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## Crafting local climate action plans: An action prioritisation framework using multi-criteria decision analysis

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# Crafting local climate action plans: An action prioritisation framework using multi-criteria decision analysis

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**Abstract.** The COP21 target to keep global warming to well below 2 (or 1.5) degrees Celsius cannot be met without massive transformation in cities. A major challenge on the road to nearly greenhouse gas (GHG) emissions-neutral cities is the successful development of a climate action plan (CAP) by the local authority, sometimes within the framework of its participation to different initiatives (e.g. the Global Covenant of Mayors). While the identification of the best actions for reaching their long-term GHG emission reduction target constitutes a common decision-making problem for local authorities, it is also an intricate one: conflicting and incommensurable aspects such as environmental, economic, social and technical issues, as well as conflicting stakeholder interests should be dealt with simultaneously when actions have to be programmed. Multi-Criteria Decision Analysis (MCDA) methods are well-known to cope with these complexities and have already been used for decades in several fields. However, they have not been systematically used within the context of local CAPs. The methodologies which are normally implemented to support the prioritisation of actions wholly or to a great extent rely on economic analyses and do not capture the potential co-impacts. In this context, this paper proposes a general participatory framework for guiding collaborative prioritisation of actions as a methodology to help local authorities with the development of more sustainable CAPs, while using MCDA. Finally, advantages, limitations and further steps in research regarding the proposed framework are discussed.

## 1. Introduction

Climate change is undoubtedly the global environmental risk currently receiving the most attention, and is, according to the Intergovernmental Panel on Climate Change (IPCC) [1] one of the most serious contemporary challenges to achieving a sustainable society. A collective response of nations to the urgency of tackling climate change is marked by the COP21 target to keep global warming to well below 2 (or 1.5) degrees Celsius compared to preindustrial levels. However, it is nowadays well-acknowledged that such ambitious global goals are predestined to fail if climate action is limited to national or regional levels [2]. Massive transformation in cities and the engagement of non-state actors in mitigation action are indispensable, since cities' residents are responsible for more than two-thirds of the global energy consumption and up to 70 percent of GHG emissions [3]. Certainly, the recognition of the vast potential of cities to mitigate climate change by both researchers [4] and policy makers [5], has led to an increasing number of local governments committing to climate and energy pledges and developing local climate action plans (CAPs), sometimes within the framework of their participation to different city networks. Examples of such networks are the EU Covenant of Mayors (CoM) and the Compact of Mayors, which were recently merged together to form the largest global coalition of cities and local governments of all



sizes, the Global Covenant for Mayors for Climate and Energy (GCoM) [6]. Particularly in Europe, already more than 60 percent of its cities have some sort of local climate plan in place [7]. In France, Slovakia and the UK, the adoption of such local CAPs is even compulsory for municipalities [7].

Although these numbers are encouraging, not any type of climate plan is sufficient. Cities should not only eventually strive to limit their emissions as close to zero as possible (i.e. become climate neutral), but also do so in the most sustainable way possible. Climate action is not an issue to be considered in isolation; it is one of the sustainable development goals (SDGs) of UN Agenda 2030 (i.e. SDG13) and is significantly linked – positively or negatively – with achieving many of the other SDGs [8]. In this sense, for local authorities on the road to developing a successful CAP the decision-making problem of identifying and choosing the best actions for practical implementation among the plethora of the possible ones is a multi-criteria and intricate one: conflicting and incommensurable aspects such as environmental, economic, social and technical issues, as well as conflicting stakeholder interests should be addressed simultaneously. It is no coincidence that a 2017 survey by the EU CoM Office on their community's capacity-building needs and knowledge gaps for the design and implementation of Sustainable Energy and Climate Action Plans (SECAPs), revealed that the second strongest methodological need of EU cities is “defining and prioritising actions based on certain criteria” [9]. In other words, local authorities lack understanding for prioritizing mitigation (and adaptation) actions.

Multi-Criteria Decision Analysis (MCDA) methods are well-known to cope with the complexities inherent in participatory and transdisciplinary decision-making and have already been used for decades in several fields. However, the methodologies which normally support the prioritisation and eventual selection of actions as part of developing local CAPs are limited to analyses wholly or partly relying on economic metrics. Most CAPs do not suggest the systematic use of MCDA. Indeed, there is still a limited number of case studies where MCDA methods have been applied to address this specific problem. In this context, this paper proposes a general participatory framework for guiding collaborative prioritisation of actions as a methodology to help local authorities with the development of more sustainable CAPs, while using MCDA. The framework is primarily built on a scan of recent literature and developments and it has not yet been systematically tested on real projects.

