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Key Performance Indicators for Sustainable Urban Development: Case Study Approach

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Abstract. Built environment energy efficiency improvement at the urban scale plays a key role to reduce the detrimental environmental impacts. However, the design and implementation of sustainable development scenarios is a complex process involving a large number of decision criteria and actors. An on-going Interreg project, "CesbaMED", emphasizes to employ a common sustainability assessment framework at the urban scale, which is a set of eight regional assessment tools, named CESBA MED SNTool. This tool is an innovative decision-making process, which supports the development of energy efficiency plans for building stock in the context of their surrounding neighbourhoods. Moreover, this tool produces the MED Passport, which compares the sustainability performances of buildings and neighbourhoods. This study aims at presenting the on-going research activities with a specific focus on the selection of the set of relevant Key Performance Indicators (KPIs) among the indicators of CesbaMED project for the case study of the city of Turin (Italy), based on stakeholders' preferences. A workshop was organized to select the criteria and to assign the stakeholders' preferences using the "Delphi" survey method. This method is used in order to investigate the stakeholders' perspectives on the impact of each indicator on the different future sustainable scenarios. The results show that the stakeholders decided to remove and modify some KPIs for the specific case study of Turin with respect to its particularities.

1. Introduction

Global urban population is constantly increasing from the beginning of XX century and in 2008 has been reached a huge turning point: more than 50% of people are now residing in a urban context instead of a rural area. [1]. Thus, cities are now key actors in facing dramatic and pressing challenges of our time, like the one related to climate change and global warming. Although urban areas occupy less than 10% of earth surface, they are responsible for more than 70% of energy-related emissions [2]. The recent Intergovernmental Panel on Climate Change (IPCC) reports are warning the need to reduce the emissions in order to contain global warming under 1.5° C instead of 2°, a control value identified by the Paris Agreement [3]. Nowadays, the increasing importance of urban areas in facing global challenges in an integrated way is reflected in the development of a set of Sustainable Development Goals (SDGs), identified by UN Agenda 2030 [4]. Among the 17 SDGs, Goal 11 is completely dedicated to cities and human settlements in general with the aim of making them more inclusive, safe, resilient and sustainable. In fact, cities are asked to give concrete and rapid solutions for more fair and eco-friendly human development [4], [5]. Transformations needed to limit global warming to 1.5° require an integrative approach that reflects links, synergies, and trade-offs between mitigation and adaptation measures and sustainable development. As said before, cities are the ultimate framework for the development of new strategies and approaches in facing climate change and global warming. Therefore, local governments have the deal of connecting local needs with global ones [6]. In this sense, new challenges raises in terms of relation and coordination between cities and other subnational and national governments [7].

New tools and methodology for the planning of more sustainable cities are necessary to address multiple objectives (e.g. mitigation of energy consumption,increase in energy efficiency of systems andadaptation of urban areas to climate change at the same time) [8][9].

According to the current research, it has now been proven that there is a need to rethink energy efficiency measures at a larger scale, considering the public building as a tile of a wider area, thus better exploiting the potential synergies between buildings, in economic, social and most importantly environmental terms [10]. In fact, it has been demonstrated that a larger scale approach is preferable to a building scale approach in order to plan significant and cost-efficient improvements at the building and district level. Nonetheless, moving from a building scale to a territorial scale (bloke, neighborhood, district or city level) progressively requires considering an all-new set of sustainability variables, and involving numerous new stakeholders, thus extremely complexifying the decision-making process.

Moreover, the proliferation of many different assessment systems does not make the work any easier for the decision makers, who in order to successfully handle the design and implementation of valid energy efficiency measures need a clear reference methodology, with a common internationally shared set of criteria and indicators.

The CESBA Med project-Sustainable MED Cities (www.cesba-med.interreg-med.eu) is an Interreg MED Programme, developed within the framework of the Priority Axis 2 "*Fostering low-carbon strategies and energy efficiency in specific MED territories: cities, islands, and remote areas*", and finalized "*to raise capacity for better management of energy in public buildings at transnational level*" [11]. The project is part of the CESBA initiative (Common European Sustainable Built Environment Assessment) [12], which mainly intends to build a harmonized building assessment system for MED territories. This fact fosters the adoption of assessment tools by public administrations, and consequently, enhance environmental sustainability and low-carbon strategy. The City of Turin, lead partner of CESBA Med in collaboration with a local scientific organisation has coordinated 12 different partners[1], both public and technical organisation, from 7 different European countries.

