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Urban sustainability assessment of neighborhoods in Lombardy

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Abstract

The paper presents a contextualized system useful in the decision-making of Public Administrators for analysis and actions concerning urban sustainability and for monitoring neighborhood transformation processes. The system is developed with an approach made up by Inputs (available data from standards and laws and state-of-the-art), Controls (i.e. technical skills of Public Administrators) and Mechanisms (know-how and software used) which implement Outputs, the main elements of the system: Sustainability indicators, Benchmarks and Scores. The set of indicators chosen allows to consider many aspects of environmental sustainability as Resource Consumption (Energy, Materials, Water, Soil) and Environmental Impacts (Pollutant Emissions, Wastes and Vulnerability). The objective parameters of the indicators are based on a benchmarking activity in relation to the Lombardy context and in order to provide reachable target performance. Finally, a baseline of weighted scores of indicators is proposed to allow to reach a final overall score of sustainability of the neighborhood.

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1. Introduction

Public Administrations and urban designers were compelled to modify the territory following industrial and technological development in order both to meet the inhabitants needs and to preserve the peculiar features of the territory itself. In Italy, starting from the second part of XX century, the fast technological development and the

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ongoing population growth and migration from the countryside to the cities [1] has led to significant urban transformation processes; many laws concerning city planning were passed in order to control this phenomenon. Despite the laws, in some cases, urban development remained unchecked causing a progressive loss of urban sustainability and resilience. To face this problem a very broad know-how is required and Public Administrations often do not have it.

Urban sustainability can be achieved when a city has an homogenous development concerning environmental, economic and social issues; in this way the city can recover from significant multi-hazard threats with minimum damage to public safety and health, economy and security. Nowadays, thanks to the broad possibility to collect data concerning many specific issues over the time, a wide range of databases, indexes and documents are available for achieving a better knowledge of the cities [2]: this is crucial to guarantee urban sustainability and resilience.

This paper proposes a new system of indicators for assessing sustainability of urban areas that could support Public Administrations in the development of strategies, policies and regulations concerning urban sustainability. The framework can be applied at two levels (i) a full version that includes environmental, social and economic profiles of sustainability; (ii) a small version, based on indicators related to the environmental and urban structure issues only, which can be applied to an urban sub-area (i.e. neighbourhood or district). This paper describes the second version, the Urban Decision Support System for Neighbourhood (UDSSN).

The development of the tool is based on a multidisciplinary approach to implement outputs represented by the set of sustainability indicators, benchmarks and the score system.

2. Methodology

The logical approach used to develop the system tries to address all the critical points according to the following IDEF0 diagram [3] (Fig.1).

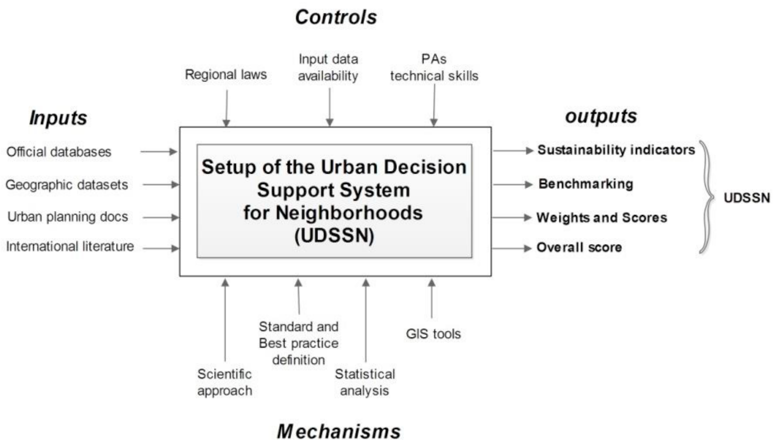

Fig. 1: Methodological approach scheme

The process is divided into four parts: (i) Inputs, which represent all data included in the process; (ii) Controls, which coincide with all factors that place constraints on the process development orienting it towards a specific direction, (iii) Mechanisms, that consider all of the tools (also human resources) used to produce outputs, (iv) Outputs, that represent the final expected results of the process.

In this system, Inputs are represented by data sources (stats, maps and other kinds of documents used to develop indicators and benchmark scales), Controls are the boundaries considered due both to the needs of Public Administrations and to the regional context in which the system is applied (Lombardy Region), Mechanisms are provided both by algorithms and scientific know-how and, finally, Outputs which refer to the elements of the overall

Urban Decision Support System for Neighborhoods (UDSSN) useful for Public Administrations and made up of sustainability indicators and performance levels.

All these process elements are described in the following subheadings, Outputs are considered in "Results".

2.1. Inputs

The analysis of the inputs suitable for developing the UDSS for neighborhoods deals with 4 kinds of source data: i) – official stats, ii) – geographic datasets, iii) – urban planning documents, iv) – international scientific literature on urban sustainability and the main voluntary assessment tools for the certification of urban areas sustainability. The analysis was mainly focused to free-access on-line official documents in order to guarantee a full and recognized access to information.