## **2. MCDA: An alternative approach to traditional methods for prioritizing interventions**

In general, in addition to traditional financial analysis, the most employed and widely accepted forms of analysis amongst governments to inform decision of whether a particular project or policy is worthwhile are cost effectiveness analysis (CEA) and cost benefit analysis (CBA) [10]. CEA is limited to identifying the most “cost-effective” action for achieving a single objective – in this case GHG emission reduction – and is therefore inappropriate for evaluating alternatives with co-impacts [11]. On the other hand, CBA can incorporate potential co-impacts by first assigning a monetary value to non-monetary aspects that need to be considered, such as environmental quality and health effects (in order to make all aspects comparable) and then comparing the aggregated costs and benefits of different alternatives expected to accrue along a specified duration [12]. However, for several social, environmental and technical aspects, monetization becomes controversial as limited examples of valuation techniques are available, or if available, significant uncertainties remain [13]. Several authors warn about converting all values into single metrics like monetary units [14].

In those cases, the use of alternative evaluation techniques, such as MCDA is advisable. MCDA enables the evaluation of the performance of an action or policy on multiple objectives/criteria and offers an alternative to the monetary valuation of environmental and social aspects when faced with the selection of actions. As pointed out by Ürge-Vorsatz et al. [13] MCDA has at least three strengths that go beyond what social CBA can offer and make it particularly suitable for climate-related decision-making. First, it provides a framework to handle together quantitative and qualitative information, therefore it can deal with incommensurability and it does not necessitate the use of any valuation technique to monetise non-monetary aspects [13, 15]. The fact that MCDA can include criteria which CBA cannot immediately makes it more suitable for strategic decision-making [16]. Second, it allows the inclusion of stakeholders' preferences into the decision-making process through the definition of

weights for the criteria. Third, it frames decision-making within a structured process of social deliberation and dialogue between stakeholders, analysts and scientists [13, 17, 18]. In other words, MCDA allows the use of qualitative information, the incorporation of stakeholder perspectives through weighting, and promotes a more democratic decision-making in the search of a compromised solution.

However, MCDA is not as standardised as CBA, despite its wide application in academic research – also in fields related to climate action – and the publication of government guidelines for some countries to support public authorities in its effective conduction (e.g. see [10]). The lack of official guidelines leads to most officials being less familiar with MCDA techniques [10]. However, when informed, they view MCDA as a useful decision-support tool for complex decisions. A study where 21 Dutch transport officials (and therefore real decision makers (DMs)) were interviewed showed that: (1) they find the composite result of CBAs pretentious and therefore they use CBA in a non-decisive manner, and (2) they are interested in appraisal tools which clearly show the important tradeoffs of different policies [19]. Therefore, it is recommended to use MCDA as a tool to support the early stages of climate action planning for first narrowing down the wide number alternatives to the most promising ones from a multi-stakeholder perspective. Then, one can switch to CBA for more detailed analysis.

### **3. The framework**

The systematic undertaking of MCDA to support the prioritisation of actions requires specific procedures, methods and tools to be available. This section provides a standardised and transparent decision procedure that integrates MCDA as a tool to help decision makers to the specific problem of climate action prioritisation and eventual selection (Figure 1). Roy [20] distinguished between four major stages of the decision procedure with regard to multi-criteria decision problems: definition of alternatives, definition of criteria (i.e. parameters characterising the decision problem), synthesis and modelling of the DMs' preferences, and solving the problem. The structure of the standardised procedure proposed in this paper expands Roy's major stages and was partly inspired by previous work in this field [21, 22]. The proposed procedure consists of three phases, namely: (a) problem structuring, which establishes the context within which the prioritisation takes place; (b) development of the MCDA model, which defines all the inputs required to run a multi-criteria evaluation according to the selected method; (c) the MCDA application including a sensitivity analysis. These steps are further subdivided into eleven further methodological steps requiring different methods/tools. Due to the limited space here, the paper focuses on steps V, VI, VIII, while Phase I is only briefly described (since it forms the basis).

#### *3.1. Problem structuring*

It is generally well-acknowledged that the participation of local stakeholders in energy and climate planning could improve not only the quality of the local CAPs due to the integration of local knowledge, but also their acceptance and effectiveness [23]. To identify stakeholders and assess them based on their power, interests, motives and attitude in relation to climate planning (as part of Step I, Figure 1) the instrument of stakeholder analysis has to be utilized. Such an analysis facilitates authorities to eventually bring the most salient stakeholders into the decision-making process. The literature proposes various methods for facilitating the process of stakeholder analysis [24]. Most papers argued that no method is better than the others and that a combination of existing methods likely produces the most useful results. The same applies to the engagement methods, where again a variety of possibilities are available [23], and the decision will depend on whether the purpose of participation is to inform, consult, cooperate, collaborate and/or empower. Regardless of the methods selected for the stakeholder analysis and their subsequent engagement, special attention should be paid to the two following aspects not enough highlighted in literature: (1) in addition to inviting powerful stakeholder groups as DMs in the process, representatives of vulnerable populations that will be most impacted by the plan must also be involved. This will help avoid situations of environmental, social and economic injustice; (2) in the creation of communication messages not only complex concepts should be simplified but also should be tailored to the mental model of each targeted stakeholder. Useful advice on how to more effectively communicate the controversial topic of climate change to non-technical public is available by Shome et al. [25].