The project aims at capitalising the available knowledge and outcomes emerged from 10 previous European projects and initiatives in order to produce a common synthesis of different scientific approaches. The strategy is to develop and test a transnational framework to assess urban sustainability, the so-called "*General Framework"* in the Mediterranean regions, based on a common set of indicators. Such transnational approach has been fundamental in order to test an innovative common assessment framework at urban scale. From the general framework has been defined a set of 8 harmonized regional assessment tools (CESBA MED SNTools), which are contextualized in order to exploit specific local features with a view to energy efficiency for public buildings in the context of their surroundings neighborhoods

The outcome consists of a common methodology suitable for the Mediterranean region, able to easier the decisional process and to reinforce the capacities of public administrations for more efficient energy retrofitting plans. Indeed, sharing common methodology and metrics between different countries makes the quality of the built environment comparable between them, allowing the sustainability assessment of both existing and new urban developments. In fact, trough the contextualisation of a SNTool at the urban scale, will be issued a "*sustainability certificate*", the CESBA MED Passport.

The present study aims at simulating a decisional process to validate the most relevant indicators for the City of Turin, based on stakeholders' preferences, using the "Delphi" survey method [13]. The study reports an experimental workshop organised by a university research team in order to test the CESBA MED framework in the local context.

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The paper is divided as follow: Section 2. illustrates the methodological approach to indicator selection, while the obtained results and a brief discussion regards the key findings are reported in Section 3. The paper lasts with conclusive remarks and some potential future developments (Section 4.

2. Methodology

This section illustrates the methodological approach that has been used to select the relevant indicators among the set of CesbaMED indicators for the case study of city of Turin (Italy).

At the urban scale, the Cesba MED Generic Framework is structured in 7 issues, 23 categories, and 178 criteria and indicators. An *issue* is a macro-theme chosen and recognised as relevant for assessing the sustainability of a building or urban area (e.g., Built Urban System); a *category* is an aspect related to a specific issue (e.g., Urban Structure and Form); a *criterion* is a specific aspect of the relative category. Each criterion is associated with an *indicator*, a methodology which allows characterising the building performance.

From this generic list of relevant indicators that constitute the common assessment framework, a set of Key Performance Indicators (KPI) at building and urban scale has been identified, in order to address all main sustainability issues (i.e., A) Built Urban Systems, B) Economy, C) Energy, D) Atmospheric emissions, E) Non-renewable sources, F) Environment, G) Social aspects). The KPIs have been selected by CESBA Med project, always taking into consideration the three pillars of sustainability; economy, environment and society.

In fact, with a set of common metrics (KPIs), shared among all the different partners, the results of an assessment sustainability evaluation are directly measurable and comparable. In the local contextualisation process (CESBA MED SNTool) of the Generic Framework, the CESBA MED set of indicators is coupled with a multi-criteria assessment methodology, in order to simplify decision-making processes and enhance urban sustainability. The model of the decision-making process is intended to support public administrations in the definition of the best retrofit scenario for public buildings in the context of their urban areas and new urban developments.

This paper reports an experimental workshop set up in October 2018 at the Politecnico di Torino (Italy), which was not officially part of the CESBA MED project but aimed at testing the selection of indicators proposed. The experiment was meant to present the framework and verify its validity among different actors, a group of students from the Politecnico di Torino with various backgrounds (urban planning, architecture, environmental engineering). The experiment served a twofold purpose: the first was an educational one in terms of involvement in a real decisional process, while the second was to define a possible alternative rank of indicators in order to assess retrofitting operations in the Turin context.

The workshop was organized using the well-known Delphi method, a iterative and participative methodology used in a variety of disciplines in order to provide consensus between different experts [14]. Particularly, the Delphi is an interactive structured group method that works through two or more rounds of panel experts' opinion collections and feedback [15]. In the literature, it is not possible to track the optimal size of the panel, however it is a methodology that allows the participation of a larger group of people [13]. In this case, it was employed in order to investigate the stakeholders' perspectives on the impact of each indicator over different future sustainable scenarios envisioned by the new urban masterplan of the City of Turin.