Some sets of indicators available from national official databases (i.e. Italian Statistic Institute – ISTAT at national level [4] and Annuario Statistico Regionale Regione Lombardia at regional sub-level) have been considered. These databases provide information concerning all the main issues of sustainability but they do not include high levels of performance which are collected periodically. CEER Lombardia (Lombardy Energy Building Register) [5], provided all the energy data of buildings. This kind of data were crucial to develop energy indicators. Finally urban sustainability analysis made by ISPRA (Italian Environmental Agency) [6], has been examined.

Concerning available datasets, the contents of the official Lombardy geographic web-portal, named "Geoportale" [7] were analyzed: in particular, several raster and vector GIS maps were useful for the identification of indicators related to the urban morphology of neighborhoods.

Existing urban planning documents were analyzed to identify the most common indicators and municipalities prescriptions related to urban development (i.e. "Piano di Governo del Territorio" which is a tool which disciplines municipal urban planning).

Finally, some papers from international literature have been considered as the most relevant sources for developing the system. The main voluntary assessment tools adopted by approved bodies for the certification of urban areas sustainability (i.e. BREEAM [8], LEED [9], CASBEE [10], DGNB [11], SBTool based on SBMethod [12]) have been studied and their most relevant elements related environmental thematics acquired.

In particular the relationship between the use and the application of these tools and Public Administrators needs and activities has been analyzed. For example the imposition of mandatory design strategies within indicators is coherent with local regulations and useful for a certification purpose within building market sector, but not applicable in Lombardy context and not always well-suited with the structure and development of Italian cities and their different municipalities city planning regulations.

2.2. Controls

The control factors have strongly influenced the process because, in this research, they represent constraints strictly related to the regional context. In particular, the role of local authorities and their activity influence the choice of most suitable indicators for sustainable analysis and assessment.

The first objective control factor was the regulatory state-of-the-art concerning urban development. The current reference urban planning Regional Law of Lombardy (L.12/2005) [13] defines the contents of urban planning documents developed in each Lombardy municipality leading to a standardization of documents available. Using a law which is rather outdated, may lead to the diffusion of a standard building practice throughout the territory [14]: sustainability indicators have to consider this standard practice as the minimum level on the performance scale [15].

The second control factor coincides with the availability of input data. One of the aims of the research work was to develop a system applicable to all typologies of Lombard cities so it was important to define only one set of indicators: statistical analysis needs a great amount of data and it could be difficult to perform analyses of small cities where there are only few available data about the neighborhood.

The third control factor is related to the behavior of local administrators: their technical skills and the time they need to make the evaluation. An ideal administrator must be equally skilled in technical, human and conceptual [16] aspects, and must have a good level of understanding and proficiency in a specific field of activity, particularly one involving methods, processes, procedures or techniques. In this sense, the complexity of the issue of sustainability does not allow to reach the best level of technical skill in each thematic area of urban sustainability (an administrator cannot be an economist, an engineer, an energy expert and a sociologist at the same time).

As a consequence, the time needed for the assessment with UDSSN could be too long and so the number of sustainability indicators was reduced for a non-pure scientific purpose, with densely packed information. In particular, according to the study of Tanguay et al. [17], about 32 indicators are enough to carry out a complete analysis of sustainability development of a city: as an objective, the final set of indicators proposed for the assessment of neighborhood includes 15 of them.

2.3. Mechanisms

Different kinds of tools and resources have been used to implement the indicators for the sustainability assessment: for an easy application of the system, indicators must be calculated with user-friendly and open-source tools. Most of the indicators and sustainability levels are defined by statistical analysis carried out with available input data where the standard level coincides with the mean performance, especially when official datasets were analyzed (i.e "Primary energy for heating" indicator) Furthermore, the best practice performance coincides with the higher sustainability level (i.e Heat Island Effect indicator). More specific information will be provided in the Results section. Especially concerning urban morphology and land use, standard features of GIS systems and software were useful to assess some indicators based on distance/areas parameters (i.e. "Connectivity of green spaces" indicator).

3. Results

3.1. Sustainability indicators

The final version of the Neighborhood DSS tool has a set of 15 sustainability indicators (Table 1).

Table 1: Sustainability indicators and parameters

Code	Indicator	Parameter
A.1.1	Intensity of water treatment	Percentage of civil pollutant loads treated in waste water purification plants [%]
A.2.1	Green fabric quota	Share of green spaces per inhabitant [m²/inhab]
A.2.2	Connectivity of green spaces	Percentage of the total of connected green spaces [%]
A.4.1	Primary energy for heating	Percentage of certified buildings with energy class for heating higher than G [%]
A.4.2	Energy for lighting	Average luminous efficiency of lighting devices [lm/W]
A.4.3	Primary energy for DHW	Average primary energy demand for DHW of certified residential buildings. [kWh/m²]
A.4.4	Production of renewable energy	Production of renewable energy from solar thermal and solar photovoltaic systems installed on certified residential buildings [kWh/m²]
A.5.1	Intensity of GHG emissions	Average level of GHG emmissions from existing buildings [kgCO2eq/m²year]
A.6.1	Light pollution	Percentage of the total of lighting devices in accordance with "Legge Regionale 27 marzo 2000, n. 17 " [%]
A.7.1	Permeability of land	Share of filtering surface area in relation to the specified minimum included in "Piano di Governo del Territorio" document [%]
A.7.2	Heat island effect	Local Climate Zone [%]
B.1.3	Diversity of building use destination	Simpson's diversity index [-]
B.1.4	Re-used of previously occupied and contaminated land	Pecentage of the total of re-used gross floor area [%]
B.3.1	Cycling routes	Equivalent meters of cycling routes per 100 inhabitants [m/100 inhab]
B.3.3	Pedestrian spaces	Pedestrian surface area per 100 inhabitants [m/100 inhab]