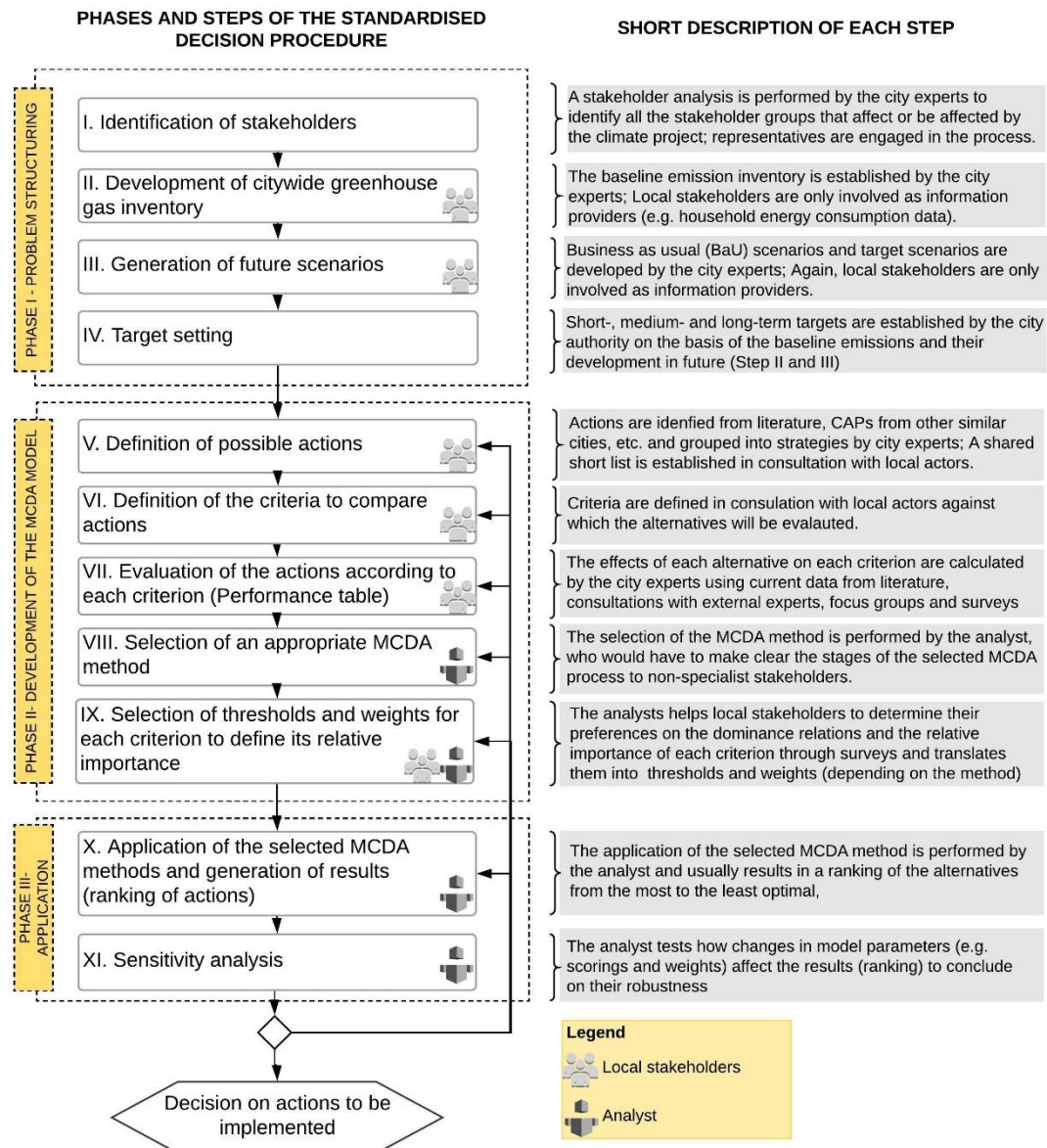


Figure 1. An action prioritisation framework for CAPs on the basis of typical MCDA procedures

The creation of a citywide GHG inventory (Step II, Figure 1) is mainly a technical task usually assigned to the related technical departments of municipality. A GHG inventory helps in determining the baseline emissions and identifying key emission sources and reduction opportunities [26]. In this step local stakeholders are involved as information providers and not as DMs. There are several inventorying methodologies in place that cities can apply [27]. The current trend is though towards the use of common reporting standards, such as the Global Protocol for Community-Scale Greenhouse Gas Emission Inventories (GPC) to allow the comparability of climate progress. Regardless of the inventorying standard used, it is noteworthy that although the city authorities are responsible for the generation of the inventory, they are not exclusively responsible for all of the emissions reported; some sources can only be influenced on a national level (e.g. industry). After selecting the strategic areas of action, cities have to conduct scenario analysis (Step III) to identify possible future emission trends on the basis of different socio-economic growth and climate mitigation assumptions [26]. This serves the basis for setting short-, medium-, and long-term citywide emission reduction targets (Step IV). The local knowledge, the baseline emissions, and the different targets form the ground of all the steps that follow.

