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Practical guide to establishing a multi-criteria and multi-actor decision-making process: Steps and tools

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1 Introduction

The purpose of this guide is to present steps and tools to establish a decision-aid process in an organization linked to public health. This decision-aid process is based on a multi-criteria analysis and is open to the potential participation of the actors (also called stakeholders) involved in the problem being addressed by the decision-making process. Figure 1 shows the decision tree of a typical planning process and maps out correspondences with the steps in a participatory multi-criteria decision-aid (MCDA) process.

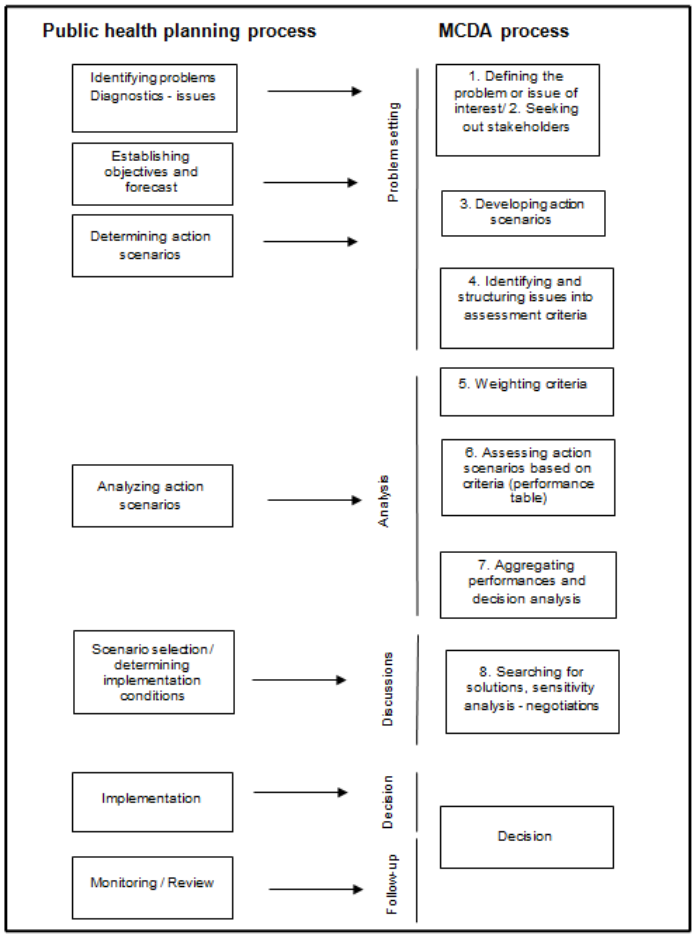


Figure 1: Public health planning process and MCDA processes

We are looking at the case where an organization linked to public health wants to either clearly understand or explore a problem, or make a decision about the implementation of actions, measures or interventions related to the management of Lyme disease or other vector-borne diseases. These are complex problems, not only because of the range of disciplines mobilized to face the issues at play, but also because of the involvement of diverse actors who may have contradictory points of view.

The organization must therefore see the opportunity not only to make a sound knowledge-based decision, but also to establish a decision-aid process that will help construct one or more solutions that are acceptable, legitimate and appropriate for those who have to implement and manage them, as well as for those who will face the positive and negative impacts. It must also do this in consideration of the means it has at its disposal (ex. human resources and skills that can be mobilized, time, financial resources). While several people may contribute at various stages of the decision-making process, ultimately, the decision on the problem posed by the organization will be made by a final decision-maker who represents the organization and is accountable.

As Taibi and Waaub (2015, p.7) pointed out, "the multi-criteria decision-aid process can mobilize either a sole decision-maker or a number of actors. Most of the time, an analyst specialized in decision aid will direct the process, unless the decision-maker is the only person involved. In such cases, it is important to ensure that the decision-maker has the expertise required. To ensure the credibility of the decision-making process and the legitimacy of the ensuing decision, it is strongly recommended that a group process be led by a qualified person who is recognized as such by the parties involved, and that this person be accompanied by a specialist in decision aid to manage the technical aspects. These two roles may be taken on by the same person, depending on the problem's scope and the available resources. In such cases, it is important to be vigilant about the skills needed for these two fundamentally different roles" [translation].

For the problems we are interested in here, it is also strongly recommended to establish a participatory and contributory working group. Depending on the issue's history, it may be useful to adopt a cautious and gradual approach, especially considering that public health problems often cause concern in the population. Initially, the organization can take ownership of the problem by assigning work to internal experts or experts from other organizations already familiar with the issue. It may then decide to expand to a broader participatory process. Strategic or sensitive decisions may require a broader consultative process at a later stage in the process, for example, after the working group.

Establishing a participatory process therefore involves intertwined cognitive mechanisms to assure the quality of the arguments (knowledge-based decisions), as well as time for discussion, deliberation, consultation, and even negotiation, to take into account everyone's values as well as the political aspects.

This guide is organized into eight steps, which we propose as a decision-aid process (see Tool 1). They provide interested parties with a collaborative and contributive framework to understand and organize public health questions, such as those involving the management of Lyme disease or other vector-borne diseases. They also give the final decision-maker the information needed to clarify his or her understanding of the problem and to make the decision.

Each of these steps is described in terms of the content, the role played by the various parties involved and the intermediate decisions. Activity and tool descriptions as well key points are also provided. The example of the pilot project on Lyme disease is used to illustrate each step (Bélanger et al., 2012; Aenishaenslin et al., 2013).

Tool 1: The eight steps in a multi-criteria decision-aid process

1. Define the problem – find the actors/stakeholders.
2. List possible or conceivable solutions (actions).
3. Identify the stakeholders' issues and organize them into criteria.
4. Assess the criteria: select indicators, determine rating scales and organize preferences.
5. Formalize the value systems involved: criteria weighting.
6. Assess how actions perform.
7. Aggregate overall preferences.
8. Construct a robust group of solutions.

This sequence is not necessarily linear since several methods allow for backtracking. In such cases, the analysts play an important decision-aid role, interacting with the decision-maker or the stakeholders.

2 Define the problem – find the actors/stakeholders

2.1 Defining the problem

The first step in the multi-criteria analysis process is to clearly define the problem and identify the actors/stakeholders concerned (see also Appendix A for further details on these concepts).

The problem is generally posed by the organization initiating the process, which may seize the opportunity to work with various actors to improve its understanding of the problem and to construct a more complete and shared definition of it. Therefore the search for the actors/stakeholders who will be invited to participate in decision-making is of paramount importance.

Once the actors/stakeholders are identified, it is useful to look back at the problem's definition. Indeed, giving a structure to the problem is one of MCDA's greatest contributions, because the way in which the problem is posed will influence the response. The confrontation of the stakeholders' different perceptions of the problem can be extremely constructive. This sometimes allows for a pluralistic redefinition of the problem objectifying its complexity, which is often reduced to a mechanical perspective arising from the tools available to handle the problem. We must remember that the problem's definition can continue to be consolidated throughout the process, at least within the limits set out by the working group (see below).

2.2 Actors, stakeholders

The concept of an *actor* is the one defined by Roy and Bouyssou (1993, p.64): "Individuals or groups of individuals are **actors** in a decision-making process if, through their value system, they directly or indirectly influence the decision, be it in the first degree because of their intentions, or in the second degree because of how they involve the intentions of others." The authors (1993, p.20, in Côté and Waaub, 2015) distinguish between two categories of actors: *interveners* and the *affected. Interveners* are people who, by their intervention, directly affect the decision based on the value system they represent. The *affected* are people (citizens, taxpayers, etc.) who, normally passively, are subjected to the consequences of the decision, which is only supposed to take into account their preferences.

The notion of **stakeholders** may be difficult to grasp. It refers to the people (or groups) who have an interest in a common goal, problem or decision. Martel and Rousseau (1993, p.20) distinguish between two categories of stakeholders: the people involved and the people affected. Stakeholders are considered involved when they participate in some way in the process of formulating and solving a problem. They can be said to have an interest because they are able to influence the course of actions directly. Other stakeholders or members of the public are not in a position to directly influence the problem's formulation or resolution because they do not participate in them. However, they are still affected by the decision.

In the rest of this guide, we use the concept of stakeholders.

