

# 1. The Multi Actor Multi Criteria Analysis framework

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## 1.1 INTRODUCTION

Decision-making in the context of sustainable mobility and the transport sector requires addressing complex problems featuring multiple interests and perspectives, conflicting objectives and different types of data and information. Typically, several levels of public policy are involved (local, province, regional, state and European levels) and several stakeholders (such as freight forwarders, investors, citizens, industry and so on) which have a vested interest in the ultimate decision, whether they encompass environmental, social, economic, technical or legal issues. If the decision-making process fails to take these interests into account, projects may fail the implementation step, lead to unacceptable delays, be ignored by policymakers, or may be attacked by the stakeholders (Macharis et al., 2012).

The question is, however, how to organize and structure the decision-making process to enable the social actors to participate? The Multi Actor Multi Criteria Analysis (MAMCA) has been developed to address such issues. It explicitly considers and involves the stakeholders from the very beginning to the very end of the decision-making process. The following section positions the MAMCA methodology within the multi-criteria group decision-making literature. In Section 1.3 we present some MAMCA application cases in the field of sustainable mobility, transport and logistics. In Section 1.4 we present the methodology step by step through an educative case study. In Section 1.5 examples of MAMCA applications in the field of sustainable mobility, transport and logistics are provided. Section 1.6 concludes.

## 1.2 A CHANGING CONTEXT: SUSTAINABILITY AT THE CORE OF MOBILITY AND LOGISTICS PROBLEMS

This section presents the key concepts in addressing decision-making problems in the field of sustainable mobility and logistics.

### 1.2.1 Sustainability Concept

The concept of sustainability was formally defined by the well-known Brundtland Commission as:

a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. (Brundtland et al., 1987)

According to Pope et al. (2004), the scope of the concept may change depending on the dimensions incorporated into the sustainability assessment. The single pillar concept is the oldest approach. It focuses on environmental impacts, assuming that socio-economic aspects can never take priority over ecological preservation (Gallego Carrera and Mack, 2010). The two-pillar concept assumes a possible substitution between economic growth and the ecological integrity. The three-pillar concept adds a consideration for social aspects (Pope et al., 2004). The four- and five-pillar approaches include considerations for cultural and institutional dimensions (Parris and Kates, 2003).

Fundamentally, the sustainability concept implies defining: What is to be sustained? How is it possible to cope with the multi-dimensional needs? How it is possible to balance the present and future needs? The answers to those questions may vary depending on the temporal and spatial scale (Mayer, 2008), but also on the preferences of individuals or geographical region too (Buchholz et al., 2009).

Focusing on these latter aspects, Sala et al. (2015) speak about cross-pillar dimensions. From their point of view, addressing sustainability issues requires appropriate ways to strengthen the legitimacy and relevance of the decision-making process by engaging stakeholders at an early stage. Stakeholder-based approaches help in structuring the scope of the problem by identifying the multiple and sometimes conflicting perspectives of stakeholders concerning their own sustainability criteria (Buchholz et al., 2009; Cuppen et al., 2010; Gallego Carrera and Mack, 2010; van Dam and Junginger, 2011). The question is, thus, how to identify and make the relevant stakeholders participate?

### **1.2.2 Stakeholder Concept**

Given the rising concerns for corporate social responsibility, the concept of stakeholder was introduced in the research field of strategic management (Buysse and Verbeke, 2003; Donaldson and Preston, 1995; Williamson, 1991). According to Freeman (1984), the stakeholder concept refers to an individual or a group of individuals who can influence or be influenced by the objectives of an organization. Banville et al. (1998) pointed out the importance of including stakeholders within Multi Criteria Decision Aid frameworks on the basis of their role in the decision-making process, implicitly suggesting that those whose potential for cooperation is low will be less likely retained for participation (Macharis et al., 2012). Such a definition is thus also influenced by organizational problem settings. Nevertheless, all relevant points of view should be incorporated when addressing socio-environmental problems.

Facing this ethical issue, Munda (2004) proposed broadening the scope of participation in the decision-making context by involving all the relevant social actors. By social actors, Munda refers to organized groups but also to unorganized actors, such as, for example, future generations. Grimble and Wellard (1997) proposed to broaden the scope of stakeholders by involving groups of people, organized or not organized, who share a common interest or stake in a particular issue or system. From our perspective, the scope of the concept should be limited based on the stakeholders' values at stake in the issue. Otherwise, this leaves the door open for any person or group who, with just intellectual curiosity, would like to be involved, which may lead to an unmanageable procedure.

In the MAMCA framework, we refer to stakeholders as people who have an interest, financial or otherwise, in the consequences of any decision taken. Focusing on sustainable mobility and logistics and depending on the problem, stakeholders may, for example, include terminal infrastructures managers, network infrastructures managers, vehicle manufacturers, passenger service operators, travelers' representatives, disabled and/or elderly transport users' representatives and/or associations, freight service operators, transport authorities, policy makers, socio-environmental non-governmental organizations (NGOs), future generation representatives, citizens, residents and so on.

### **1.2.3 Multi Criteria Analysis: A Methodological Framework to Support Decision-makers in Making More Sustainable Decisions**

Decision-makers require a wide range of information to demonstrate whether our complex human-based system is becoming more or less

sustainable. Without an adequate methodology, the decision-makers tend to focus on a small set of decision criteria, leading to decisions taken based on insufficient information. Rising concerns for environmental and social impacts have made Multi Criteria Decision Aid (MCDA) processes increasingly popular (Løken, 2007; Wang et al., 2009) as it allows the integration of different dimensions in the decision-making process. The MCDA offers structured and comprehensive frameworks in addressing complex problem settings.