### 3.2. Definition of possible actions

Actions are the fundamental building block of CAPs [26]. In addition to the categorisation and examples of climate actions provided by the EU CoM [28], there is nowadays an abundance of sources (either in the form of reports, tools or databases) that provide similar generic listings and categorisations (e.g. see [27, 29, 30, 31]) and can form a basis for this step. Many of them only incorporate actions in critical sectors where cities have the greatest control (i.e. buildings, transportation and waste management). Of course, actions can also be cross-sectoral. In addition to these typical lists, cities can also learn from implementation experiences in other cities. However, each city has its own geographic and socio-economic context and an action proved to be effective in one city may not be in another. Although the usefulness of learning from already realized good practice initiatives has been acknowledged by the EU CoM through the provision of a related database [32], the only context specific factors provided to filter the provided real examples of (more than 6000) measures are the population and country.

A need for more contextualized comparisons (with the purpose of learning) among cities is better expressed in CURB tool – the recommended tool to use by the Compact of Mayors for the development CAPs [30]. This tool, through its “benchmarking module” allows comparison of cities with similar characteristics on the basis of three filters: (1) region; (2) socioeconomic development (measured on the basis of the Human Development Index (HDI) rating); (3) climate. The latter parameter is an especially strong driver of energy consumption and associated GHG emissions in buildings, since heating and cooling demand may vary widely across cities with different climates, even in the same region. Although this “module” primarily aims at comparison, cities in the process of developing a CAP can use it to identify similar cities with already some experience and learn from their successes or failures.

Another critical point for cities to consider in this step is that achieving ambitious targets means that cities should also consider the inclusion of testing of more innovative actions in their climate plans. They should therefore grasp the opportunity to move from an above typical (or good) practice to becoming a leading paradigm for cities of a similar type. In this sense, for populating the list of possible actions cities can also seek inspiration from initiatives, such as C40 and Carbon Neutral Cities Alliance (CNCA), which actively encourage the recognition of the boldest and most ambitious climate actions in cities not only through climate leadership awards [33] and innovation funds [34], but also through reporting on best practice (e.g. in the Cities100 report [35] or the CNCA game changers report [36]).

Finally, for this step, it is not only important to identify possible actions per stakeholder (with the main one being the local authority), but also to develop a typology of actions and group them under certain strategies. A good practice example of such a typology is the distinction between “major actions” (i.e. actions for which the direct GHG emissions reduction can be quantified) and “enabling actions” (i.e. indirect actions that enable, accelerate, or multiply the effect of the major actions – e.g. campaigns about climate change and better training for the workforce) employed by New York City [37].

### 3.3. Review of criteria used in MCDA models

Using multiple criteria to evaluate, prioritise and select actions to be included in local CAPs is not yet a common (or transparent) practice. In most action plans, although an impressive list of actions is included, no clear-cut reference to the use of some kind of criteria to help in the choice of actions can be found [38, 39]. Indeed, out of the seventeen CAPs of CNCA cities only two of them, the City of Toronto and New York City, present a distinct prioritization approach (see [40] and [37]). To identify a set of generic criteria against which DMs can evaluate the feasibility and impact of actions as part of an MCDA framework, the present author investigated selected literature sources, including the two above-mentioned local CAPs. Specifically, the survey included: (1) studies and guidance frameworks developed by major national, regional and international organisations, i.e. the German Federal Institutes BBSR and BBR [27], the United Nations [41] and the C40 cities [42]; (2) Three open access decision support tools for city-level climate action planning, i.e. the CLIMACT Prio Tool [43], the BEST Cities Tool [29] and the most recent CURB tool [30]; (3) individual researches [22].

The results of the literature survey are presented in Table 1. In the case of the EU CoM signatories one can argue that the proposed indicators by the CoM already used by local authorities to describe key

actions as “Benchmarks of Excellence” can also be applied as criteria to solve the MCDA problem of action prioritisation [44]. In this regard, this has also been included as a source in Table 1 (see [28]). One can easily observe that, in addition to effectiveness (GHG emissions saving potential) the most common type of criteria found in the different sources are the ones of primarily economic nature (initial investment cost, annual running cost and generation of jobs). The ones that follow in popularity are the technical feasibility and the speed of implementation. When combined with “effectiveness” the first most recommended/used criteria (except for job generation) help in finding the most cost-effective actions, while the second ones help in identifying the key easy to implement short-term opportunities (i.e. “quick wins”). With the inclusion of quick wins in an action plan, municipalities can effectively demonstrate the added value produced by the plan and more easily engage people in contributing to the reductions until the longer-term benefits of the plan become apparent [16].

Table1. Parameters identified in selected literature sources that can act as criteria in an MCDA model.