2.3 Stakeholders involved in the decision-aid process

We can identify various categories of stakeholders involved in decision-making as a whole: the decision-maker(s), the process managers and the experts who support them, the working group participants, the officials who implement and follow-up on decisions, and the public.

The public consists of people for whom the problem resolution process is put in place, to whom the decisions apply, and who are impacted by the decision's positive and negative consequences. The public plays a more or less passive role in the decision-making process; however, it can be mobilized at various levels: in sector-based enquiries, consultations, voting, protests, etc.

Identifying the stakeholders can be done with the support of a subject-matter expert (ex. sociology, political science, organizational management, etc.). The literature proposes a large number of

approaches to identify stakeholders, a discussion of which could fill another guide; this falls outside the scope of this work.

From an organizational standpoint, various roles are taken on by either one or more organizations.

- Decision-making authority, which generally initiates the process (initial definition of the problem) and makes the final decision. We must be especially careful not to limit the search for solutions to the areas of expertise of the decision-making authority. Because public health problems are complex, they may require the collaboration of various decision-making authorities, which must be coordinated.
- Authority in charge of the decision-making process, or the one that handles administrative matters and also supports the process itself. A range of skills can be mobilized for this purpose, either directly within the authority in question, or contracted by it. This includes industry experts in public health, ecology (ecosystems, plants, wildlife, physical components, etc.), sociology, economics and also decision aid. Many intermediate decisions of varying scopes can be made during the process to guide it.
- Authority or authorities responsible for implementing the decision. This authority is not necessarily also in charge of follow-up.

2.4 Prerequisites for a participatory process

The organization initiating the decision-making process must ensure that a number of conditions are met before embarking on establishing a participatory decision-making process (see Tool 2).

Tool 2: Prerequisites to consider before undertaking a multi-criteria process in a multi-actor context

1. Assess the organization's human and financial capacity as well as the time constraints to determine the feasibility of a participatory approach; and especially,
   (a) Assess the need and feasibility of establishing a decision-aid support team (composition, roles, humility position) and avoid the technocratic temptation;
   (b) Assess the organization's ability to establish a sense of fairness, especially through the potential use of a mediator/facilitator/communicator.
2. Assess the stakeholders' potential level of acceptance as compared to the organization's expectations in the following areas:
   (a) Decision-making (procedural legitimacy);
   (b) Representativeness of the working group in view of the problem posed.
3. Make sure the parties are willing to negotiate (defining the balance of power).
4. Ensure that the parties recognize the need to assess using several criteria.
5. Have confidence in the tools and avoid the temptation to use so-called "black box" super systems.

2.5 Stakeholders involved in the working group

Various stakeholders may be brought into the process, especially at the working group stage. This may include, for example, representatives of public organizations or civil servants whose elected representatives are accountable; representatives of economic sectors; representatives of civil society (multiplicity of interest groups); or representatives of organizations whose legitimacy is based on their expertise (orders or professional associations, universities etc.).

Identifying these stakeholders may be quite complex and require the input of subject-matter experts (see above). A simple way to address the issue is to proceed in concentric circles starting from a basic nucleus. It may also be helpful to leave open the possibility of expanding the working group to include new stakeholders that may become interested in an action or issue at a later stage (see below).

Like Côté and Waaub (2015) we emphasize that "the criterion to apply in the search for actors should be relevance with regard to the identified issues rather than political representation. Thus,

specific individuals or organizations should be chosen on the basis of their representativeness relative to an "actor rationale" (elected officials, environmental or economic interest groups, affected people, etc.)" [translation].

In addition, organizations and stakeholders are represented by people in various positions and at multiple hierarchical levels. These aspects must be considered when making up the working group (see below). It is advisable, wherever possible, to have people who are at the same hierarchical level and who are duly mandated work together.

2.6 Make-up of a working group

Once the organization is certain about setting up a participatory process and feels the required conditions have been met, the first step in the process of multi-criteria analysis in a multi-actor context is to establish a working group. Setting up the working group must be done in concert with stakeholders and in an iterative manner. A number of steps must be carried out jointly (see Tool 3).

Tool 3: Aspects to consider when making up a working group

1. Actively seek out stakeholders.
2. Make sure the working group is representative of the milieu.
3. Ensure the stakeholders are representative of their home organization.
4. Give yourself the possibility of simulating fictitious stakeholders (absent, weak, etc.).
5. Agree on a mediator, facilitator or communicator.
6. Select a support team for the decision-aid process (analysts) and make sure it is well accepted by working group participants.
7. Agree on a "statement of work" for the working group, reflecting the available resources (especially in terms of deadlines), mode of operation (information availability, intermediary decision-making, accountability, transparency, etc.), degree of involvement, conflict resolution mechanisms, etc.
8. Agree on the modes of communication to be used throughout the process.
9. Agree on the distribution of power within the working group.
10. Prepare and give all stakeholders training on the process and its related support tools.

Like the CRE-AT (2014, p.15), we believe "It is important to mention here that all participants... are considered to have equal influence in the decision-making process, regardless of the actual power each one has in society. Indeed the committee's mandate is to provide decision support to a competent authority that is responsible for implementing a compromise solution. It is the final decision-maker who is responsible to arbitrate, based on the decision support elements provided to him/her during the process. For the purposes of analysis, the different stakeholders are therefore considered to have equal influence and their views are weighted equally" [translation].

2.7 Key points: problem, stakeholders

- What is the problem posed?
- Who should be there to represent whom?
- At what level of decision-making?
- How does each stakeholder contribute to an understanding of the problem?

At the end of this step, the stakeholders must reach an agreement on the definition of the problem.

2.8 Lyme disease example: problem, stakeholders

In the case of the pilot project on Lyme disease in Quebec, the problem was posed by the Canadian Public Health Agency (CPHA), which initiated the project as the decision-making authority. Its experts established the scientific and social relevance of working on tools to manage this disease and

other vector-borne diseases, which had been spreading gradually in Canada for several years and are likely to continue to spread as a result of climate change.

The means were established by CPHA through the input of our research team, led by Denise Bélanger with the collaboration of Jean-Philippe Waaub, over a period of two years and according to the terms of a contribution agreement. This team therefore acted as the authority in charge of the decision-making process.

The problem consisted of prioritizing interventions to monitor and control the disease, either at the provincial policy level (Quebec's public health institute—Institut national de santé publique du Québec, or INSPQ) or at the regional level (Montérégie public health department—Direction de la santé publique de la Montérégie). The problem of prioritizing communications tools for various audiences was first broached at the regional level. These organizations, along with the CPHA itself, are the authorities that could potentially be partly responsible for the decision's implementation, even if coordination with other organizations should be considered.

The research team identified a first circle of stakeholders from competent organizations (INSPQ and the Montérégie public health department). In concert with them, and given the project's exploratory nature, it was decided to use a cautious approach to prevent raising expectations or causing excessive fear among the broader circle of all potential stakeholders. The stakeholders involved were therefore restricted to those directly involved in managing the problem within these organizations and their closest partners. The idea was to test an innovative approach within a limited context, in order to face the challenges inherent to the project's "pilot" nature (learning), and to maximize interactions with participants and ensure proper ownership of the process and of the tools within this "inner circle" of stakeholders.

3 List possible or conceivable solutions (actions)

3.1 Identifying the actions

During this second stage, the stakeholders, with the help of the decision-aid analysts must select a set of possible actions (or action scenarios) to address the defined problem. It is also at this stage that multi-criteria negotiations begin (see Appendices B to D). The stakeholders must agree on a reasonable number of actions. Still using an iterative logic, this is also an opportunity to ensure that the problem is well posed and that the proposed solutions are relevant.

Several methods are available to develop the list of actions (see Tool 4). There is an extensive literature on this subject (e.g.: Roy and Bouyssou, 1993; Checkland and Scholes, 1990; Macharis, Springael, De Brucker and Verbeke, 2003; Guay and Waaub, 2015). A discussion of this topic would require another paper, which falls outside the scope of this work.

Tool 4: Ways of developing the list of possible or conceivable solutions (actions)

- Simple enumeration within a known set.
- Bibliographic research to establish the list of potential solutions.
- Construction of a hierarchy of goals, whose execution may require a few choices at every level. Note that, with this method, the number of actions increases very quickly. For example, 3 goals, each involving 3 possibilities, lead to the construction of 27 potential actions.
- Construction of actions corresponding to various visions or intervention approaches, which the stakeholders generally represent.
- Mapping approach and use of geographic information systems.
- Soft systems methodology.