According to the literature, during the initial phase each participant is asked individually to express a preference using a pre-defined questionnaire, taking into account different aspects such as economic, environmental, cultural, and architectural [15] [16]. The participants should provide their list of preferred indicators and should express the relative motivations. Afterward, their judgments are fed back to the other participants in order to reflect, discuss, and eventually re-assess the range of selected indicators. It is important to stress that Delphi method was not used to define a new ranking but to promote discussions and create consensus regarding the final set of indicators.

During the workshop, the authors played the role of analysts, aiding and moderating the panel without expressing any personal preferences [17]. As anticipated before, stakeholders with different backgrounds have been involved and have been divided into six different groups, containing an average

of five people. A specific role has been assigned to each group: Group 1 and Group 2 represent the interests of the public administration, respectively of the Planning Department and of the Environmental Department; the citizens and the companies are represented respectively from Group 3 and Group 4; Group 5 is constituted by transportation experts, while Group 6 by social science experts.
The workshop has been divided into two separate phases:

1. During the first half, participants had to work within their own group in order to explore and discuss the importance of each indicator within a perspective of sustainable urban development. Each "expert" is asked individually to express their own list of indicators taking into account different aspects such as economic, environmental, cultural, and architectural. The indicators can be for example running costs energy for buildings, recycling and disposal of solid waste, and so on. Into this end, the analysts (authors) asked them to think about the relative importance of indicators in terms of urban sustainability. Stakeholders can assess the importance of each indicator using a range of three colours: green to accept the indicator, red to reject it, and yellow to modify the description of indicator in terms of the description or the impact assessment (Table 2).
2. Successively, they got together to share groups' opinions and ideas, in order to achieve a single and shared solution. Therefore, all the group lists were illustrated, and stakeholders had to convince other ones to accept their choices proving the motivations. The participants were asked to review the information and to resubmit their initial list. This process is repeated until a consensus was not reached [15].

3. Results and discussion

A set of 14 indicators, listed in Table 1, had been selected in advanced by authors, as external experts. Each group had to decide if validate or reject each indicator from the pre-defined list, or slightly modify it to make it more suitable for the context in analysis.

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Table 1. List of urban indicator used in the workshop and selected from Transnational Indicators analysed in the CESBA Med project [18].

Issue		Indicator	Description	Unit
A	**Built Urban Systems**	Conservation of Land	The total area of undeveloped land considered to be of value for ecological or agricultural purposes by relevant authorities, as a percent of the total local area	%
B	**Economy**	Running costs energy for buildings	Running cost of energy aggregated	€/m^2/year
C	**Energy**	Total final energy consumption for building operations	Aggregated total final energy	kWh/m^2/year
		Share of energy generation from on-site renewable sources on final	Share of renewable energy in final thermal energy consumptions	%
D	**Atmospheric Emissions**	Total GHG Emissions from energy used in building operations	CO2 equivalent emissions per useful internal floor area per year	kgCo$_2$eq/m^2/year
E	**Non-renewable Sources**	Consumption of potable water for residential population	Water consumption per occupant	m^2 per occupant * year
		Recycling and disposal of solid waste	Volume of waste that is recycled on the total solid waste produced in households	%
F	**Environment**	Recharge of groundwater through permeable paving or landscaping	Permeable area in relation to total area	%
		Ambient air quality with respect to particulates <10 mu (PM10) over a one-year period	Number of days exceeding the daily limits in a year	n
		Accessibility to green areas and leisure areas	Percentage of inhabitants that are within 1 km walking a green space or park	%
G	**Social aspects**	Performance of public transport	Percentage of inhabitants that are within 400 m walking distance of at least one public transportation service stop	%
		Quality of pedestrian and bicycle network	Total walkway meters of dedicated pedestrian paths and meters of bicycle path per 100 inhabitants	m/100 inhabitants
		Availability and proximity of key services	Percentage of inhabitants that are within 800 meters walking distance of at least 3 key services	%
		Community involvement in urban planning activities	Level of involvement of users in urban planning	Level

As expected by the application of the Delphi methodology, different decisions made from the debate phase that in some case changed the initial list of indicators by confirming or modifying it. In the following paragraph a brief summary of outcomes is illustrated in order to show how the Delphi methodology works.