Criterion group	Criterion	[41]	[28]	[27]	[42]	[43]	[30]	[29]	[40]	[37]	[10]	
<b>Feasibility criteria</b> (Efforts required)	Economic	Initial investment cost	✓	✓	o	-	✓	✓	✓	✓	✓	✓
		Annual running cost	✓	✓	o	-	✓	✓	-	✓	✓	✓
	Economic	Annual financial savings	-	✓	-	-	✓	✓	-	o	-	✓
		Payback duration/period	-	✓	-	-	-	✓	-	-	-	✓
		Return on investment (ROI)	-	✓	-	-	-	-	-	-	-	✓
	Regulatory	External funding programmes	-	-	-	-	-	-	-	-	✓	✓
		National regulation necessity	✓	-	✓	-	✓	-	-	-	-	-
	Technical	Level of technical difficulty	-	-	✓	-	✓	✓	-	-	✓	✓
		Possibility of pilot projects	-	-	✓	-	-	-	-	-	-	-
	Temporal	Speed of implementation	✓	-	✓	✓	-	-	✓	-	-	✓
	Social	Citizen acceptability	-	-	✓	-	✓	-	-	-	-	✓
		Stakeholder acceptability	-	-	✓	-	✓	-	-	-	-	-
		Social compatibility (mainstreaming potential)	-	-	-	-	✓	-	-	-	-	-
	Governance	Level of city power	-	-	-	✓	-	✓	✓	-	✓	-
<b>Impact criteria</b>	Climate-related	Effectiveness (GHG emissions saving potential)	✓	✓	✓	✓	✓	✓	✓	✓	✓	
	Economic	Private investment mobilization potential	✓	-	-	-	o	-	✓	✓	✓	-
		Generation of additional jobs	✓	✓	-	-	o	✓	✓	✓	✓	-
	Socio-economic	Mobility	-	-	-	-	o	✓	-	✓	✓	-
		Affordable housing	o	-	-	-	o	-	-	✓	✓	-
		Energy poverty	o	-	-	-	o	-	✓	✓	✓	-
		Exemplarity/image	-	-	-	✓	o	-	-	-	✓	✓
		Deferred infrastructure	-	-	-	-	o	✓	-	✓	✓	-
	Enviro-economic	Renewable energy produced	-	✓	-	-	o	✓	-	✓	-	-
		Environmental impacts	Adaptability to climate change	✓	-	-	-	o	-	-	✓	✓
	Energy resource use		✓	✓	-	-	o	✓	-	o	✓	o
	Other resource use (e.g. water, material, land)		-	-	-	-	o	-	✓	o	o	o
	Socio-environmental	Biodiversity conservation	✓	-	-	-	o	✓	-	-	✓	o
		Health: Air quality	o	-	-	-	o	✓	✓	✓	✓	-
		Health: Waste management	o	-	-	-	o	✓	-	-	✓	-
	Social	Preserve cultural heritage	✓	-	-	-	o	-	-	-	o	o
		Comfort	-	-	-	-	o	✓	✓	-	✓	-
		Noise pollution	-	-	-	-	o	-	-	✓	✓	-
		Aesthetic quality	-	-	-	-	o	-	-	-	✓	o
		Social mobilisation potential	✓	-	-	-	o	-	✓	-	✓	✓

Note 1: “✓” indicates that the parameter is explicitly mentioned; “o” indicates that it may form part of a broader category

Note 2: In some sources the cost(s) and revenue(s) (financial feasibility) are examined as part of marginal abatement curves (cost-effectiveness), e.g. [40]

However, for achieving ambitious 2030 and 2050 targets cities will need to ensure that they move beyond low cost and quick win opportunities and also pursue more investment intensive ones that take longer to play out but will be critical in achieving the required decarbonisation (such as urban densification and land-use planning) [45]. The business case for including such actions can be made by looking at their co-benefits. Actions delivering multiple benefits at once not only can be considered as cost-efficient, but they also increase the likelihood of their success by engaging more diverse communities of interest (also as investors) and demonstrating compelling added value for them [46]. These are the so-called “win-win” actions. Table 1 shows that although an increasing interest in the inclusion of co-benefits is observed, the inclusion of a larger list of sustainability indicators to account for positive side effects of actions as criteria in a MCDA model is still not the norm. In addition to that, an action may also be associated with unintended adverse consequences (co-harms). Most guides, however, solely use expressions such as “co-benefits” or “multiple benefits” introducing a positivity bias towards the impacts. For actions to be “no-regret”, they should not only be cost-effective and involve co-benefits but also be free of hard negative side effects with other objectives. For these and many other reasons, municipalities must seek comprehensive coverage of potential co-benefits and co-harms in their prioritization process to avoid counterintuitive results [46].