The core of the MCDA procedure is the formal specification of how the different inputs are combined together to come to multi-criteria outputs (Damart and Roy, 2009). MCDA frameworks usually adopt a rather similar pathway: (1) the scope of the problem has to be defined; (2) a relevant set of options – or alternatives – and a criteria set have to be defined; (3) criteria can eventually be prioritized through the weight elicitation step; (4) the different options are evaluated based on the different criteria; (5) the multi-criteria evaluation is performed; (6) results have to be presented and discussed; (7) decision-makers make the final decision. Depending on the method and problem setting, steps may be executed in a different order, executed in parallel and the learning process during the procedure may also lead to the repeat of some steps (Lahdelma et al., 2014; Salo and Hämäläinen, 2010).

When addressing sustainable mobility and logistics problems, a wide range of stakeholders may be affected. Depending on the problem characteristics, stakeholder participation may take many forms and different degrees of involvement ranging from informing the public to co-producing knowledge (Cuppen et al., 2010). The questions are thus: Who should participate? In which steps? To what extent? Table 1.1 presents how the participants should be involved in these typical MCDA framework steps.

Typically, MCDA processes require involving the decision-maker(s), various stakeholders, experts in the appropriate fields, planner(s) and analyst(s) who manage the process (Lahdelma et al., 2014). Most of the decision-making methods have been adapted to enable group decision-making (for an overview, see Álvarez-Carillo et al., 2010). The difference between the methods mainly lies on the extent to which the information is brought together. Traditional methods aim at reaching a consensus among the stakeholders about the election of a common set of criteria. However, such an approach often fails to capture the whole variety of viewpoints, and thus the full scope of the problem (Cuppen et al., 2010).

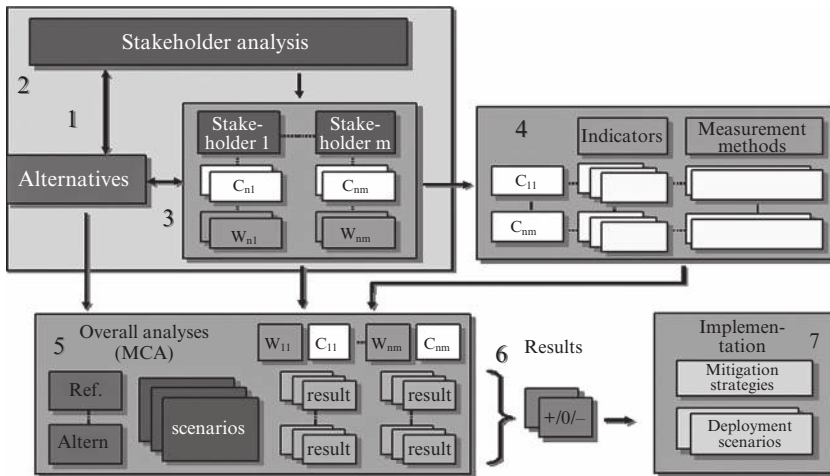
The prerequisite consensus between social actors is not necessarily an achievable target at the very beginning of the procedure because of the high divergence between their respective interests. Such a lack of consensus may hamper the decision-process and the eventual implementation of

Table 1.1 Typical MCDA steps and actors' involvement

Actors	Define problem scope	Define alternatives & criteria	Elicit stakeholders' preferences	Measure of alternative performance	MCDA method choice	Perform MCA analysis	Make the final decision
Decision-makers	x	x	x		(x)		x
Stakeholders	x	x	x	(x)	(x)		
Experts	x	x		x			
Planners	x	x		x	x	x	

Note: x: participant is involved; (x): depends on the decision-context characteristics and on the methodological choices.

Source: Designed by the authors. Adapted from Lahdelma et al. (2014).



Source: Macharis et al. (2012).

Figure 1.1 Overview of the MAMCA methodology

solutions (Breukers and Wolsink, 2007; Di Lucia and Nilsson, 2007; Elghali et al., 2007). The MAMCA approach takes into account a specific criteria tree for each stakeholder to overcome this inherent consensus requirement (Macharis et al., 2009).

### 1.3 MAMCA METHODOLOGY

The MAMCA is an iterative methodology that consists of seven steps (Figure 1.1). The first three steps are very important and will influence each other (Macharis et al., 2012). This is why the methodology should be done in an iterative way.

#### 1.3.1 Step 1: Defining the Problem and the Alternatives

The first stage of the methodology aims at defining the scope of the decision-making problem, including identification of the relevant alternatives. Depending on the problem setting, alternatives can take various forms such as policy options, technological solutions, site locations and so on. A reference alternative may be added to provide a benchmark against which the other alternatives can be compared, typically a “business as usual” reference.

For some problem settings, alternatives can be pre-determined. In such cases, the alternative identification step is straightforward. Otherwise, the set of alternatives can be tracked from a literature overview, possibly complemented by stakeholders' interviews. Alternatives may also be screened in terms of feasibility regarding legal, economic, social, environmental and technical issues.

This screening can be performed through risk analysis, early involvement of the stakeholders combined with an insight into their concerns (Lahdelma et al., 2014). In this case, stakeholders have to be involved at the very beginning of the process, which means performing Steps 2 and 3 before defining the alternatives.