The Urban DSS developed for the city as a whole [18], has a common indicators master list (47 elements) with different indicators for the assessment of cities and neighborhoods. In particular, issues related to the environment and urban morphology have a direct impact on the neighborhood behavior, so the indicators used are related to "Environment" (A) and "Urban Structure" (B) thematic areas. Neighborhood level indicators are related to more 'analytical' sustainable aspects, because of more restricted "spatial boundaries" of application. Each indicator allows to assess a single neighborhood identifying the difference of performance of neighborhoods in the same city also for that next. For this reason some typical urban indicators are not consider: e.g. the external air pollution refers to measurement devices that are not assigned to a specific neighborhood but they are often placed in few points of the city as a whole.

The indicators of indicators are chosen according to the scope of the application that is the encouragement of sustainable urban transformation interventions focused on a homogenous development of the territory. E.g. the A.4.1 indicator supports the refurbishment of worst energy performance buildings, instead of assessing the average energy performance which could be also achieved acting in high performance buildings. The B.1.3 indicator encourages the mix of use destination of neighborhoods buildings and the A.6.1 indicator evaluates the compliance with lighting regulation and not the average night sky illuminance levels.

3.2. Benchmarking

In the Benchmarking, reference performances are defined to be compared with performances of the evaluated neighborhood. These performances allow to score the indicator performances in a scale. Benchmarking is based on the identification of the relevant regional and or national performance levels to which the indicator for the urban area can be compared to. Benchmarks are based either on the reference standards and laws in force in the specific context or on the average levels of the indicator. In UDSSN, the average value considered is the regional one. In this way, the assessment of the sustainability of urban areas is contextualized with the Region context in which it is located, thus avoiding comparison with benchmarks at too broad performance scales that are inconsistent with those of the urban areas evaluated. Thanks to this type of benchmarking, UDSSN can be easily replicated anywhere.

The benchmark scale elaborated includes four scores which coincide with different sustainability reference performance levels, as summarized in Table 2.

Table 2: Score and Performance Scale

Score	Description
-20	Performance below the standard or average
0	Minimum acceptable performance defined by laws or regulations in force or the average value among Region Lombardy cities
100	Best performance compared to regulations in force or the average value among Region Lombardy cities
120	Higher performance compared to the current best practice (excellence)

3.3. Weighting and Scoring

The Weighting step consists in assigning percent weights to all levels of the assessment system (Thematic areas, Categories and Indicators). The weighting method of this tool is based on the Sustainable Building Method (SBMethod).

The importance (weight) of the thematic areas and categories reflects the policy making context. In the logic of the Urban System this weight might change according to policy priorities (i.e. a policy maker can assign a higher weight to the "Environment" thematic area because of its great relevance in the field of sustainability): in this case weights are assigned directly in percent values.

The weights of single indicators instead reflect technical choices, assigned by experts considering two criteria: i) "governability" which reflects the possibility of Public Administrations' intervention to modify the specific phenomenon represented by the indicator; ii) "stability", namely the expected duration of the impact on sustainability after the interventions. The votes are aggregated and converted into weights at a later stage.

Finally, in the Scoring step, each indicator's performance is compared with the reference scale and a score is assigned by interpolation in the 0-100 interval. If the performance is below the 0 value, the -20 score is assigned, while, if the performance is above the 100 value, the 120 score is assigned according to a bonus-penalty approach. The weighted average of scores provides the final overall sustainability score.

4. Conclusions

The tool presented includes indicators that are well recognized and included in official national and regional statistical data and allows to evaluate sustainability of neighborhoods in relation to the specificity of environmental, social and economic context.

Thanks to its modularity it can be used in different versions in relation to the aim and complexity of design and planning assessment or purposes. While in this version the choice of indicators, benchmarks and weights reflects Lombardy context, the system can be replicable with a limited commitment by potential end users of local PAs, using different indicators, benchmarks or weights also facing the availability of data and their typologies in the specific context where it is applied.

UDSSN could be useful for design purposes because it can support the definition of performance targets, the selection of optimal environmental and energy design strategies to reach the sustainable targets defined. It can also be useful for policy monitoring: Public Administrations can be supported by this system in the development of strategies, policies and regulations concerning urban sustainability of city's neighborhoods.

Each design or intervention strategy can be simulated in order to evaluate the impacts on the area evaluated and it is possible for the users quantify them with a performance and score scale for monitoring the behavior of the urban system and choosing the best solution.

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