3.2 Key points: actions to assess

- Is the objective well identified? Should the definition of the problem be reassessed?
  - Clarify whether the goal of the exercise is to select an action or a basket of complementary actions (portfolio).
  - Often, problems are defined in terms of the following: the areas of expertise of the responsible institutions (federal/provincial/regional/municipal); the available tools and data; the available human and financial resources; etc.
- Do the proposed alternatives or actions address the problem, in accordance with the institutional context, level of decision-making, etc.?

3.3 Lyme disease example: actions to assess

With regard to Lyme disease, we propose various actions (interventions) drawn from (Bélanger et al., 2012; Aenishaenslin et al., 2013) (see Tables 1 and 2).

In the case of the pilot project, a hybrid approach was used to identify monitoring and control actions. In the first stage, the project team, made up of public health experts, parsed the problem through a literature review and, from there, established a preliminary list. It is recommended not to start from scratch when working with stakeholders and using a contributory approach. Note, on the one hand, that participants may be frustrated to have to start from scratch when the support team could have offered a basis for discussion. On the other hand, if the presented list already seems finished, this may sap their motivation to contribute. In a second stage, the list was consolidated during workshops with the selected stakeholders. The same process was followed for the communications actions. Combinations of actions were also constructed with a view to comparing them to each other.

Table 1: Examples of lists of Lyme disease surveillance actions

Surveillance actions

Categories	Codes	Actions
1	SURV1a	Passive surveillance of the vector Ixodes scapularis of human origin
	SURV1b	Passive surveillance of the vector Ixodes scapularisof animal origin
2	SURV2a	Active surveillance of the vector Ixodes scapularis (flannel method)
	SURV2b	Active surveillance of the vector Ixodes scapularis (capture and examination)
	SURV2c	Active surveillance of the vector Ixodes scapularis (deer)
3	SURV3a	Passive surveillance of seropositivity cases in Borrelia Burgdorferi in animals (ministry of agriculture)
	SURV3b	Passive surveillance of seropositivity cases in Borrelia Burgdorferi in animals (industry)
	SURV3c	Passive surveillance of seropositivity cases in Borrelia Burgdorferi in animals (subsidised)
4	SURV4	Active surveillance of LD cases in animals
5	SURV5	Passive surveillance of LD cases in humans
6	SURV6	Sentinel surveillance of suspected LD cases in humans

4 Identify and organize the stakeholders' issues into criteria

4.1 Identifying concerns and issues

At this stage in the process, stakeholders express their concerns and perceptions of the issues and needs. The analysts, experts in decision aid and public health, foster discussion in order to gradually consolidate a common and shared understanding of these issues with stakeholders (co-construction).

It is always good to prepare material to launch the discussions. Even if the analysts are familiar with the problem, their role is not to propose a finalized list that just needs to be adopted. Instead, the idea is to place participants within contributive dynamics, while ensuring ownership at both the individual and collective levels. Bring in the essential, easily defined elements to launch the discussions, and then step back to allow participants to contribute.

Table 2: Examples of lists of Lyme disease control actions

Categories	Codes	Actions
0	CONT0	Status quo, basic preventative communications
1	CONT1a	Small-scale environmental acaricide application on public land (peridomestic environment)
	CONT1b	Large-scale environmental acaricide application on public land (aerial spraying)
2	CONT2	Application of desiccants or insecticidal soaps
3	CONT3a	Small-scale habitat modification to reduce suitable habitats for ticks
	CONT3b	Large-scale habitat modification to reduce suitable habitats for ticks
4	CONT4	4-poster system
5	CONT5	Oral treatment for deer
6	CONT6a	Reduction in deer populations by increasing hunting quotas
	CONT6b	Reduction in deer populations through culling
7	CONT7	Containment of deer by installing barriers
8	CONT8	Damminix system
9	CONT9	Installation of bait boxes to treat rodents with Fipronil
10	CONT10	Exclusion of individuals in high-risk public areas
11	CONT11	Vaccination
12	CONT12	Special clinics for diagnosis and treatment of Lyme disease

As mentioned by the CRE-AT (2014, p.20 and p.22), "The challenge is the emergence of ideas. Often, the most meaningful conversations and the best ideas are lost because they are not properly listened to, expressed, understood or followed-up on... Creating the ideal climate is necessary to allow ideas to emerge. This means taking the time to listen for the participants' intent within their contribution to the meeting, as well as their mindset, their goals. The very fact that the participants are expressing something predisposes them to be committed to the meeting [translation]."

Stakeholders must be able to express their concerns during the discussions, and analysts must help them to first reveal/identify these concerns, and to then organize them into issues. An issue may be defined as something that can "improve" or "worsen" a situation, or, more prosaically, a "win" or a "loss".

Different MCDA procedures (stages) are possible. Each has its advantages and limitations (see Appendix B).

Issues are constructed and defined through the stakeholders' interactions (see Tools 11 and 12 in the Appendix, which respectively address meeting facilitation and facilitation tools for the meetings). In some circumstances, where, for example, the issues are highly divisive, it is better to identify the issues before defining the actions in detail, to prevent the stakeholders from being tempted to guide the issues toward a given action. Once the issues are validated by the working group, they are then formalized into criteria by the support team.

4.2 Translating issues into criteria

Translating the issues into criteria consists in seeking the cloud of consequences for each potential action (expressed by stakeholders as concerns or issues), and then breaking down the clouds into basic consequences, that is, untangling the verbal complexities into a series of simple items (translation operation often carried out by the decision-aid experts). This comes down to defining measurable criteria that reflect the issues identified as being essential to the decision. The analysts translate these into performance criteria. The listed criteria should have these properties:

- **Exhaustiveness:** No criteria must be forgotten.
- **Consistency:** Consistency between the local preferences of each criterion and the global preferences.
- **Non-redundancy:** Criteria should not be duplicated, that is, there should not be more criteria than necessary.

It is preferable to adopt a flexible and pragmatic approach so that stakeholders take ownership of the problem and have confidence in the way it is being analyzed. It is up to the analysts to ensure that the list is exhaustive and consistent. On the issue of redundancy, the analysts may choose to tolerate some redundancy to ensure the stakeholders' support for the proposed evaluation model. On the other hand, in such a case, it is important to be careful during the weighting stage to ensure that the redundant criteria are not overvalued.

It is good to **validate the criteria** with the working group. Experience has shown that, with complex problems, this step may take two or three rounds. The key is to establish a working basis, according to a common and shared understanding. A solid working basis is a major asset for the rest of the process and is often an important factor in saving time throughout the process.

4.3 Key points: issues and criteria

- Importance of clarifying the meaning given to the expressions used by stakeholders to express their concerns.
- Check that the list of criteria meets the properties of exhaustiveness, consistency and non-redundancy, but adopt a flexible approach that promotes the stakeholders' support for the process.

At the end of this step, the working group will have validated the list of criteria and the detailed actions to be assessed.

4.4 Lyme disease example: criteria and categories

With respect to Lyme disease, we offer a baseline for consideration, whether for the broad categories of criteria or the list of detailed criteria. Table 3 uses the final list from the pilot project (Aenishaenslin et al., 2013).

Table 3: List of categories and criteria for Lyme disease

Category	Criteria
Public health criteria (PHC)	PHC1 Reduction in incidence of human cases PHC2 Reduction in entomological risk PHC3 Impacts of adverse health effects
Animal and environmental health criteria (AEC)	AEC 1 Impact on habitat AEC 2 Impact on wildlife
Social impact criteria (SIC)	SIC 1 Level of public acceptance SIC 2 Proportion of population benefitting from intervention
Strategic, economic and operational impact criteria (SEC)	SEC1 Cost to the public sector SEC2 Cost to the private sector SEC3 Delay before results SEC4 Complexity SEC5 Impact on organisation's credibility
Surveillance criteria (SUC)	SUC1 Detection of zones where tick populations are present SUC2 Identification of zones where tick populations are established SUC3 Identification of Lyme endemic zones SUC4 Quality of data

Source : Aenishaenslin et al. (2013)

5 Assess the criteria: select indicators, determine rating scales, organize preferences

5.1 Selecting indicators and rating scales

The next step is for the analysts to determine the indicator that will best represent each criterion. This indicator can be either qualitative or quantitative. Data availability is a major issue, although the Visual-PROMETHEE software makes it possible to process the problem even with missing data. A good indicator has several characteristics (see Table 4 below).