### **1.3.2 Step 2: Stakeholder Analysis**

An in-depth understanding of the stakeholder's objectives is critical in order to appropriately assess the different alternatives. Stakeholder analysis can be considered an aid to properly identify the range of stakeholders – the people or group of people who may affect or may be affected by the consequences, financial or otherwise, of any decision taken – who need to be consulted and whose views should be considered in the decision-making process.

Although there are no strict rules or consensus about stakeholders' involvement, the literature provides several appropriate methods to identify the relevant stakeholders (Banville et al., 1998). Savage et al. (1991) suggest identifying the stakeholders based on their potential for cooperation within the decision-process. Weiner and Brown (1986) suggest identifying the potential reasons for people to mobilize around any aspects of the decision-problem. Munda (2004) propose performing an in-depth analysis of historical legislative and administrative documents complemented with stakeholders' interviews to identify the relevant social actors.

The approach proposed by Munda (2004) and Weiner and Brown (1986) may be considered a good start to identify the stakeholders in the MAMCA framework. Next, one should define the border of the problem regarding its impacts, for example, through the scope of the policy level (community, region, country and so on) or through the scope of the demand and supply side, the supply chain and so on. Stakeholders can themselves be involved in the identification of the relevant actors to integrate into the process.

Given the sustainability issues within the mobility and transport context, special care has to be given when the consequences of decisions may affect unorganized groups (Munda, 2004). As an illustration, there is the risk of child labour in the production of palm oil, which is one of the main feedstocks for biofuels in Europe. In such cases, specialized NGOs and associations may be included to represent those values at stake within

the decision-context. In other words, all the relevant points of view have to be captured in the process. This is called the completeness requirement (Macharis et al., 2012).

Stakeholder groups may consist of one or several actors characterized by quite homogeneous objectives and priorities. In other words, stakeholders with divergent viewpoints must be considered in separate groups. The priorities and weights might differ a little, but the same criteria tree is used within the stakeholder group. Stakeholder groups' weights are aggregated by the geometric mean, in which case analytic hierarchy process (AHP) is used, or the average. A sensitivity analysis should be executed when the stakeholders' weights differ markedly within a group (see Chapter 3).

### **1.3.3 Step 3: Defining Criteria and Weights**

In the MAMCA, the definition of criteria is primarily based on the identification of the stakeholders' objectives and the purposes of the considered alternatives, not the impacts of the actions per se as is usually done in a MCA. Nevertheless, if all the relevant stakeholder groups are considered, these impacts should naturally be reflected in the objectives of the stakeholders.

From a theoretical perspective, the identification of the stakeholders' criteria can be determined through a bottom-up (Roy, 1985) and/or a top-down (Keeney and Raiffa, 1993) approach(es). The first approach consists of revealing criteria starting from how the alternatives affect the stakeholders. The second one consists in constructing the criteria through the decomposition of the stakeholders' objectives. The aggregation of the multiple social actors within stakeholder groups depends on their concerns and priorities. Each stakeholder group has to be homogeneous in term of concerns and preferences in order to draw a common criteria tree ().

On the one hand, the definition of criteria must comply with methodological requirements (Keeney and Raiffa, 1993; Macharis et al., 2012), which can be addressed by the researcher as mentioned by Munda (2014):

- **Non-redundancy:** the criteria should not measure the same thing within each stakeholder group. Nevertheless, two groups can have common criteria as long as they represent their own preferences.
- **Minimality:** the number of criteria should be kept to a minimum to remain manageable.
- **Homogeneity:** an agreement about the set of criteria within each group is required. Otherwise, two separate groups need to be considered.



- **Operationality:** anticipating the requirements of Step 4, criteria can be used meaningfully in the process. In other words, the alternative capacity to fulfil criteria must be properly measurable through indicator(s).

On the other hand, elicitation of the criteria is usually pursued through an interactive discussion with the stakeholder groups. From an operational perspective, criteria lists can first be provided to the different stakeholder groups based on a literature overview. Next, each stakeholder group gets the opportunity to evaluate and validate the pre-defined criteria, for example, in workshops or by telephone. It is important to come to an agreement concerning the meaning, the definition, of each criterion. Sub-criteria elicitation may be considered in detailing the stakeholders' objectives. On this basis, a hierarchical tree can be set up.

Within each group, weights can be allocated to capture the expression of the stakeholders' priorities between their criteria. Literature provides various methods to express these weights, such as pairwise comparisons, direct ratings, points allocation and so on (Eckenrode, 1965; Nijkamp et al., 2013). The choice of method depends on the MCA framework that is used in Step 5 concerning the type of required inputs. Moreover, the choice of the MCA framework may also depend on operational constraints. For example, the time availability of stakeholders may rule out the most time-consuming methods.

Wang and Yang (1998) studied the theoretical validity, predictive and perceived performance of three weight measurement methods: Saaty's AHP (Saaty, 2008), Edward's simple multi-attribute rating technique (SMART) and the functional measurement (FM) method as a theoretical validity standard (Zhu and Anderson, 1991). All three methods were perceived as equally valid but in terms of perceived performance, AHP is significantly preferred and perceived as easier to use. The AHP friendliness and understandability for users is widely highlighted in the literature, particularly in decision-contexts that address sustainability and energy issues (Kaya and Kahraman, 2011; Løken, 2007; Pohekar and Ramachandran, 2004; Wang and Yang, 1998). In these contexts, PROMETHEE is one of the most popular methods but no specific guidelines yet exist to determine the weights. Indeed, PROMETHEE assumes that decision-makers are able to weight their criteria appropriately, at least when the number of criteria is not too large. A combination of different methods can also be used (Marttunen et al., 2017). Macharis et al. (2004), for example, suggest combining the strengths of the weight elicitation of AHP (Step 3) and the PROMETHEE tool as the decision-method (Step 5) in the MAMCA. Consequently, most of the MAMCA case studies use Saaty's AHP process