A problem that can arise in the case of including the numerous sustainability aspects as individual criteria in the MCDA model is that its complexity increases and therefore the interpretability of its results decreases. Some researchers agree that an average person can handle a maximum of nine criteria because of the general limitations of abstract thinking [47, 48]. When the number of the criteria is more than nine, the aggregation of criteria into groups is generally recommended. Several attempts to develop an ordinal scoring method for quantifying the qualitative mapping the positive and negative interactions between SDGs and their targets have been observed in the literature (e.g. see Nilsson et al. [49] for a sophisticated seven-point scoring method). This way of thinking can be easily transferred to the analysis of synergies and trade-offs between specific climate actions and other objectives. This is evident in the New York City’s plan where a five-scale qualitative system is employed, ranging from “major risk” (score 1) to “major benefit” (score 5) [37].

In regard to other underrepresented criteria in the various sources, it becomes clear that only a few MCDA models include social feasibility criteria. In general, social feasibility is concerned with gaining people’s acceptance regarding the actions to be programmed. In participatory frameworks where anyway representatives of stakeholders are included in the overall process, measuring their “acceptance” and include it as a criterion in the MCDA becomes easy. However, for a broader public acceptance the process of asking a considerable sample of local residents of the willingness to accept certain solutions may be impractical and time consuming. The present author suggest that the criterion of social compatibility is applied in any case, which can indirectly provide information on public acceptability [16]. Social compatibility captures the extent to which a solution is compatible with people’s current frame of mind and does not challenge their values and habits. Solutions with low social compatibility are usually met with a low degree of acceptability. For example, car sharing requires a significant shift in people’s mindset and travel habits. This was also revealed in an EU-wide survey [50], which found that only a minority of the respondents were interested in a car-sharing service, and even fewer considered this service as an actual alternative to car ownership. Information on social compatibility can be fairly easily retrieved from a discussion with the main stakeholder groups, literature sources and common sense.

Finally, it is also significant that cities take into account their “level of power” (i.e. control). Again, this criterion is not as highlighted as expected in the different guides. This factor can be included in a local CAP either as a criterion in the overall action prioritization exercise or it can form the starting point for a first shortlisting of actions, which are later evaluated and prioritized against all the rest criteria. To assist the first case, C40 provides a scoring framework broken down into four main categories, each with a score from 0-3 [42]: (1) Own/operate; (2) Set/Enforce Policies and Regulation; (3) Control Budget; (4) Set Vision. A similar framework is also employed by the BEST Cities Tool [29].



All these considerations are taken into account in the generic criteria tree presented in [16]. This tree may be used by city leaders as a starting point in order to facilitate the implementation of this step and/or may form the heart of a potential future standardization of the prioritization procedure in the context of climate action planning. Whatever the criteria tree used from literature (or a future standard) is, it should only be seen as a foundation to start this step; its acceptance by all involved DMs is crucial and criteria might be added and/or dropped depending on the specific objectives of the different DMs and the CAP.

### *3.4. Selection of an appropriate MCDA method*

Selecting a suitable MCDA method (Step VIII) is a multi-criteria problem in itself. Each method has its weaknesses and strengths (e.g. for a comparison see [17]) and there is no consensus about which methods are more appropriate in a particular context. A comprehensive review of studies comparing the application of selected MCDA models in the same case study to investigate whether the resulting rankings and the derived recommendations vary depending on the method shows that no definitive answer can be given [51]. In some cases, different methods led to the same best alternatives and in others the rankings changed significantly. Under these circumstances, to increase the robustness of the results, several authors recommend to use different methods in parallel [52, 53]. Usually the analyst decides which method(s) to use based on discussions with the DMs and his own competencies. The proposed framework does not aim to recommend a specific method. What can only be advised is to consider the use of methods that do not allow a high degree of compensation, and therefore support the strong sustainability concept [54]. Although it is argued that many of the compensatory MCDA techniques, such as the weighted sum model, use simpler algorithms, are easier to communicate, and potentially have less problems in gaining acceptance from stakeholders [17], any mathematical complexity can be handled if user friendly softwares are available. Several researchers [16, 17, 55] point out that the availability of software support to implement an MCDA method, manage the information and visualise the results in a clear, dynamic manner can provide considerable additional value for the user, and therefore can also be an important reason for choosing one method over the other. Indeed, the availability of such tools is growing – even the ones allowing the parallel use of different methods (e.g. Diviz [56]).

## **4. Conclusions and next steps**

Whereas the technologies and expertise are in place for cities to reach climate neutrality, the challenge to change their emissions trajectory while meeting multiple competing priorities is still tremendous. It has become evident by surveys that local authorities lack understanding and methodological bases with respect to the definition and prioritisation of actions based on certain criteria. The present paper attempted to translate the decision process with respect to action prioritisation into a standardised or formal procedure which integrates MCDA technique to enhance the bindingness of the overall exchange between stakeholders. Due to limitations, the paper focused on particular steps in the process and attempt to shed light on the latest sources and developments that could support them. It is recognised that quantifying stakeholder's preferences and a great number of criteria may be a laborious and time-consuming process. For this reason, city governments, when faced with limited resources, should make effective use of all ready-at-hand existing tools to support this task. Next steps in research that could help improving and accelerating the implementation of such a framework in the context of next generation local CAPs are: (1) the creation of a common database of best practice of climate actions in cities allowing the application of “filters” – so that to enable local authorities to focus on cities with similar geographic and socioeconomic context – to facilitate and accelerate the definition of actions. It is recommended that this becomes part of the future activities of GCoM to promote shared learning; (2) the development of “co-impacts” tools assisting their integration into the prioritization of actions; (3) Group decision-making software tools especially designed for the task of action planning that guide the municipalities throughout the entire action prioritization process, from the stakeholder analysis (Step I) to the sensitivity analysis (Step XI) and streamlines the communication process between stakeholders.