There are three broad categories of rating scales:

- A cardinal scale allows the intervals between values to be identified, ranked (hierarchy) and assigned meaning; it is compatible with logical, arithmetic and mathematical operations;
- An ordinal scale allows for identification and ranking (hierarchy), and is only compatible with logical operations;
- A nominal scale only allows for identification and is only compatible with a limited number of logical operations.

Table 4: Characteristics of a good indicator

Issues	Criteria	Definitions
Applicability	**Financial feasibility**	The costs associated to implementing and administering the indicators should not be too significant.
	Data availability	The data essential for calculating the indicator are readily available and updated at the required frequency.
	Clear	The indicator must not be ambiguous or interpretable in various ways. It must clearly and explicitly demonstrate what it is measuring.
Scientific relevance	**Scientifically valid**	The selected indicators must be based on quality-controlled measures and on well-founded scientific bases (theories, models).
	Comparable to a reference value	To be useful, the indicator must be comparable to standards, historic values or values from elsewhere. Insofar as possible, the units, subjects and time periods should be standardized.
	Predictive	The indicator must comprise a value that can be periodically reported, at a frequency that makes it possible to monitor the evolution of an environmental pressure, state or response. It must help identify trends.
Decision aid	**Representative**	The indicator allows for an understanding of the phenomenon analyzed relative to the objectives and problems that need solving.
	Easy to interpret	The indicator must be easy to understand for the targeted users. It must not only be comprehensible to the specialists who designed it.

Source : Risse and Waaub (1999)

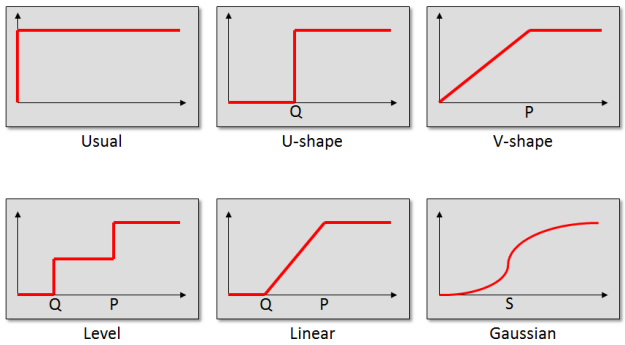
Selecting a measurement scale should also be based on the available data sources and on the resources (human, financial and time) required to collect and analyze them.

5.2 Preference functions

The next step is for each stakeholder to question how s/he takes into account the magnitude of the differences between the evaluations for each criterion. This is done by selecting a preference function for each criterion. This fundamental aspect of the approach is based on the premise that decision-makers and stakeholders always proceed by comparing assessments and by assigning preferences to observed gaps for each criterion and not to their absolute values. Moreover, the preference function standardizes the gaps between assessments and thus eliminates all scale effects related to the units with which the criteria are expressed.

A **preference function** therefore defines how differences in assessment for each pair of actions are translated into degrees of preference. It reflects the decision-maker's or stakeholder's perception of the rating scale. The Visual PROMETHEEE software offers six different shapes of preference functions to accommodate most practical situations (see Tool 5).

Tool 5: Directions for selecting a preference function by taking into account the type of measurement scale



Checklist
Preference Functions

1. Selecting a preference function:
   - Quantitative criterion:
     - Indifference threshold desired → Linear.
     - No indifference threshold → V-shape.
   - Qualitative criterion (or "discrete" quantitative):
     - Small number of strongly differentiated levels → Usual.
     - Higher number of less-differentiated levels → Level.
2. Determining corresponding threshold(s):
   - Q : from the bottom, starting with small gaps.
   - P : from the top, starting with large gaps.
   - S : between Q and P.

Source : Mareschal (2015)

To establish the preference structure, each stakeholder in the working group, potentially with support from the analysts, must set, depending on the applicable preference function, thresholds of *indifference (q)* and of *strict preference (p)*, as well as *low preference zones* for the selected criteria.

This information represents each stakeholder's viewpoint. For example, in the case of a new car purchase, different decision-makers could have a different assessment of the gap between the costs of two automobile models, based on their personal financial situations (e.g.: one decision-maker might be indifferent to a cost difference of $1,000 between the two models, while another might be indifferent to a difference of $3,000 or even more).

The parameter q (indifference threshold) is the largest difference between a pair of actions that a stakeholder can "tolerate" before the stakeholder's preference changes. Parameter p (strict preference threshold) is the smallest difference that can trigger a change from indifference to a strict preference.

These thresholds define zones that can be described as follows:

- **Zone of indifference**: where the difference between two actions is negligible and the decision-maker does not have a preference for either;
- **Low preference zone:** indicates a hesitation between indifference and strict preference for one action over another;
- **Strict preference zone**: where one action is distinctly preferred over another, based on their respective evaluations.

Stakeholders very often find it difficult to select a preference function associated with the criteria and to determine the thresholds, and require individual support from the analysts. Tool 5 provides a good starting point (see also Brans and Mareschal, 2002).

As a starting point for a type-5 preference function (linear), the analyst may suggest that the value of the standard deviation of the data be used for the indifference threshold (q), and two standard deviations for the strict preference threshold (p).
As a starting point for a type-3 function (V-shaped), the analyst may suggest that the strict preference threshold (p) be equal to the difference between the largest and the smallest evaluations of a criterion to be maximized.

5.3 Key points: measurement indicators and preference function

- Check the fit between the available data and the targeted criteria measurements by way of indicators; use qualitative scales as needed.
- The type of threshold set for each criterion corresponds to a shape of preference function associated with that criterion.
- Determining the preference structure is a very important step because it allows the decision-maker to either amplify or attenuate the impact of a criterion on the decision-making process.

At the end of this step, the evaluation model is finalized. All of the actions can be assessed for each of the criteria. The indicators and measurement scales have been selected on the basis of constraints (means; data). Stakeholders have had their say about the preference functions associated to the criteria.

5.4 Lyme disease example: indicators and measurement scales

As regards Lyme disease, we offer a baseline list of criteria and measurement scales taken from the pilot project, to serve as a starting point in the reflection process (Aenishaenslin et al., 2013) (See Table 5). In the pilot project, stakeholders were not consulted about preference functions or the associated parameter values. Given that the process consisted of designing a performance table for the actions that was shared by all stakeholders, the preference functions were established by the support team and then validated with the group. Several criteria were measured with qualitative scales, and a standard function was assigned to them. Quantitative criteria were assigned V-shaped functions, and the value of the strict preference threshold (p) was set according to the maximum amplitude of the data (see above).

6 Formalize the value systems involved: criteria weighting

6.1 Weighting criteria

The **criteria weighting stage** enables the stakeholders' value system to be formalized. Each criterion is assigned a weight that articulates its relative importance. The interplay of the weights thus translates the stakeholders' priorities or their relative preferences.

Table 5: List of criteria and measurement scales for Lyme disease

Criteria	Scale
PHC1 Reduction in incidence of human cases	0: Nil; 1: Low; 2: Moderate; 3: High
PHC2 Reduction in entomological risk	0: Nil; 1: Low; 2: Moderate; 3: High
PHC3 Impacts of adverse health effects	0: Nil; 1: Indirect effects on mental or social health; 2: Direct effects on physical health
AEC 1 Impact on habitat	Surface*Sensitivity*Intensity[1] Surface : 1: Nil; 2: Small scale; 3: Large scale; Sensitivity: 1: Nil; 2: Land; 3: Water ; 4: Land and water; Intensity: 1: Nil; 2: Fences; 3: Mowing; 4: Acaricides; 5: Removal of vegetation or burning
AEC 2 Impact on wildlife	Number*Species*Intensity[2] Number: 1: Nil; 2: Effect on specific species; 3 : Effect on several species; Species: 1: Nil, 2: low valued species; 3: Highly valued species; Intensity: 1: No effect; 2: Morbidity; 3: Mortality
SIC 1 Level of public acceptance	1: Nil; 2: Low; 3: Moderate; 4: High
SIC 2 Proportion of population benefitting from intervention	1:<25%; 2:25-50%; 3:50-75%; 4:>75%
SEC1 Cost to the public sector	0: Nil; 1: Low; 2: Moderate; 3: High
SEC2 Cost to the private sector	0: Nil; 1: Low; 2: Moderate; 3: High
SEC3 Delay before results	1: Days; 2: Weeks; 3: Months; 4: Years
SEC4 Complexity	1: Simple (minor institutional changes); 2:Intermediate (necessitates new hires); 3: Moderate (necessitate new work teams in one sector of intervention); 4: Complex (requires inter-sectoral/inter-institutional changes); 5: Very complex (necessitates creation of new structures or organisations)
SEC5 Impact on organisation's credibility	0: Nil; 1: Low; 2: Moderate; 3: High
SUC1 Detection of zones where tick populations are present	1: Less than 10%; 2: Low (11-50%); 3: Moderate (51-70%); 4: High (>71%)
SUC2 Identification of zones where tick populations are established	1: Less than 10%; 2: Low (11-50%); 3: Moderate (51-70%); 4: High (>71%)
SUC3 Identification of Lyme endemic zones	1: Less than10%; 2: Low (11-50%); 3: Moderate (51-70%); 4: High (>71%)
SUC4 Quality of data	1: Poor; 2: Medium; 3: High