Table 1.2 An illustration of Step 3's inputs

Stakeholder	Criterion	Criterion definition	Weight (%)
Retailer	High level of service	Customer satisfaction, deliveries on time and of the right quantity	30.0
	Socio-environmental concerns	Positive attitude towards environmental impact	25.0
	Profitable operations	Making a profit	16.5
	Viability of investment	A positive return on investment	16.5
	Employee satisfaction	Employees are satisfied with their work and working environment	8.0
	Security	Security of the goods and the drivers; no thieves and no attacks	4.0
Local authorities	Quality of life	Attractive environment for citizens	58.7
	Network optimization	Optimal use of existing infrastructure	21.6
	Social and political acceptance	Citizens' support for measures	9.4
	Cost measures	Low costs to implement measures	6.5
	Positive business climate	Attractive environment for companies	3.9
Citizens	Safety	Positive impact on road safety	31.0
	Emissions	Reduce emissions of CO <sub>2</sub> , NO <sub>x</sub> , PM <sub>2.5</sub> , PM <sub>10</sub>	26.4
	Urban accessibility	Reduce freight transport; less congestion	20.8
	Noise nuisance	Reduce noise nuisance	15.7
	Visual nuisance	Less space occupancy by trucks	6.1

Source: Verlinde and Macharis (2016).

for the elicitation of stakeholders' weights (AHP and PROMETHEE procedures are explained step by step in Chapter 3).

Table 1.2 presents the set of criteria and their associated weights extracted from the MAMCA application performed by Verlinde and

Macharis (2016) that compared different scenarios on off-hours deliveries to supermarkets in Brussels. Three stakeholder groups were identified who were asked to define their objectives (criteria) and priorities (weights).

One may also consider weights to express the prioritization between the different stakeholder groups. All stakeholder groups are considered of equal importance in all the MAMCA applications so far. In other words, stakeholder groups are given an equal weight to consider each point of view on an equal basis. Nevertheless, sensitivity analysis can be performed to consider different weight setting, which may lead to new insights.

The first three steps of the methodology should be considered circularly interlinked until all the relevant stakeholders, alternatives and criteria are identified. Indeed, each step may provide new ideas, visions or inputs, leading to consider new stakeholders, alternatives or criteria. This circle may be seen as a refinement process for the problem structuration.

### **1.3.4 Step 4: Indicators and Measurement Methods**

Step 4 aims at “operationalizing” the criteria by constructing quantitative or qualitative indicators that will measure the extent or the capacity of each alternative to contribute in meeting each stakeholder’s criterion. These indicators must remain explicit for understanding purposes.

Based on the literature and/or expert consultations, alternative performance regarding each criterion can be evaluated. Expert consultation can provide a scientific and solid foundation for the evaluation process, which may help social acceptance of the results. Indeed, depending on the complexity of the decision-making context, the analyst can try to acquire the necessary knowledge and expertise to properly complete the evaluation. This evaluation can be performed by the analyst and/or the experts, based on the literature, empirical data collection and expert consultations. When the decision-context features multi-dimensional issues, it may be preferable to cooperate with a multidisciplinary team of experts to ensure a solid basis for the evaluation. The evaluation has then to feed the decision-method, which requires data to be suited to the selected method.

### **1.3.5 Step 5: Overall Analysis**

Using the measurement methods (Step 4), Step 5 consists of the evaluation of the alternatives through a MCA framework. It is possible to translate alternatives into scenarios to get a clearer evaluation. Different actors may provide the inputs for the evaluation of alternatives depending on the decision-making process objective: (1) the analysts, (2) the experts or (3) the stakeholders. Analysts may acquire the necessary expertise for the problem

to make the evaluation properly. Nevertheless, cooperating with interdisciplinary experts may be more suited when addressing multi-dimensional problems, as previously mentioned. Stakeholders may also evaluate the alternatives themselves (for example: when the problem requires assessing stakeholder support for an alternative). Such an approach could, however, induce strategic bias because stakeholder groups could influence the decision towards their own strategic ultimate outcome. Stakeholders may also be consulted to validate the input given by the analyst or the experts.

The literature provides a wide range of MCA methods which can be used in the MAMCA framework. Among the most popular methods: the MACBETH approach (Bana and Costa, 1986); the Multi Attribute Utility Theory (MAUT) (Keeney and Raiffa, 1993); the AHP method (Saaty, 2008); ELECTRE (Roy, 1991); PROMETHEE (Brans and Vincke, 1985). The choice of a particular method depends on the decision-context and group members' characteristics (Salo and Hämäläinen, 2010). For example, the researcher/project manager may be more familiar with a particular method; the degree of participation in the process may imply operational constraints; the availability/price/friendliness of the software may drive the choice a specific method and so on (Kurka and Blackwood, 2013).

### **1.3.6 Step 6: Results and Sensitivity Analysis**

Based on the decision-method output, the MAMCA eventually leads to a classification of the different options but more importantly reveals the critical stakeholders and their criteria. In other words, the strengths and weaknesses of each option with regard to each of the stakeholder groups' concerns can be identified. The MAMCA provides a comparison of the support of the stakeholder for the different options while pointing out the elements that have positive or negative impacts. In other words, it clearly shows which points of view are in disagreement and which ones could possibly come to a consensus.

