

Background

Implementation of remedial actions after a radiological contamination of the environment has to take into account, alongside with radiological and feasibility criteria, also the acceptability of the countermeasures, ethical and environmental considerations, as well as the spatial variation and the needs of people in urban, rural and industrial environments. This highlights multi-criteria analysis as a suitable tool, since it is able to structure discussions and to facilitate a common understanding of the decision problem, with the values and priorities of the actors involved. The related theoretical framework, multi-criteria decision aid (MCDA), has emerged from the operational research field as an answer given to a couple of important questions encountered in complex decision problems. Firstly, the aim is not to replace the decision maker with a mathematical model, but to support him to construct his solution by describing and evaluating his options. Secondly, instead of using a unique criterion capturing all aspects of the problem, in MCDA one seeks to build multiple criteria, representing several points of view. The methods belonging to MCDA can be classified as multi-attribute utility/value methods, outranking methods and interactive methods.

Past attempts to apply multi-criteria analysis in the context of nuclear emergency management have highlighted however the need to better integrate the operational and socio-political context of the decision-making process into the tools and models developed for decision-support.

Objectives

This PhD project had two main objectives: 1) to develop a multi-criteria decision aid model for the decision problem on countermeasures for contaminated milk, that better accommodates the nuclear crisis management context in Belgium and 2) to build prototype tools implementing and demonstrating the methodology developed.

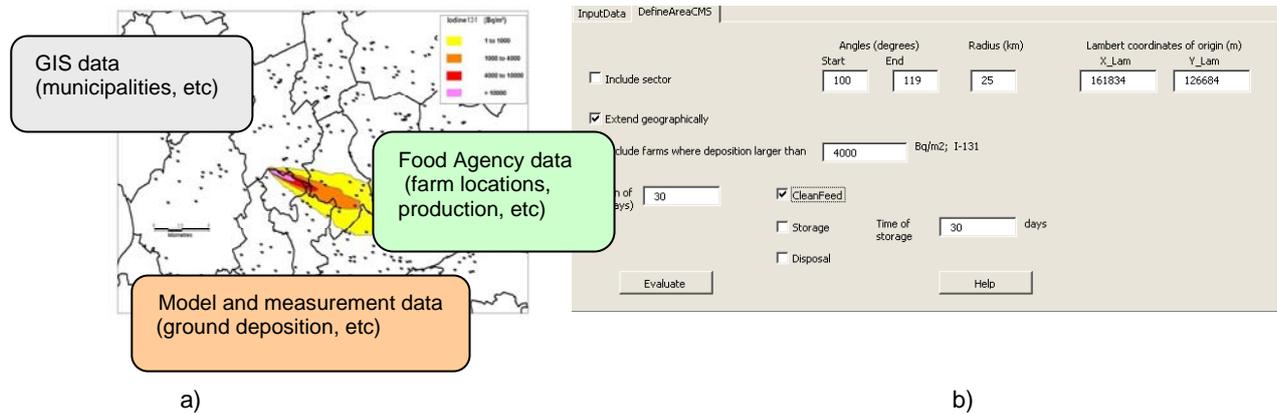
Principal results

The nature of the problem addressed has inherently led to a number of multi-disciplinary research routes, all of these bringing their contribution to the problem definition, structuring and solving. Firstly, a critical review was made on the governmental use of MCDA, given that nuclear crisis management takes place in Belgium at a federal level. MCDA has seen a widespread decision support function in the last decades and sometimes is even legally prescribed. MCDA is generally chosen in order to gain insight into the complexity of public good decisions with consequences on multiple dimensions (economic, social, environmental and institutional, etc), or when these decisions are coupled with uncertainty. Some practical issues to be considered when using multi-criteria analysis are summarised in the table below.

Strengths of multi-criteria analysis	Difficulties in multi-criteria analysis
Learning process, stimulates discussions, brings a common understanding of the problem	Technical complexity, e.g. elicitation of parameters
Openness to divergent values and opinions	Choice of stakeholders and timing of their participation
Capability to tackle qualitative and intangible factors	User-driven subjectivity in the evaluation criteria
Accountability (systematic, transparent)	Decide on the degree of simplification of the decision content
Conflict resolution; helps reaching a political compromise	Potentially time consuming process
Supports a broad stakeholder participation	Experts' reluctance to share their knowledge/power
Helps legitimise decision-makers' behaviour	Decision-makers may prefer exemplary decisions
Integration natural and increasingly used at local level for environmental decisions	On a higher decision level, experts are more suspicious of new instruments
Preferences revealed in a more direct and practical way	Information bias from certain stakeholder groups