Source : Aenishaenslin et al. (2013)

This information is very important because it directly affects the aggregation of preferences.

The stakeholders gathered around the table must independently and with the help of the analysts assign a relative weight to each criterion.

There are several methods to help stakeholders formulate their priorities regarding the criteria's relative importance, including allocating a maximum of 100 points to share among the criteria (see Tool 6), and the card game method (see Tool 7).

6.2 Key points: criteria weighting

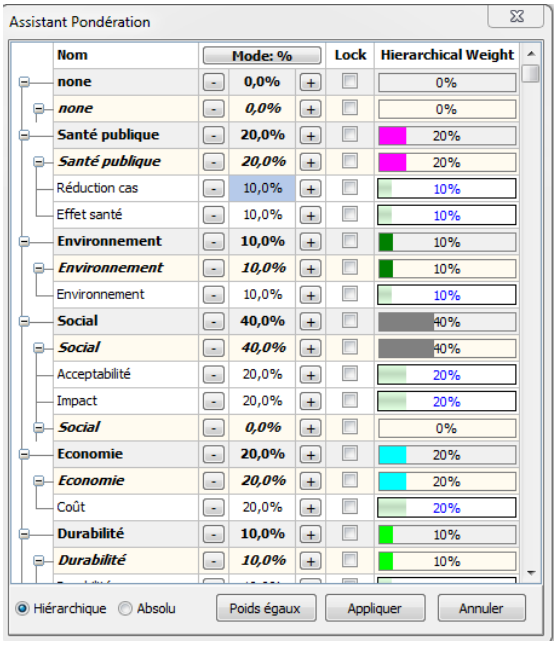
- Differentiate between our values and personal priorities, and those of the organization we represent.
- Is there any uncertainty about the interplay of weights?
- Would we use different weightings in normal vs. crisis situations?

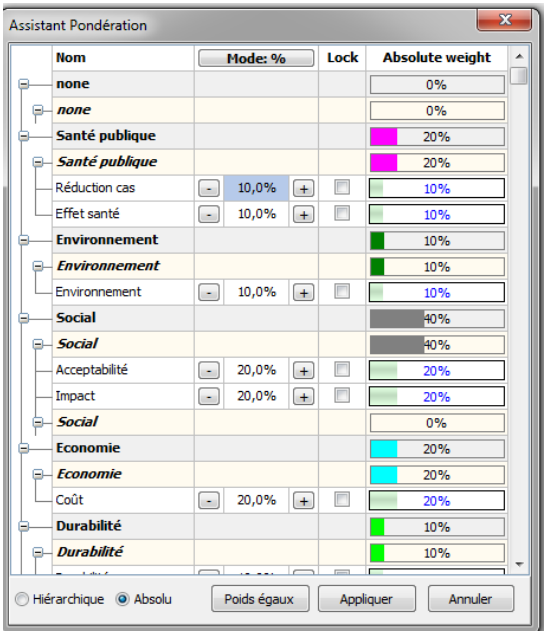
At the end of this step, each stakeholder has established the relative importance of each criterion according to his/her priorities.

Tool 6: Criteria weighting method: allocating 100 points

The 100-point method Each participant weights the criteria on the basis of his or her priorities and values. Two options are available. In hierarchical mode, 100 points are divided up among the criteria categories, according to their relative importance. The process is repeated for the criteria within each category. In absolute mode, the 100 points are allocated to the criteria directly. There may be up to three levels. The Visual PROMETHEUS (VP) software offers clusters, groups and criteria.

A questionnaire can be emailed to each member of the working group. Space is provided to write comments, especially where the points given are unusually high or low.





6.3 Lyme disease example: criteria weighting

In the pilot project on Lyme disease (Aenishaenslin et al., 2013), weights were assigned by each stakeholder under two scenarios. The first was the current epidemiological situation in Quebec ("emergence" situation). The second scenario consisted of a substantial increase in the annual number of cases reported in humans in Quebec, along with media coverage and increased awareness within the population ("epidemic" scenario). Weights were established by each stakeholder, using the method of allocating 100 points among the different categories of criteria and then 100 points among the criteria under each category (hierarchical approach). An Excel file was then used to convert the relative weights into absolute weights.

During the training workshops, a simplified version of the card game method was used.

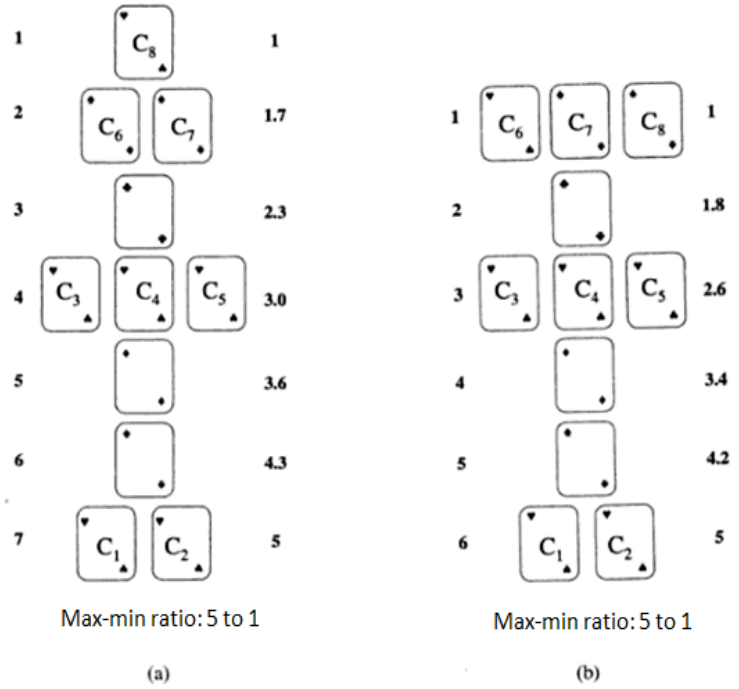
7 Assess how actions perform

7.1 Developing the performance table

During the evaluation stage, each action is assessed according to the measurement indicator(s) associated with each criterion. All of the ratings are then presented in a double-entry table called the matrix or performance table. We recommend that **a single table** be jointly constructed for the performance of the actions. This table will be the result of a sharing step that takes place beforehand and it will constitute a common and shared understanding of the problem.

Tool 7: Criteria weighting method: card game

Card game method (Maystre and Bollinger, 1999) Each stakeholder ranks all criteria in order of preference and then inserts cards between each one. A one-card gap will be assigned a difference of 1 in the weighting; a no-card gap will mean a difference of 0; etc.



A mathematical algorithm was proposed by Figueira and Roy (2002) for determining normalized weights from the positions in the card game.

Other methods allow each stakeholder to build his or her own performance table. Sharing then takes place later on in the discussions of the results that emerge from the individual and the more-or-less shared understanding of problem.

We feel it is more advantageous to have all the required discussions ahead of time, to clarify the issues, criteria and indicators. This also helps to distinguish between uncertainties and ambiguities. Uncertainties correspond to a probabilistic reality, while ambiguities are resolved bit by bit during the discussions, by verbally clarifying meaning.

