step approach allows for the integration of quantitative and qualitative criteria along with stakeholder perspectives, represented as criteria weights.

These *consequences mappings* (CMs) differ from traditional risk-benefit assessments because no weights are assigned to the evaluation criteria. A risk-benefit tree is created per case without assigning any value to these risks and benefits in this stage. As such, literature-based RBMs follow the first three steps of the standard multi-criteria decision analysis (MCDA) framework, resulting in a shorter and lighter approach.

- Steps 1 & 2: Definition of a problem and a set of alternatives
- Step 3: Sketching of a risk-benefit tree and categorization according to sub-criteria

Rather than a top-down decision problem with predefined alternatives, the mappings will focus on a specific problem that is compared to one or multiple alternative scenario(s): either implementing the novel technology, not implementing the novel technology (often the current discourse / status quo) and an alternative scenario (e.g. implementing any other solution). For each of these scenarios, potential consequences are mapped using available data from scientific and grey literature and available expertise (if relevant). These consequences can either be positive (benefits), negative (risks) or neutral (changes), indirect or direct and short or long-term. Mitigation measures for the potential negative consequences are mapped accordingly. Following the creation of the risk-benefit tree, all identified consequences can be categorized according to different sub-criteria, as a way of verifying that a broad range of consequences is taken into account. Sub-categories can include but are not limited to: environmental (e.g.: biodiversity, land use, human/animal health & safety), socioeconomic (e.g. income, inequalities) and technoscientific (e.g. protocols, tools) sub-criteria. An attention point for the last sub-criterium is that the focus should be on the consequences *of* the (implementation of the) technology. All risks or benefits *for* the (implementation of the) technology are no part of this consequences mapping.

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STEPWISE MANUAL

In this manual, the different steps of the RBMs are illustrated using the example of precision fermentation for food ingredients/additives.

STEPS 1 & 2: DECISION PROBLEM AND A SET OF ALTERNATIVES

In this step, we evaluate scenarios with or without a specific technology, in this case precision fermentation for food ingredients/additives. Further comparisons with other alternatives (e.g. other novel technologies) could be added if relevant.

Scenario 1	Future *without* precision fermentation = the original situation
Scenario 2	Future *with* precision fermentation = the alternative situation

It's important to fully understand and document the novel technology (e.g. precision fermentation) and its alternative(s). Since technologies can have multiple application fields, specific attention should be given to the context (e.g. precision fermentation for human food *versus* feed).

Important note

Always foresee a dated reference to the source of your information (list of references) and note down any consequences/mitigation measures you might already come across.

Some tips & tricks

- *Scientific literature* is a first go-to source of trustworthy information. A certain level of scientific knowledge might be required for research articles, while review papers are usually more accessible for a birds-eye overview. It's advisable to use different keywords and try synonyms to increase the reach of the search and to rely on peer-reviewed, published literature. Google scholar is a good starting point, complemented with thematic journals (e.g. Nature Microbiology). The reference list at the end of a scientific publication often provides additional resources that can be consulted. If a publication is not open access at a first glance, it might be worthwhile to expand the search to different websites or try via institutional access. Non-peer-reviewed preprints can be accessed via BioRxiv in case of need, but should be treated with caution.
- *Grey literature* can provide summarised, more accessible information. Expert publications outside of academia can be found on governmental, industry or other websites (e.g. NGO websites). As these websites are not always peer-reviewed, extra caution should be taken, and all info should be critically evaluated.
- If possible, *expert consultations* can help to fill knowledge gaps or clarify literature statements. This can be an in-person conversation with someone of your network, but online webinars or interviews might also be helpful.

STEP 3: SKETCHING OF A RISK-BENEFIT TREE AND CATEGORIZATION OF SUB-CRITERIA:

3.a: Mapping consequences and mitigation measures

As a first sub-step, a thorough literature search will need to be performed to map all consequences, including mitigation measures to overcome the risks of the technology in its specific context (e.g. precision fermentation for food) and in comparison to the current scenario (e.g. no precision fermentation). The risks *for* the technology (e.g. risk of low investments) should not be included; we focus on risks *of* implementing the technology.

Some tips & tricks

- It's often not necessary to read a scientific article fully. Most of the consequences will either be in the 'results' section or in the critical analysis of the 'discussion and conclusion' section. This last one often contains the mitigation measures. Searching for keywords like 'risk', 'benefit', 'advantage', 'consequence', 'impact' etc also helps to browse through different article sections, and AI-based summaries might help identifying risks and benefits. You might notice that risks are often easier to find and better documented than other consequences, as scientific articles always need to include critical reflections. When new literature sources do not provide new input anymore, the search can be considered complete.
- The tips and tricks related to literature searches of step 1&2 also apply here. Expert consultations might be particularly useful for discussing mitigation measures.
- Practically, an excel file might be most convenient to make the risk-benefit tree. A raw file with all risks, benefits and mitigation measures per literature source (publication,...) should be created at first in order to track literature references. The 'raw' excel file can be copied and 'cleaned' by deleting all duplicate risks/benefits/mitigation measures. Here, all risks will be in one column, with associated mitigation measures in the column next to it. In a third column or in another tab, all benefits and other consequences can be listed (unrelated to the risks).

3b: Categorising risks and benefits

All input can now be divided in different categories:

Environment, health & safety	Everything related to human, animal and planetary health
Socioeconomic	All economic, societal or social implications
Techno-scientific	Technical, technological and scientific implications

The easiest way to make this categorisation is asking yourself in which domain a stakeholder is most impacted by the technology: is its health affected (e.g. risk of allergies) then you're dealing with a risk of the first category, is its financial situation impacted (e.g. risk of losing income) then we're probably in the socio-economic category, and technical challenges (e.g. upscaling) are rather techno-scientific. Each category has different dimensions: environment, health and safety can range from biodiversity to land and energy use, human and animal health, misuse and bioterrorism, long-term effects etc. Socioeconomic covers everything related to livelihood, social situation, culture & traditions, religion and beliefs, equity and equality, financial situation, global vs local markets, competition, investments etc. The technoscientific category is mainly related to reputation, (dis)trust and investments in science or technology or platform development etc. After mapping, the different categories can be colour-coded to have a better overview, resulting in a complete risk-benefit mapping excel file (see addendum). In a next step, this table will be translated to laymen's terms before starting the co-creation phase so that everything is clear and understandable for a more general audience.

Below is an example of risks, benefits and mitigation measures of a case of precision fermentation:

	Risk	**Benefit**	**Mitigation measure**
Socio-economic	Example 1: Competition with traditional farming: threatens the livelihood of (small) farmers and small local companies.	A future in which different production methods coexist is most likely. Also, this technology still depends on agriculture to create 'feed' for the cells and will thus create a shift in farming rather than replace it.	Example 1: Easy to produce Halal, Kosher and 'animal-free' ingredients
Environment, health and safety	Example 1: Micro-organisms may produce unwanted components that have undesirable effects on health or cause allergic reactions.	A problem that is no different from current practices, as proven by history (ex. ergotism) Enforce thorough mechanisms to monitor and control the process and the final product to ensure no unwanted negative effects on health.	Example 1: Compounds can be tailored to avoid allergic reactions or have specific nutritional advantages
Techno-scientific	Example 1: Mistakes, misuse and failure to take action might cause problems for future research and might give science a bad reputation	Open and transparant communication on the scientific process, including potential pitfalls is necessary.	Example 1: Production method results in very pure ingredients

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Funded by
the European Union