## References

- [1] IPCC 2007 *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* ed R K Pachauri and A Reisinger (Geneva: IPCC)
- [2] Hsu A, Widerberg O, Weinfurter A, Chan S, Roelfsema, M, Lütkehermöller K and Bakhtiari F 2018 *Bridging the Emissions Gap: The Role of Non-state and Subnational Actors: Pre-release Version of a Chapter of the Forthcoming UN Environment Emissions Gap Report 2018* (Nairobi: United Nations Environment Programme)
- [3] UN-Habitat 2011 *Cities and Climate Change: Global Report on Human Settlements 2011* (London: Earthscan Ltd, UN-Habitat)
- [4] Broto V C and Bulkeley H 2013 *Global Environ. Chang.* **23** 92-102
- [5] Global Commission on the Economy and Climate 2014 *Better Growth, Better Climate: The new Climate Economy Report* (Washington, DC: World Resources Institute)
- [6] Global Covenant of Mayors for Climate and Energy (Online: [www.globalcovenantofmayors.org/](http://www.globalcovenantofmayors.org/))
- [7] Reckien D, et al. 2018 *J. Clean. Prod.* **191** 207-19
- [8] Ambition to Action 2017 *SDG Climate Action Nexus Tool (SCAN-tool)* (Online: [http://ambitiontoaction.net/scan\\_tool/](http://ambitiontoaction.net/scan_tool/))
- [9] Covenant of Mayors for Climate and Energy 2017 *Covenant Community's Needs for SE(C)AP Design and Implementation* (Available at: [www.covenantofmayors.eu](http://www.covenantofmayors.eu))
- [10] Dodgson J, Spackman M, Pearman A and Phillips L 2009 *Multi-Criteria Analysis: A Manual* (London: Department for Communities and Local Government)
- [11] Browne D and Ryan L 2011 *Environ. Impact Asses.* **31** 226-33
- [12] OECD 2006 *Cost-Benefit Analysis and the Environment: Recent Developments* (Paris: Organization for Economic Cooperation and Development)
- [13] Ürge-Vorsatz D, Herrero S T, Dubash N K and Lecocq F 2014 *Annu Rev Environ. Resou.* **39** 549-82
- [14] Saarikoski H, et al. 2016 *Ecosyst. Serv.* **22** 238-249
- [15] Munda G 2004 *Eur. J. Oper. Res.* **158** 662-77
- [16] Balouktsi M 2018 Principles and Tools for Designing Strategies for Sustainable Urban Development: A "Process-based" and "Action-oriented" Approach at Neighbourhood Level (Karlsruhe: Karlsruhe Institute of technology) PhD Thesis available at: <https://publikationen.bibliothek.kit.edu/1000088490>
- [17] Cinelli M, Coles S R and Kirwan K 2014 *Ecol. Indic.* **46** 138-148.
- [18] Gerber J F 2013 *Guide on Multicriteria Evaluation for Environmental Justice Organisations* (EJOLT Report No. 08) (Available at: <http://www.ejolt.org/>)
- [19] Annema J A, Mouter N and Razaeei J 2015 *Trans. Res. Proc.* **10** 788-97
- [20] Roy B 1990 *Eur. J. Oper. Res.* **45** 324-31
- [21] Belton V and Stewart T J 2002 *Multiple Criteria Decision Analysis: An Integrated Approach* (Berlin: Springer Science & Business Media)
- [22] Markl-Hummel L and Geldermann J 2014 *EJDP* **2** 121-52
- [23] European Commission 2010 *How to Develop a Sustainable Energy Action Plan (SEAP): Guidebook* (Brussels: Covenant of Mayors)
- [24] Reed M S, et al. 2009 *J. Environ. Manage.* **90** 1933-49
- [25] Shome D, et al. 2009 *The Psychology of Climate Change Communication: A Guide for Scientists, Journalists, Educators, Political Aides, and the Interested Public* (New York: Center for Research on Environmental Decisions)
- [26] Tuts R., et al. 2015 *Guiding Principles for City Climate Action Planning* (Nairobi: UN-Habitat)
- [27] BBSR and BBR 2017 *CO<sub>2</sub>-Neutral in Cities and Neighbourhoods: The European and International Perspective* (Bonn: BBSR-Online-Publikation)
- [28] Covenant of Mayors for Climate and Energy 2016 *The Covenant of Mayors for Climate and Energy Reporting Guidelines. Version 1.0* (Available at: [www.covenantofmayors.eu](http://www.covenantofmayors.eu))