Of course, each stakeholder also has the opportunity to express his or her own preferences (Section 7: preference functions; information about the assessment scales for each criterion) and his or her own priorities (Section 5: criteria weighting; information on criteria prioritization).

The analysts are involved to ensure process consistency and to measure validity for the subsequent multi-criteria analysis. Stakeholders are informed of the results after the analyses have been carried out according to appropriate sector-based methods. They will have the opportunity to provide feedback after an in-meeting presentation. This stage of interaction with the stakeholders, on the data and criteria evaluations, is useful for planning the **sensitivity analyses** (see Step 8 below) with regard to disagreements that may arise about the evaluation of some criteria and for any uncertainty regarding the data.

Once the matrix has been filled out, the decision-aid specialists apply the operational approach using the multi-criteria analysis tool (see following section and VP software guide).

This step can take up a great deal of time and human and financial resources. This is where it becomes appropriate to mobilize sector-based experts who thoroughly understand the stakes involved in the criteria, and where the necessary compromises must be made. It remains preferable to have

a qualitative evaluation for a criterion rather than eliminate it from the problem-solving process. It can also be very useful to indicate whether the data is reliable, uncertain, etc. This may allow the decision-makers to take steps that would make it possible to obtain better data in the future.

7.2 Key points: action performance table

- Co-constructing a common action performance table that is shared by all stakeholders.
- Determining the available means (human and financial resources, time) to measure the criteria and indicators according to appropriate sector-based approaches.
- Analyze the sources of uncertainty and the degree of measurement precision, to establish the sensitivity analyses that will be required for the evaluations.

At the end of this step, the discussion group has in hand all of the information needed to analyze the problem, be it factual information related to knowledge of the criteria, or information on the value of the gaps between evaluation criteria (preference functions; intra-criteria information) or on the stakeholders' priorities (weighting of criteria; inter-criteria information).

7.3 Lyme disease example: action performance table

In the pilot project on Lyme disease (Bélanger et al., 2012*;* Aenishaenslin et al., 2013), the development of the evaluation criteria and the evaluation of the actions according to those criteria were done by the research team and then validated with the stakeholders. The actions were assessed by the research team, which drew on data from the literature, surveys and consultations with experts. The DELPHI method (see also Appendix E) was used to assess the qualitative criteria. This method made it possible to produce a matrix of action performances across the various criteria.

8 Aggregating the stakeholders' preferences

8.1 Selecting an aggregation method and the analysis software

This step consists of "an operation to obtain information on the overall preference among all the potential actions, from information on preferences by criteria" (Maystre, Pictet and Simos, 1994). This is where the data from the assessments of the actions, thresholds and criteria weights are integrated into the multi-criteria analysis software and are processed.

We suggest using the PROMETHEE and GAIA methods executed by the Visual PROMETHEE software (see VP Software Manual and Tool 8). Note that the VP software has a number of functionalities that go far beyond the calculation of action rankings. It is especially well-known for its results visualization tools that create reports that are easy for stakeholders and decision-makers to understand.

The PROMETHEUS 5 module solves the problem of selecting a portfolio of actions by using the action performance evaluation and adding additional constraints.

There are other methods and software solutions available on the market (see Figueira, Salvatore and Ehrgott, 2005).

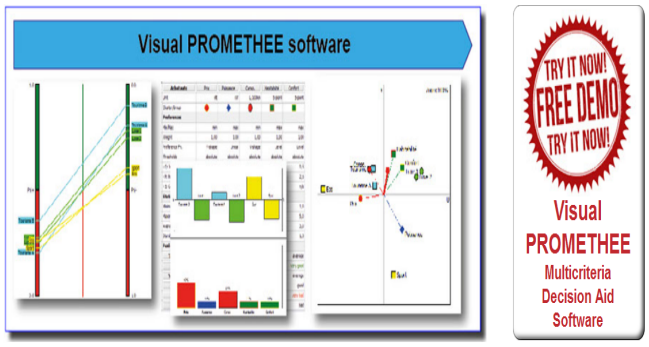
8.2 Single-actor results

With single-player aggregation, the result is a ranking of the actions for each stakeholder according to his or her preferences (see VP Software Manual and Tool 9).

Tool 9 presents the main questions that a stakeholder or decision-maker may ask him/herself and the analysis functions to help answer them. It is a good starting point in order to start a "participant's workbook" and to allow the participant to own his or her results.

Tool 8: Visual PROMETHEE software

The Visual PROMETHEE software exists in several languages, including English and French. An academic version is available free of charge. A business version is also available. (See http://www.promethee-gaia.net/softwareF.html)



Powerful, user-friendly, interactive software < 2 - 3 >

- http://biblio.promethee-gaia.net : over 900 scientific publications
- Visual PROMETHEE Users' Manual (PDF and e-book)
- Services: training, coaching, seminars
- http://blog.promethee-gaia.net
- http://faq.promethee-gaia.net
- LinkedIn, Twitter, ResearchGate groups, and more.

A sensitivity analysis is always possible at the end of this step, especially to factor in uncertainty about the interplay of weights and/or the values measured for the criteria (indicators).

8.3 Multi-actor results

Then, it is time to conduct the multi-criteria, multi-actor aggregation (with potential inclusion of the stakeholder-assigned weights) using a relatively similar procedure (see VP Software Guide and Tools 8 and 10).

This result must then be understood and validated by of the each stakeholder. The GDSS (Group Decision Support System) module in Visual PROMETHEE compares the individual rankings and generates an overall ranking that takes all the stakeholders into account (in VP GDSS, stakeholders are modelled as scenarios).

GAIA analysis is adapted to generate an overall visual representation of the criteria (importance to the decision, conflicts, synergies, etc.), a global visual representation of the stakeholders (coalitions, conflicts) and a visual representation of the role of each criterion.

Tool 10 presents the main questions a stakeholder or decision-maker may ask themselves, and the analysis functions that can help answer them. This is a good starting point for building a "group workbook" and to allow all of the stakeholders to take ownership of the results.

Tool 9: Single-actor questions to support the production of multi-criteria analysis results using Visual PROMETHEE

1. What is/are the best option(s)?
   - PROMETHEE rankings
2. Why is this a good option (strengths, weaknesses)?
   - GAIA, Profiles, Rainbow
3. What is the impact of the criteria weightings?
   - GAIA, Walking Weights
4. Why not select another option?
   - GAIA, Profiles, Rainbow
5. Did we forget any criteria?
   - Brainstorming
6. Is the proposed option a robust choice?
   - Visual Stability Intervals

Tool 10: Multi-actor questions to support the production of group multi-criteria analysis results using Visual PROMETHEE

1. Is there a consensus about the best option?
   - PROMETHEE group ranking, GAIA-Scenarios
2. Who disagrees with the proposed option? Why?
3. How does each stakeholder influence the proposed option?
4. Is it a robust option?

8.4 Key points: analysis results

- This step makes it possible to aggregate and model the overall preferences by taking into account the convergences and divergences expressed by the stakeholders during the decision-making process, while respecting the possibilities of non-comparability, of indifference and of preference for one action over another.
- Does a consensus emerge?

At the end of this step, stakeholders have their individual results and the multi-criteria analysis results for the group. Deliberations and negotiations can begin, with the support of the mediator/facilitator/communicator.

8.5 Lyme disease example: results

As indicated in the project's final report (Bélanger et al., 2012), "A summary document... was prepared for the participants... These summaries present the main analysis results and an interpretation. They were presented and discussed with the participants in the follow-up meetings..."

9 Construct a robust group of solutions

9.1 Sensitivity analyses

At this stage, the analysts interact with stakeholders to carry out sensitivity analyses on criteria weights and/or evaluations, on preference thresholds, etc.

This is an iterative process involving negotiations, and a consensus must emerge from it.

The sensitivity analysis is defined (Maystre et al. 1994, p.22) as an analysis consisting of repeating the original multi-criteria analysis while varying the values originally allocated to the various parameters, values that are often approximate or uncertain.

9.2 Negotiations between stakeholders

Once the results have been produced by the support team and they have been appropriated by the stakeholders, and once the sensitivity analyses have (at least in part) been done, then the deliberations and negotiations can begin. Appendices B, C and D offer tools and food for thought to facilitate the discussions. The mediator/facilitator/communicator can be instrumental in managing various sources of conflict. These must be clearly identified to deal with them appropriately. According to Taibi and Waaub (2015), "there may be conflicts: be they cognitive (risks, uncertainty, ambiguity, lack of knowledge, etc.) or based on personality, procedure, value system, interests, power or context relative to past relationships, etc. It is therefore important to establish conflict resolution mechanisms with the actors, in advance."