As an illustration, Figure 1.2 shows the government's point of view extracted from the case study proposed by Turcksin et al. (2011) that evaluates the support of stakeholders for different biofuel options in Belgium.

The X-axis presents the extent to which biofuel options contribute to the government regarding each criterion presented in the Y-axis. The higher the score, the better the option contributes to comply with the objective. The importance of the criteria for the stakeholders – the weights – is represented through bars for each criterion (Y-axis). The higher the bar, the higher the criterion importance for the stakeholder group.

Biogas constitutes the most suited option regarding the government's

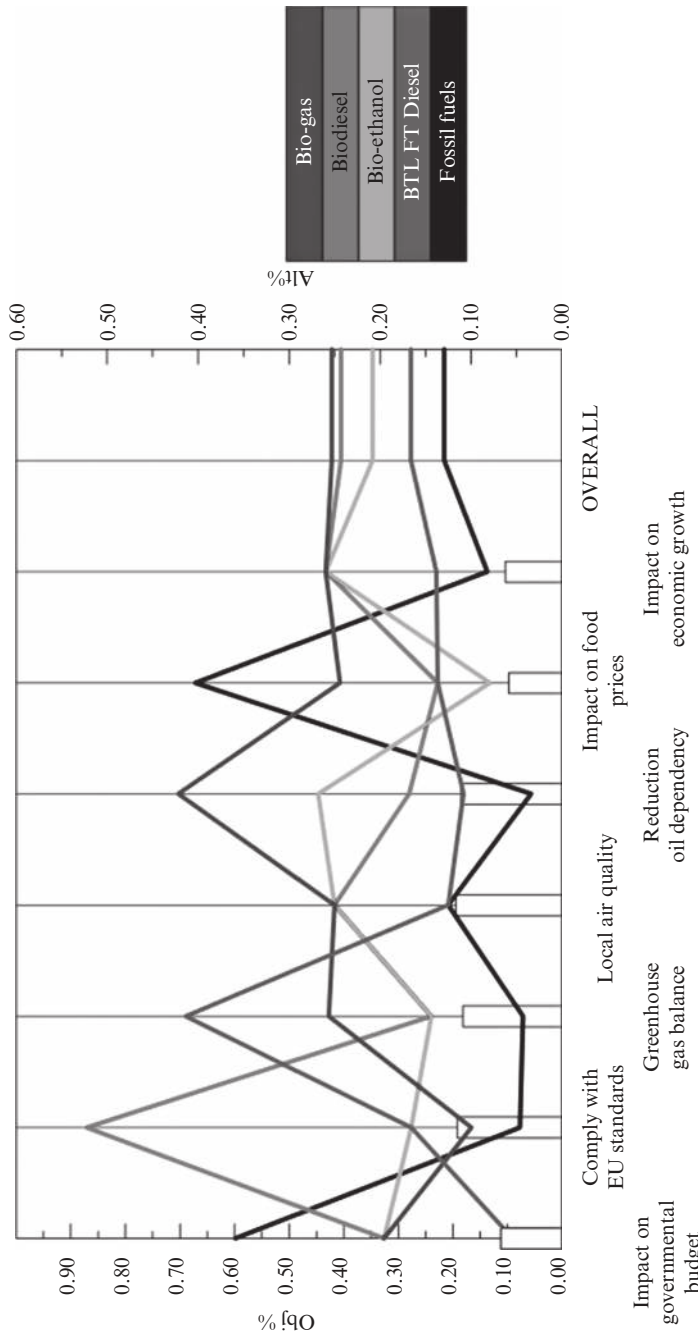


Figure 1.2 An example of MAMCA output (using AHP, government output)

criteria (Figure 1.2). Even if the overall line might suggest that the final ranking will also lead to the best solution, we think that this is not the aim of the MAMCA output. Its objective is to provide insights into what is important, what is affecting positively or negatively each stakeholder group but certainly not to just sum up these perspectives to come to a final decision. Consequently, the overall line should always be commented on with care.

### **1.3.7 Step 7: Implementation and Recommendations**

Based on the MAMCA outputs, policy recommendations can be formulated by the decision-maker, which is often a public authority. These recommendations are defined to help the decision-maker in the search for a deployment scenario, suited to the concerns of each stakeholder group, and ensuring overall coherence and sustainability. To this end, two approaches may be considered.

The first approach consists in considering the public authority to follow as it is the most relevant in representing the viewpoint of society. Based on its perspective, the public authority may choose its most suited option while considering the extent of the other stakeholders' support for it. The decision-maker can then develop additional and well-suited measures to compensate the negative consequences for some stakeholder groups (if any). In other words, the decision-maker can identify and tackle the barriers that may occur to facilitate the implementation of an option. For example, in Figure 1.2, biogas constitutes the most suited option for the government but it is also an unsuited alternative for end-users, especially given its user-unfriendliness. The government may, for example, implement additional measures to lower the cost for end-users and to demonstrate user-friendliness through advertising campaigns to overcome rejection by end-users.

In a second approach, the decision-maker may choose the option that offers the best consensus, that may face less barriers or simply prevent stakeholders' opposition. For example, in the case of the Oosterweel connection (Macharis et al., 2012), several "bridge and tunnel" possibilities were evaluated and the public authority finally chose an option that faced less barriers and was more socially acceptable, regardless of its own preferences.

In any case, the "consensus process" might take place through a negotiation round with all the stakeholders and possibly with a facilitator. During the process, new options can potentially be identified which will lead to a feedback loop towards the beginning of the procedure.