- [29] Price L, et al. 2016 *Low-Carbon City Policy Databook: 72 Policy Recommendations for Chinese Cities from the Benchmarking and Energy Savings Tool for Low Carbon Cities* (Report Number: LBNL-1006326) (Available at: <https://repository.usfca.edu/>)
- [30] The World Bank 2016 *The CURB Tool: Climate Action for Urban Sustainability* (Online: <http://www.worldbank.org/en/topic/urbandevelopment/brief/the-curb-tool-climate-action-for-urban-sustainability>)
- [31] ClimateTechWiki (Online: <http://www.climatetechwiki.org/>)
- [32] Covenant of Mayors for Climate and Energy (Plans and Actions, Online: <https://www.covenantofmayors.eu/plans-and-actions/good-practices.html>)
- [33] C40 Cities (C40 Cities Bloomberg Philanthropies Awards (Online: <https://www.c40.org/awards>)
- [34] CNCA Innovation Fund (Online: <https://carbonneutralcities.org/initiatives/innovation-fund/>)
- [35] Brown J, Sako D 2016 *Cities100: 100 Solutions for Climate Action in Cities* (Copenhagen and London: Sustainia and C40 Cities Climate Leadership Group)
- [36] Plastrik P and Cleveland J 2018 *Game Changers: Bold Actions by Cities to Accelerate Progress Toward Carbon Neutrality* ed M Shank and J Partin (Copenhagen: CNCA)
- [37] C40 2017 *Case Study: Action Prioritisation Methodology Applied for New York City's 1.5 °C Climate Action Plan* (Available at: <https://resourcecentre.c40.org/>)
- [38] Neves A R F 2013 *Decision Support Methodology for Local Sustainable Energy Planning* PhD Thesis (Porto: Faculty of Engineering of the University of Porto)
- [39] OECD 2010 *Cities and Climate Change* (Paris: OECD Publishing) Chapter 7
- [40] SSG 2017 *TransformTO: Climate Action for a Healthy, Equitable, Prosperous Toronto: Results of Modelling Greenhouse Gas Emissions to 2050* (Vancouver: Sustainability Solutions Group)
- [41] Scricciu Ş, Bristow S and Puig D 2011 *MCA4climate - A Practical Framework for Planning Pro-Development Climate Policy* (Milan: United Nations Environment Programme)
- [42] C40 Cities and Arup 2016 *Deadline 2020* (Available at: [www.c40.org/other/deadline\\_2020](http://www.c40.org/other/deadline_2020))
- [43] Institute for Housing and Urban Development Studies (IHS) 2014 *ClimactPrio: Climate Actions Prioritization Tool* (Available at: [www.ihs.nl/research/research\\_projects/climact\\_prio\\_tool/](http://www.ihs.nl/research/research_projects/climact_prio_tool/))
- [44] Marinakis V, Doukas H, Xidonas P and Zopounidis C 2017 *Omega* **69** 1-16
- [45] McKinsey Center for Business and Environment and C40 Cities 2017 *Focused Acceleration: A Strategic Approach to Climate Action in Cities to 2030* (Available at: <https://www.mckinsey.com/business-functions/sustainability/our-insights/a-strategic-approach-to-climate-action-in-cities-focused-acceleration>)
- [46] SSG 2017 *Technical Paper No 4: Considerations of Co-Benefits and Co-Harms Associated with Low Carbon Actions for TransformTO* (Vancouver: Sustainability Solutions Group)
- [47] Yavuz M and Altay B L 2015 *Environ. Earth Sci.* **73** 6167-79
- [48] Žak J 2016 *The Methodology of Multiple Criteria Decision Making/Aiding in Transportation Advanced Concepts, Methodologies and Technologies for Transportation and Logistics* ed J Žak, Y Hadas and R Rossi (Cham: Springer) pp 9-38
- [49] Nilsson M, Griggs D and Visbeck M 2016 *Nature* **534** 320-22
- [50] Fiorello D, Martino A, Zani L, Christidis P and Navajas-Cawood E 2016 *Trans. Res. Proc.* **14** 1104-1.
- [51] Mysliak J 2006 *Environ. Plann. C* **24** 257-77
- [52] Yatsalo B I, Kiker G A, Kim J, Bridges T S, Seager T P, Gardner K, et al. 2007 *Integr. Environ. Assess.* **3** 223-33
- [53] Convertino M, Baker K M, Vogel J T, Lu C, Suedel B and Linkov I 2013 *Ecol. Indic.* **26** 76-86
- [54] Polatidis H, Haralambopoulos D A, Munda G and Vreeker R 2006 *Energy Sources Part B* **1** 181-93
- [55] Mustajoki J and Marttunen M 2017 *Environ. Modell. Softw.* **93** 78-91
- [56] Decision Deck Consortium 2018 *Diviz* (Online: <https://www.diviz.org/>)