Negotiations must enable the construction of a negotiated solution. Building consensus can be very difficult. It involves searching for a compromise and, sometimes, resolving conflicts. Bourrée et al. (2008, p.416) define consensus as follows: "...a general agreement, be it tacit or expressed formally, among the members of a group. Consensus is an agreement about something, but it does not necessarily mean everyone agrees about everything, or unanimity. Consensus tends to make differences coexist, not eliminate them. As a method of knowledge production or decision-making, consensus emphasizes the importance of each participant's opinion and makes it possible to express a result that is not formally objected to."

There are several conditions that can promote (or not) the success of a participatory process (see Table 6). There are also several principles that can help us achieve these ends (see Appendix E, Tool 13).

It is important to note that if the discussions lead to compromises through the construction of new actions, it is not necessary to include them in the actions' performance table in order to compare them to the others and see if they rank first. Indeed, the aim of this process is not to select the best action in terms of its performance, but to assess the best possible compromises.

Table 6: Conditions for an effective participatory process

- Genuine dialogue facilitated by the process
- Stakeholders' credibility
- Pedagogy of the project under study
- Sound planning of the public participation mechanisms
- Influence on the final decision
- Inclusion of a meaningful follow-up process
- Consultation initiated by the authorities
- Timeliness of the consultation (as early as possible)
- Project with alternatives
- Clear, honest and true information
- Consultation performed in view of ultimately making a decision
- Consultation carried out so as to be accessible to the public.

9.3 Key points: sensitivity analyses and negotiations

- Who disagrees with the proposed solution? Why?
- How are stakeholder hesitancy and uncertainties and disagreements about the data taken into account and how do they influence the compromise solution?
- How does each stakeholder influence the compromise solution?

At the end of this step, the stakeholders have, with the analysts' support, explored the set of parameters for which a slight modification would likely influence the compromise situation. This information feeds the debate and allows the stakeholders to focus on hot-button issues.

9.4 Lyme disease example: balance sheet

The pilot project to prioritize Lyme disease monitoring and control interventions in Quebec (Bélanger et al., 2012; Aenishaenslin et al., 2013) clearly illustrated the relevance of using a multi-criteria approach to handle this problem. The analysis goes beyond simply ranking the potential interventions. It also gives their respective strengths and weaknesses, as well as other indicators linked to the stakeholders' priorities. What's more, this material may also allow stakeholders to think about a portfolio of interventions. It is rare, in fact, that a single measure can achieve the targeted objective.

The pilot project also demonstrated that the process itself is an important enrichment of the overall understanding of the problem and its possible solutions. In particular, it highlights the areas that are poorly or not documented, or for which there are incomplete, inaccurate, fragmented or uncertain data. In keeping with continuous improvement and social learning, the process generates a number of considerations about, for instance, the research required or the organizational measures that should be implemented to ensure better communication between stakeholders or to provide appropriate documentation of the issues, etc.

However, the same project (Bélanger et al., 2012) concluded that the approach was not very easy to implement and that it was not very relevant for prioritizing means of communication about Lyme disease, given the large number of actions or action combinations that could be implemented. It is therefore important to make sure that the problem posed can really benefit from a multi-criteria and multi-actor decision-making process.

10 Conclusions

Drawing inspiration from our varied experiences with the pilot project on Lyme disease and from our experience as trainers, and following the example of Taibi and Waaub (2015), we summarize in conclusion the advantages and limitations of using multi-criteria, multi-stakeholder decision-aid processes.

10.1 Advantages of multi-criteria, multi-actor decision-aid processes

Resolution of complex problems

The most important benefit of multi-criteria analysis is its ability to simply and accessibly model complex problems. Beyond a few criteria, most decision-makers are no longer able to integrate all of the information into their decision-making. MCDA makes it possible to decompose and organize the analysis in order to proceed step by step with the search for a solution.

Transparency

Even if the mathematical tools used to process information can be complex and require special skills, the bases on which the choices are made throughout the eight steps of the process are simple, understandable and transparent. The contribution of the analysts is very important in this regard.

Transparency contributes to the legitimacy of the decision. Stakeholders constantly have a good view of the process and of each successive choice.

Knowledge-based solutions integrating stakeholder values

The decision process is structured, systematic and integrated. The method of analysis integrates the available knowledge on the problem and on the subject of the decision. It also makes it possible to consider the stakeholders' value systems in a simplified but significant way. This is a great advantage, but also a challenge, because problem-solving using traditional approaches is more often presented as neutral and objective since it is done by experts. This method enables a stable appreciation of the various elements involved in the analysis and, in this sense, it rationalizes the process leading to choice.

Capacity to support negotiations in a multi-actor context

By fostering the use of knowledge and by taking values into account, the approach ensures greater content and procedural legitimacy when solving complex problems in situations that often involve conflict. The clarity of the methods makes it possible to take the heat out of the debate and to develop communication among the stakeholders. It therefore constitutes a tool for discussion, deliberation, dialogue and negotiation. The method can be used to explore a complex problem as well as to make a decision.

10.2 Limitations of multi-criteria, multi-actor decision-aid processes

Prerequisites

Implementing such a process requires a minimum of agreement points between stakeholders. For example, a multi-criteria process can only be undertaken if stakeholders agree on the definition of the problem. A shared understanding may be constructed as the process moves forward. All parties must demonstrate a genuine willingness to negotiate (definition of the power balance) and recognize the importance of evaluating over several criteria. It is also important to be able to establish a working group that is representative of the viewpoints. The decision support team must act humbly and avoid the technocratic temptation to be. To foster a sense of equity, it may be useful to involve a mediator/facilitator/communicator. Finally, it is strongly recommended to provide training that addresses both the process and the tools that support it. It should be planned as early as possible, at the start of the process, especially if the tools are new to the decision-makers and the stakeholders. This provides a sense of confidence and ownership of the tools and prevents the feeling of dealing with a black box.

Need for time

Mobilizing stakeholders and the associations they represent in the decision-making process requires financial and human resources, as well as time. This can be a limiting factor. Multi-criteria analyses are based on slow and iterative processes, which may require significant negotiations, which in turn take time. However, we must also consider that beyond finding a compromise solution and ensuring its legitimacy, the process itself builds greater ownership of solutions by stakeholders, which constitutes a serious advantage for solution implementation and follow-up. It is up to the decision-maker to assess the risks of making a decision quickly and on the basis of a single criterion: this may result in significant delays and additional costs during the implementation stage, when significant issues may resurface and impede the process. Furthermore, organizations can think about the most appropriate ways to benefit from the multi-criteria decision-aid process within a reasonable timeframe. Various operational difficulties must be overcome and should not be underestimated. Debates can sometimes be very long and complicated. Potential conflicts sometimes require management (see Section 8.2).

Data availability

The lack of data and their reliability over a sufficient period of time to develop and validate the methods can be problematic. It is always possible to assess the actions qualitatively, even if the data on certain criteria are not available or are patchy. In fact, such assessments are preferable to ignoring an important issue that can influence the decision. In this regard, multi-criteria decision-making processes are opportunities for decision-makers to diagnose weaknesses in the information systems.

Subjective aspect of analysis

Finally, while multi-criteria analysis undoubtedly rationalizes the approach to complex problems, including objective and subjective data, the fact remains that it can be considered by its critics as a subjective approach. For example, the weighting of the criteria is subjective and left up to each of the decision-makers and stakeholders. On the other hand, all of the steps where subjective choices are made by the decision-makers and stakeholders are made explicit and transparent.

Technical level and resistance to innovation

The technical aspect involves both the engineering of the process and the software component The processes used are innovative (multidisciplinary, multi-actor context) and represent challenges to existing structures used to working in silos. We must also know how to use software tools that support the process. The concepts and mathematical data-aggregation methods require a high-level of expertise to avoid erroneous or confusing conclusions. It is therefore important to ensure that the skills and abilities needed are available either within organizations or externally. Although human resources are becoming better trained with such tools, it may be necessary to use consulting services to manage the transfer of tools and the transition within the organization. It is also important to consider the human factors that may inhibit the penetration of innovations into organizations. Finally, it should be noted that the software packages available on the market are very affordable. They do not require sophisticated computer equipment. Simple desktops are largely sufficient to process the data.