All groups agreed on the importance of environmental and social KPIs. Social KPIs gained major consensus and were never identified as “less important”, however, some groups asked to modify them in order to have a more precise and specific description of the indicator. For example, Group 1 and Group 2 (representing different departments of municipality) asked for more details about the forms of engagement and level of participation of citizens in urban planning activities expressed in a general form in the indicator number 14. During the following discussion, the first two groups were able to convince the others to ask for a modification of the last social indicator.

All participants to the experiment converged on the acceptance of environmental indicators as “recharge of groundwater through permeable paving or landscaping” and “ambient air quality with respect to PM_{10} <10 mu over a one-year period”, accepted in both case by 83% of participants, except for the Group 4, representing the private sector, that stated that these aspects are not a priority for firms and do not directly positively influence wellbeing of employees. There was no need to discuss further about these environmental indicators, since a preliminary full agreement was found among participants.

The only indicator among which all groups agreed on the less importance is “consumption of potable water for the residential population” – 67% of stakeholders decided to reject it. Probably, in the context of Turin, problems related to water consumption are not perceived as crucial aspects. However, “Environmental department” group and “Social Science expert” group accepted the indicator without any modification, probably because of their background that makes them think with a less local and more global view of environmental impact.

Major disagreements were related to energy and environmental sustainability categories, caused by a different point of view on specific aspects – for example, total GHG emission for building operation obtained 67% of acceptance, 17% of rejection and 17% of modification request. In fact, every group acted with a specific focus on some aspects of sustainable development. Citizens accepted the KPI related to GHG emissions, but not the one conceiving energy consumption, however, accepted by the private sector. Results are reported in Table 2.

The experiment was useful for authors in order to test the validity of indicators selection in a more informal context, using an inclusive methodology in which participants are not intimidated or inhibited from expressing their views[13]. The use of a solid and widely tested methodology led to achieve a shared outcome among participants, representing a first occasion to researchers to experiment a new process for indicator selection. Finally, students had the possibility to try new teaching approaches by simulating a real process.

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Table 2. Results of the workshop.

Indicator	Groups' assessment						Shared solution
	G1	G2	G3	G4	G5	G6	
Conservation of Land							
Running costs energy for buildings							
Total final energy consumption for building operations							
Share of energy generation from on-site renewable sources on final							
Total GHG Emissions from energy used in building operations							
Consumption of potable water for residential population							
Recycling and disposal of solid waste							
Recharge of groundwater through permeable paving or landscaping							
Ambient air quality with respect to particulates <10 mu (PM10) over a one-year period							
Accessibility to green areas and leisure areas							
Performance of public transport							
Quality of pedestrian and bicycle network							
Availability and proximity of key services							
Community involvement in urban planning activities							

4. Conclusions

The paper reports an educational experiment to test the selection of KPI in the local decision model of the new masterplan of the City of Turin. The initial set of indicators is part of the Cesba Med generic framework, which derive from previous European assessment of urban sustainability. The final selection of KPI was conducted during a workshop in which the Delphi method was applied. In the first phase students participating to the workshop were grouped in a different role, are asked to assess the indicators as “accepted”, “rejected” or “to be modified”. During the second phase a discussion between groups was developed and a final shared solution was defined for each indicator.

As a result, all indicators could be applicable for the Turin case study. In fact, almost all indicators are accepted, someone with the necessity to be slightly modified in the description field. Only the indicator related to the consumption of potable water is rejected in the final solution, probably because it is not perceived as a primary problem within the specific local context by the most of involved actors.

Forward steps are related to the real CESBA MED process, developing the SN tool, the decisional model developed for the specific local context in accordance with KPI selection from the general framework. At the same time, another Interreg project aims at scaling the Cesba Med sustainability assessment from the district scale to the city scale, acting some modifications in order to better include all aspects that characterise the complexity of an urban area of city of Turin.

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