## 1.4 A MAMCA EDUCATIVE CASE STUDY

The following sub-sections present the methodology step by step through an educative case study.

### 1.4.1 Step 1: Defining the Problem and the Alternatives

Our daily lives are full of multi-criteria decisions which may range from simple to complex problems: buying a new phone, a new car, hiring an employee and so on. In real life, decisions are rarely based on a single criterion and they rarely affect the decider only. In this chapter, we illustrate the MAMCA methodology by means of an intuitive case study. Let us consider a group of people who want to choose among four skiing holiday destinations: Morzine, Châtel, St Martin and Les Menuires.

### 1.4.2 Step 2: Stakeholder Analysis

Step 2 consists in identifying the relevant participants to involve in the decision-process. Let us consider three families – the Corijn, Demeester and Macharis families – as our stakeholder groups. The families have different objectives, for example, the Corijn family is gourmand while the Demeester family is sportive.

### 1.4.3 Step 3: Defining the Criteria and Weights

To properly structure the decision-problem, each family has to define its own criteria tree and, potentially, they may elicit weights, expressing their preferences in between their criteria. Depending on the decision-method (Step 5), weights may be elicited to express the relative preferences between the criteria for each family.

Table 1.3 presents the criteria trees and the weights of our three families. Some decision criteria are common between the families such as the proximity to ski runs. The weights express the trade-offs between the families' preferences. For example, the Corijn family considers the conviviality 2.3 times more important than being near the ski runs.

### 1.4.4 Step 4: Indicators and Measurement Methods

Indicators enable the capacity of each alternative to be measured that fulfil the different criteria, that is, the alternatives' performances. Quantitative and continuous scales may, for example, be used to measure the proximity to ski runs. Discrete scales may be used to measure the presence (1) or the

Table 1.3 Families' criteria and weights

Stakeholder group	Criterion	Weight (%)
Family Corijn	Kitchen	67
	Conviviality of the chalet	23
	Near ski runs and bus	10
Family Demeester	Large ski resort	47
	Near ski runs	34
	Sauna	13
	Conviviality of the chalet	6
Family Macharis	Room setting	54
	Conviviality of the chalet	22
	Near ski runs	15
	Large ski resort	9

Source: Designed by the authors.

Table 1.4 Macharis family's score evaluation

Criterion	Morzine	Châtel	Menuires	St Martin	Unit
Room setting	Neutral	Very negative	Positive	Neutral	Qualitative
Near ski runs	6.8	7.1	1.2	1	km
Conviviality of the chalet	Neutral	Very negative	Positive	Neutral	Qualitative
Large ski resort	2.4	2	4.8	5.2	km

Source: Designed by the authors.

absence (0) of a sauna. Qualitative scales can be used for criteria such as the room setting, allowing preferences to be ranked for different chalets. For some criteria, composite indicators may be required to measure the option performance. As an illustration, the “conviviality of the chalet” criterion may refer to different sub-criteria such as the availability of a chimney and the surface of the living room. Table 1.4 illustrates the score evaluation of the different chalets.



### **1.4.5 Step 5: Overall Analysis**

In this step, the final scores can be compared and ranked (Step 5). In the MAMCA software, two decision-methods are available (see Chapter 3 for further details) which are both very popular in the context of sustainability problem settings: the AHP – the analytic hierarchy process – developed by Saaty (2008) and the PROMETHEE – the preference ranking organization method for enrichment evaluations – developed by Brans and Vincke (1985).

### **1.4.6 Step 6: Results and Sensitivity Analysis**

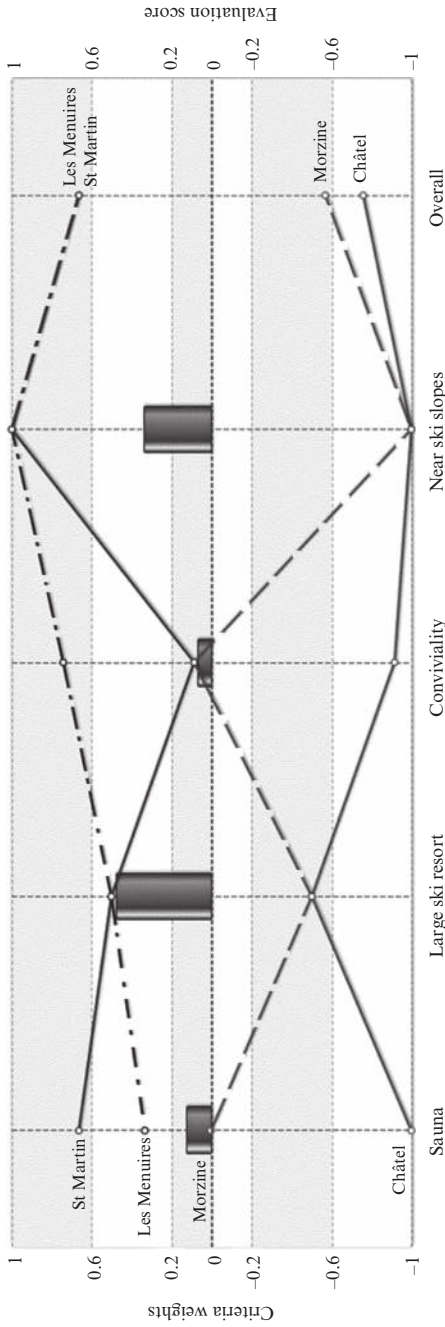
Figure 1.3 presents the alternatives ranking of the Demeester family. The right Y-axis represents the evaluation scores, the left one the weights (vertical bar) regarding the different criteria (X-axis). Les Menuires and St Martin are equally suited at the overall level and regarding the “large ski resort” and “near the ski runs” criteria.