Appendices

Appendix A Actors, stakeholders

The concept of an *actor* is the one defined by Roy and Bouyssou (1993, p.64): "Individuals or groups of individuals are **actors** in a decision-making process if, through their value system, they directly or indirectly influence the decision, be it in the first degree because of their intentions, or in the second degree because of how they involve the intentions of others." The authors (1993, p.20, in Côté and Waaub, 2015) distinguish between two categories of actors: *interveners* and the *affected. Interveners* are people who, by their intervention, directly affect the decision based on the value system they represent. The *affcted* are people (citizens, taxpayers, etc.) who, normally passively, are subjected to the consequences of the decision, which is only supposed to take into account their preferences.

The notion of stakeholders may be difficult to grasp. It refers to the people (or groups) who have an interest in a common goal, problem or decision.

We feel it is important to clarify this by citing Côté and Waaub (2015): "We associate the term "stakeholders" with organized groups, and we reserve "public" for individuals. Martel and Rousseau (1993, p.20) distinguish between two categories of stakeholders: the people involved and the people affected. Stakeholders are considered involved when they participate in some way in the process of formulating and solving a problem. They can be said to have an interest because they are able to influence the course of actions directly. This category is an integral part of what we have called

interveners. Other stakeholders or members of the public are not in a position to directly influence the problem's formulation or resolution because they do not participate in them. However, they are still affected by the decision. This category corresponds to what we earlier termed the "affected"."

As mentioned by Martel and Rousseau (1993, p. 21, in Côté and Waaub, 2012), there is a very close link between the stakeholders' identification with a decision, and how the problem was defined.

"...while it is necessary to have some idea of the problem in order to begin identifying the set of stakeholders, it should not be forgotten that, through a circular effect, identifying the stakeholders will serve to specify the problem. A problem is not an independent reality that must be discovered. Rather it is a construct; it is a result of the relationship between one or more subjects and a reality on which the subject(s) want to act in order to modify it to their advantage (Landry, 1988). From this perspective, we cannot talk about a problem independently of the subjects who "own" that problem. Identifying those subjects helps to specify the problem itself. Thus, the stakeholder identification process is a valuable aid for the formulation."

Appendix B Procedures involved in negotiation

Different MCDA negotiation procedures (stages) are possible (see Table 6). Each has its advantages and limitations (see Table 7).

Table 7: Procedures that can be used during negotiations

Procedure	Objective	Means	Manner	Operational Concept
Share	Obtain areas of convergence in the group	Consensus	Discuss points of view and negotiate an agreement	Identify points of divergence and try to reduce them by discussing the causes
Aggregate	Obtain areas of convergence in the group	Aggregation	Calculate, by voting or through another method, the values that are representative of the group	Acknowledge points of divergence and try to reduce them without discussing the causes
Compare	Obtain individual points of view	Consensus, after reaching individual agreements	Negotiate individual agreements	Acknowledge points of divergence without trying to reduce them

Table 8: Advantages and limitations of each approach

Approach	Advantages	Limitations
Share	Possibility of identifying divergent interpretations at each step of the process and developing a shared understanding of the issues related to the actions and their evaluation.	More demanding for the facilitator because s/he must lead participants from a mode where they are expressing their views to a position of negotiation, without them feeling like they are losing face.
Aggregate	Less demanding than sharing because it is not necessary to arrive at a consensus, or even to include all viewpoints in the debate. However, if the decision is made to open up the discussion, it has been recommended by some that it be time-limited.	Aggregation does not allow for the identification of divergent interpretations.
Compare	Less demanding than sharing but may require the facilitator's intervention to negotiate min and max values.	Aggregation does not allow for the identification of divergent interpretations, or does so late in the process.

Appendix C Meeting facilitation techniques

Tool 11: Meeting facilitation techniques

The strength of the circle Throughout the process, participants gather in a circle, whether seated or standing. Being truly present in a meeting also means not having an invisible "force field." It means seeing each other and acknowledging each other in order to act and to think together.

Meeting structure: the diamond This refers to a diamond shape, where, moving from one point to the next, we can see a three-part progression representing the three important components of a meeting or portion of a meeting. All meetings must include an emergence period, a period of idea mixing (group zone) and, above all, a period of closure. Creating the right climate is crucial to allow ideas to emerge. This means taking the time to listen for the participants' intent within their contribution to the meeting, as well as their mindset, their goals. The very fact that the participants are expressing something predisposes them to be committed to the meeting.

This can involve going around the table or doing an ice-breaker. Interactions between participants must take place in a climate of trust and listening. Dialogue is not debate. Rather, it is characterized by open discussion made possible by the participants' sincere desire to contribute to a group effort (common goal). Dialogue is based on a win-win approach, where each participant can both contribute to the discussion and benefit from it. The assessment of a meeting must be done jointly, by going around the table or simply with a thumb-vote technique. Group participants all together give a visual appraisal through a thumbs-up (positive), thumbs-down (negative) or thumbs-sideways (we can do better) sign.

Source : Abitibi-Témiscamingue regional conference of elected representatives (CRÉ-AT) (2014, p.21).

Appendix D Tools to facilitate the MCDA process

Tool 12: Tools to facilitate the MCDA process

Tools	**Objective**	**Method**
Post-up	See what we have in common and what motivates us to invest time in the proposed approach.	Make piles of Post-it pads and markers available to the group. Participants are invited to answer questions individually on the Post-its and to stick them together on a large-sized sheet. With the group, analyze the statements to draw out common and distinctive elements.
Trending Exercise	Explore the goal collectively.	Project into the future to build a vision together so that it becomes meaningful in the present and so that it can be made concrete through actions for the future. The group stands in front of a very large sheet of paper affixed to the wall. The central element is written in the center of the page. A heuristic map can be constructed for prospecting purposes.
Motorola	Discover what works well in this subject area, what unites these positive points, or mark out the scope of a subject, what unites these elements, and especially, draw inspiration in order to imagine the upcoming steps with a view to organizing them.	The group is subdivided into working groups of three or four, which must answer substantive questions on the main subject: "What can be done?" "What cannot be done?" "What do we want to do?" "What do we not want to do?" Answers are pooled together to draw out the aspects that will be important for the upcoming steps.
World Café	Foster the emergence of the group's knowledge.	The practice fosters the emergence and expression of knowledge that no individual person thought existed within the group (group's unconscious knowledge). Requires a table or work space (max. of 3 or 4 people) with paper and pencils in the centre. At least 2 rounds of 15-20 minutes are needed to get results. People change tables at each round to cross-pollinate ideas.
Market Price	Pool technical aspects, issue viewpoints in order to identify convergences together.	Participants have kiosks where they summarize a position for a given amount of time to convince a group of listeners. Listeners go from kiosk to kiosk. Group sharing is used to find points of convergence.
Start/Stop/Continue	Draw up a collective balance sheet.	Question participants on upcoming strengths and challenges. This activity is carried out with all the groups and a summary is created. This method can be an excellent way to create a meeting overview or to close a meeting.

Source : Abitibi-Témiscamingue regional conference of elected representatives (CRÉ-AT) (2014, p.20).

Appendix E Principles for compromise-seeking, inspired by the DELPHI technique

Tool 13: Principles for compromise-seeking, inspired by the DELPHI technique

- Convergence principle
  - Assumption of reversibility of individual choices and irreversibility of collective choices.
  - Stability of divergence elements (the frequency of divergence elements that tends to fade in successive rounds of discussion).
  - Choice arising from the persistence of random responses.
- Normality principle
  - Over successive rounds, the average of responses, regardless of response location and distribution, tends toward a single, representative response.
  - The frequency of choices through successive rounds reflects a convergence toward the normalization of choices. The distribution of responses takes the form of a normal curve.
- Basic principle: three types of information
  - Speculation: information without obvious support (prob. = low)
  - Opinion: information based on belief, but little confirmation
  - Knowledge: sufficiently confirmed information (prob. = high).
- Group principle
  - Two (or more) heads are better than one.
- Sharing principle
  - A collective choice is not the result of interpersonal influences (influence of dominant individuals, semantic alteration, pressure to conform).

Source : Adapted from Wotto (2005).

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