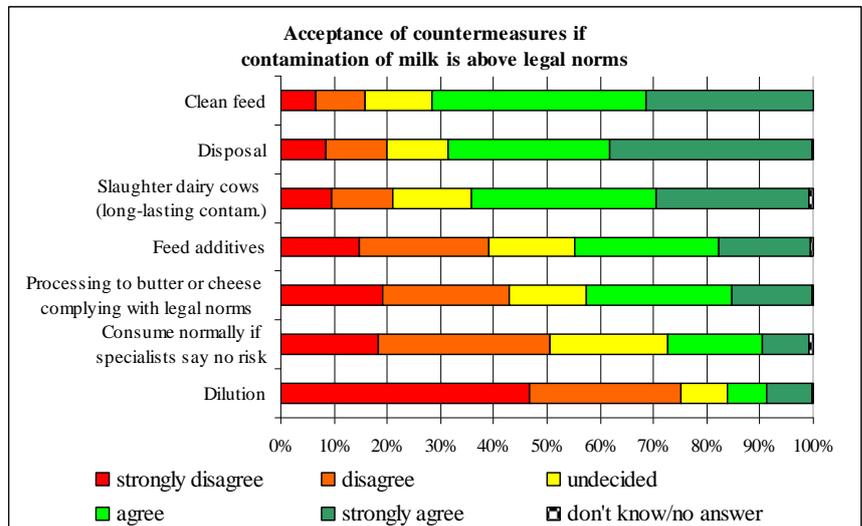
Strengths and difficulties in the use of multi-criteria analysis in public decision-making

The key elements of a multi-criteria decision aid model for the management of contaminated milk were derived through a stakeholders process. This allowed a thorough interaction with multiple stakeholders, as well as the exploration of a broad spectrum of decision aid methods. Related to the latter aspect, we see that in the context of nuclear emergency management, in a majority of situations when MCDA has been proposed for facilitating the decision-process, the use of such tools has been restricted to multi-attribute utility/value methods. On the other hand, a number of characteristics of the problem studied (e.g. tradeoffs between criteria are difficult to assess) suggest that outranking methods might be a valuable alternative. The stakeholder process had also an important learning dimension. The discussions about the definition of potential actions revealed for instance the need for more flexible and pragmatic modelling tools for evaluating feasible countermeasure strategies. We have addressed this by developing two prototype tools that integrate several types of data: geographical, production-related and food chain modelling data. An example is provided in the figure below.



Integration of various types of data and selection of areas and countermeasures: concept (a) and user interface (b)

A family of evaluation criteria for potential actions was built and may be used in future emergency exercises. One such criterion is public acceptance, which has been revealed as an essential criterion. To have a better assessment of it, we included in a public survey in Belgium (SCK•CEN 2006 Barometer) a number of issues relevant for the decision-making process: 1) public acceptance of various countermeasures; 2) consumer's behaviour. A tendency towards a precautionary policy is revealed by these results: although normal consumption seems well accepted for contaminations below legal norms, this is not reflected by the expressed consumer's behaviour. In order to compare the acceptance of various countermeasures at the level of the whole population, such that this information can be further used in a multi-criteria analysis, several methods are proposed. One of these methods is based on stochastic dominance and yields a preference-based ordering of the various countermeasures. Despite the inherent uncertainty connected to assessing the public acceptance of countermeasures in "peace time" we consider that our study is useful for emergency planning purposes, especially for situations when there is a time constraint as it is the case for the management of contaminated milk.



Concerning the relative importance of the evaluation criteria, most stakeholders interviewed inclined towards a qualitative expression of such information. We have therefore adopted an outranking approach and modelled comprehensive preferences through ordinal aggregation. The choice of the ranking procedure to be used subsequently took account of desirable properties and yielded satisfactory results for a set of case-studies analysed. A number of algorithms touching on the robustness analysis of results have been proposed for the preference aggregation method chosen. To provide a clearer interpretation of the analysis, we have also proposed and implemented a visual representation of the resulting ranks together with the comprehensive preference relation.

Future developments

Further validation in exercises and workshops will contribute to improving the proposed methodology. Additionally, the codes of the prototype tools can be adapted for future use in connection with a Geographical Information System.

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Main references

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