When focusing on the “sauna” criterion, St Martin outperforms Les Menuires whereas it is the opposite regarding the “conviviality of the chalet”. The strengths and weaknesses of each chalet for each family’s concerns can be identified.

Figure 1.4 presents the alternatives ranking of all the families. The X-axis presents the families, the Y-axis the alternatives scores. The figure clearly shows that the chalet in Châtel is the worst option for all the families. Nevertheless, the most suited option of each family differs. For the Corijn family, Morzine constitute the most suited option, followed by Les Menuires, St Martin and Châtel. As mentioned previously, Les Menuires and St Martin contribute equally to the Demeester family’s criteria. For the Macharis family, Les Menuires is the best option, followed by St Martin, Morzine and Châtel.

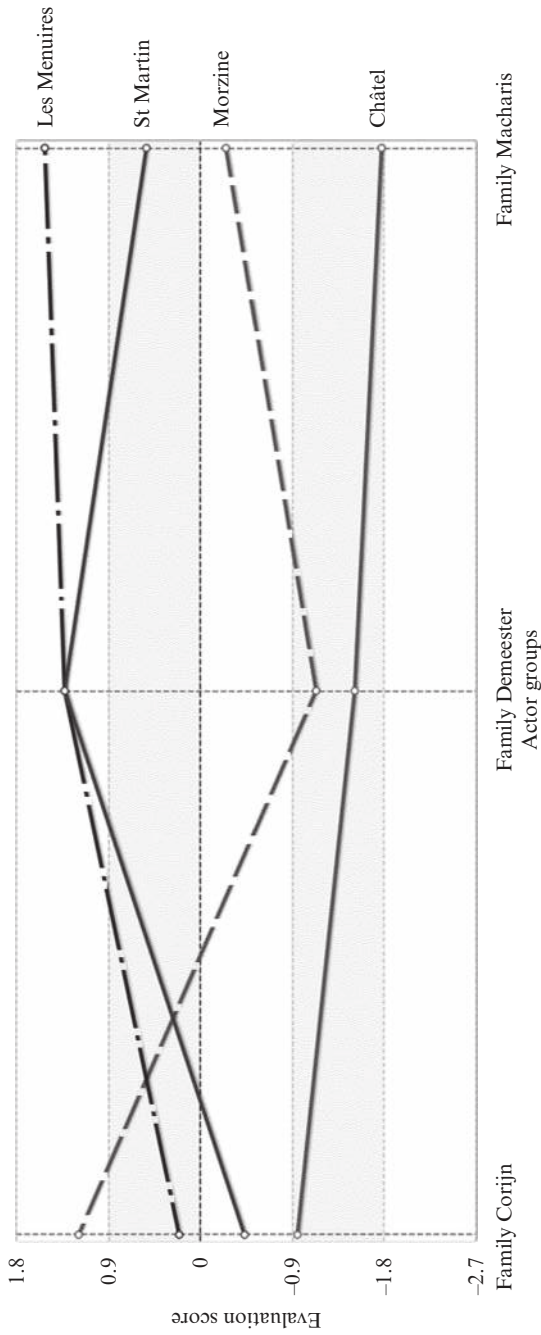
### **1.4.7 Step 7: Implementation and Recommendations**

Based on the MAMCA outputs, a structured discussion among the stakeholders can be set up and suitable recommendations can be formulated. These recommendations are defined to help in the search for a deployment scenario, ensuring overall coherence and sustainability of the solution. Thanks to the structured way of sharing the pros and cons for each option, the stakeholders can come to a shared solution. In our present illustration, Les Menuires may be the best compromise as it is the most suited option for two families and the second best for the third family. Nevertheless, another alternative can be chosen and implemented.



Source: Designed by the authors.

Figure 1.3 Chalet alternatives ranking of the Demeester family



Source: Designed by the authors.

Figure 1.4 Chalet alternatives ranking of the three families

Figure 1.5 presents the alternatives ranking of the Corijn family which shows that the weakness of Les Menuires is related to the “kitchen” criterion. For example, the two other families may compensate this weakness by inviting the Corijn family to the restaurant.

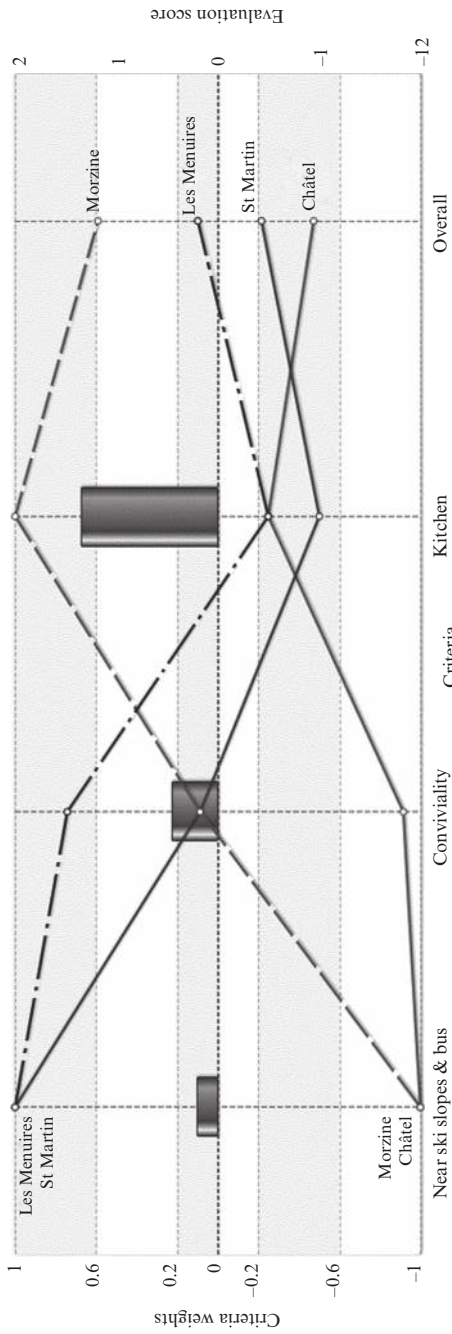
## 1.5 SOME MAMCA APPLICATIONS IN THE FIELD OF SUSTAINABLE MOBILITY, TRANSPORT AND LOGISTICS

The MAMCA was developed by Cathy Macharis in the 2000s and it has been applied in multiple case studies in the field of sustainable mobility and transport since then. The methodology can cope with a variety of problem settings such as the evaluation of technology options, location sites, policy alternatives and so on. This section provides examples of the most recent MAMCA applications starting from 2010 – the previous ones can be found in Macharis et al. (2012).

Macharis et al. (2010) deployed the MAMCA in the context of the “Flanders in Action” project to provide insight into the support by different stakeholder groups for different policy measures to fulfil the sustainability ambitions of the Flemish Government for 2020. What was specific about this application was that criteria were pre-defined and common for the 11 stakeholder groups. Each group was, however, invited to express their criteria preferences through the elicitation of the weights. They were also allowed to assess the impact of the different measures of these criteria. Out of these measures, spatial planning, multimodality and bundling were identified as the most effective options for attracting logistic activities and that technology, multimodality and tax reformation would be best suited for reducing the detrimental impact of mobility and logistics on the environment.

Turcksin et al. (2011) deployed the MAMCA to assess stakeholder support for different biofuel options in Belgium in the context of the 2020 objectives for climate change. Results showed that biodiesel, ethanol and biomass-to-liquid are the most suited options to comply with the different stakeholders’ objectives while reaching the Belgium renewable energy objectives in the transport sector. The research also pointed out the lack of adequate biofuel support measures for end-users and vehicle manufacturers whose preferences were still higher for the fossil fuel reference.

Vermote et al. (2013) assessed four alternatives of freight transport infrastructure at Anzegem (Flanders). The research led to the most interesting transportation infrastructure option, namely, the external western ring,



Source: Designed by the authors.

Figure 1.5 Chalet alternatives ranking of the Corijn family

to reconcile accessibility and livability, based on the transport companies, public authorities and citizens' criteria.

Brucker et al. (2014) used the MAMCA to obtain a selection and preliminary ranking for several ways to design innovative tools that have the potential to improve road safety. Results showed that alternatives based on speeding receive the highest priority except for users and manufacturers. Manufacturers generally prefer autonomous infrastructure-based alternatives because of liability issues. Users give low priority to vehicle-related alternatives because of the high user cost and the relatively small effect on driver safety.

Kourtit et al. (2014) analysed, by means of the MAMCA, the performances of 40 world cities regarding managers', researchers', visitors', residents' and artists' viewpoints. Based on 70 indicators, results showed that there is no single efficient city but there are dominant cities that score higher on all indicators than others, namely, Paris, London, New York and Tokyo.

Macharis and Crompvoets (2014) deployed the MAMCA to evaluate different alternatives for spatial data infrastructure (SDI) for Flanders. The results showed that each of the considered alternatives has their own drawbacks. The results also showed that the development of SDI in Flanders is more than just implementing the European INSPIRE directive, but also requires the integration of the market in the SDI. Decision-makers may thus consider a combination of different alternatives/measures to deal with the different stakeholders' objectives.

Verlinde et al. (2014) applied the MAMCA to research when a mobile depot for last-mile deliveries and first-mile pick-ups could become profitable and how stakeholders would be impacted. A mobile depot is a trailer fitted with a loading dock, warehousing facilities and an office. Results showed that the objectives of the economic stakeholders (TNT Express, shippers and receivers) are well addressed while the objectives of the societal stakeholders (citizens and local authorities) are better addressed. Nevertheless, the research also showed that the viability of the investment and profitable operations criteria of TNT Express must be met better to become interesting, for example, by using the mobile depot at full capacity and by increasing the drop density.

Verlinde and Macharis (2016) compared different scenarios on off-hours deliveries to supermarkets in Brussels. Their analysis showed that a shift towards such deliveries should receive overall support because the scenarios that envision a high proportion of night deliveries receive a high score.

Lebeau et al. (2015) used the MAMCA methodology to assess the support of stakeholder groups for the electrification of city logistics. Other applications are currently being performed.

## 1.6 CONCLUSION

Effective decision-making requires an explicit structure that jointly considers the objectives of the different stakeholders in evaluating alternatives. Contrary to traditional MCDA methods, the MAMCA methodology enables the objectives of each stakeholder group to be considered. In other words, the methodology enables visualization of the different points of view and facilitates the structuring of the discussion between stakeholders. Moreover, by enabling stakeholders to be involved throughout the whole process, it fosters social acceptance and facilitates implementation of the solutions. The MAMCA methodology has been further developed into different tools, namely, the COMCA (Competence-based Multi Criteria Analysis) and the range-based MAMCA, to cope with a wider range of decision-making settings.

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