How green is a "Green City"?

A review of existing indicators and approaches

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Abstract

More than half of the world's population currently lives in cities and, consequently, urbanization has been among the major drivers of global environmental change. The fast urban growth, likely to result in a share of 75% of people living in cities by 2050, has resulted in the development of cities which are unfriendly to people as well as to the environment. As a contribution to reverse this trend, various institutions have organized competitions between cities by ranking the degree of their "greenness," based on quantitative and qualitative indicators accessing economic, social and environmental performances. Most of these competitions have only been conducted once and the studies include different cities because their attendance was voluntarily. In this paper we analyze the potential of city rankings to contribute to a positive development of cities. The first part of this paper analyzes and defines the "Green City" concept comparing the definitions in the literature. Three keywords have been identified to characterize a "Green City": the "environmental quality," "human well-being," and the "political and social action" that aims at the first two dimensions. For measuring the "greenness" of cities, we analyzed the urban indicators of four popular indices, representing 13 categories which were then grouped into the three "Green City" dimensions. Regarding "environmental quality" and "human well-being," quantitative indicators are used, while qualitative indicators seem better suited to define the "societal and political action." By monitoring the quantitative indicators over time, we are also able to assess the "Green City" performances and at the same time verify the effectiveness of "social and political action." Thus, more clarity in the "Green City" definition is achieved, making constant monitoring of cities' performances possible. The use of quantitative and multidimensional indicators can be a valuable tool for urban governance and planning.

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Introduction

Richard Register first coined the term "Eco-city" in his 1987 book, *Ecocity Berkeley: Building Cities for a Healthy Future*. This concept was strongly influenced by other movements such as Appropriate Technology (AT), Community Economic Development (CED), Social Ecology, the Green Movement, Bioregionalism, and finally Sustainable Development, which gave it an interdisciplinary dimension (Roseland, 1997). The origins of the term "Eco-city" are also linked to the foundation of Urban Ecology, an interdisciplinary field of study that analyzes the relations of humans with each other and their surroundings including cities and urbanizing landscapes (Niemelä, 1999).

In literature the expressions "Eco-city" or "Sustainable city" are often used synonymously with "Green City." The term is associated with "sustainable development," as an extension of this concept but within the frame of a city's actions. Thus the adjective "green" does not only refer to environmental issues, but also seeks to integrate social and economic considerations into urban development processes (Lewis, 2015).

More than half of the world's population currently lives in cities and this share is to increase to 75% by 2050. Today the most urbanized regions are Northern America (82%), Latin America and the Caribbean (80%), and Europe (73%) (FAO, 2015). The growing population of urban centers and the contributions of urbanization to global environmental change have increased the attention to the sustainability of cities and led to the emergence of the "Green City" concept.

How can the "greenness" of a city be assessed? Previous studies have tried to measure cities' "greenness" through the use of urban indicators, indices, and rankings. They cover categories such as energy, transport, water, waste, air quality, etc. Most of them, though, were conducted only once. Only the European Green Capital award is repeatedly granted since

2010, but doesn't constantly analyze the same cities. The cities apply voluntarily for the award. The winner city cannot candidate for a period of ten years after receiving the European Green Capital title. The fate of European Green Capitals after the competition is not known. They may flourish or deteriorate.

Each of these rankings uses different indicators to assess the cities' degree of "greenness," so that their final results are not comparable. Furthermore, they are based on quantitative and qualitative indicators. The presence of the latter, though, without a specific unit of measure, doesn't allow to monitor cities' performances over time and thus to understand their real progress or decline.

The question arises: What *is* a "Green City"? The first part of this paper collects and analyzes some definitions in order to determine the essential components of a "Green City." The aim is to create more coherence in the understanding and evaluation of "Green Cities." All the analyzed indicators have been aligned more closely to definition dimensions in order to identify a set of synergetic and quantitative indicators able to assess and monitor Green cities performances over time.

This paper analyzes and compares the indicators used in European indices (European Green City Index, European Green Capital award, Urban Ecosystem Europe), and those suggested in the Global Sustainable Development Goal (SDG) 11. It then assesses the effectiveness of these urban indicators, proposed by different institutions, in measuring the "greenness" of cities. In doing this, we pay tribute to multidimensionality, an approach acquired from the sustainable development discussion. Nevertheless, in accordance with the disciplinary expertise of its main author, the focus of this Working Paper remains on the environmental dimension.

1. The "Green City" concept

In this study, several definitions of "Green City" have been reviewed using various literature sources. These definitions have been analyzed to determine communalities among them and to give a comprehensive definition. The terms "Eco-city" or "Sustainable city" are used synonymously with "Green City" in this paper.

Here we cite several important definitions of "Green City," before extracting some recurring and essential elements from them (table 1).

- *"Eco-cities, or sustainable communities, represent a goal, a direction for community development. The 'Eco-cities' theme does not stand alone but is situated in a complex array of relevant variations (sustainable development, sustainable urban development, sustainable communities, sustainable cities, bioregionalism, community economic development, appropriate technology, social ecology, green movement, green cities/communities) "* (Roseland, 1997);

- *"Green cities have clean air and water and pleasant streets and parks. Green cities are resilient in the face of natural disasters, and the risk of major infectious disease outbreaks in such cities is low. Green cities also encourage green behavior, such as the use of public transit, and their ecological impact is relatively small"* (Kahn, 2006);

- *"Green cities are defined as those that are environmentally friendly. The greening of cities requires some, or preferably all, of the following: (1) controlling diseases and their health burden; (2) reducing chemical and physical hazards; (3) developing high quality urban environments for all; (4) minimising transfers of environmental costs to areas outside the city; and (5) ensuring progress towards sustainable consumption"* (UNEP, 2011);

- *"The Green City is the model of the future, creating urban structures with environments with life-quality. The sustainable green development of cities is a task to be continuously developed, which calls for integrated and regionally coordinated activities of all disciplines"* (ELCA, 2011);

- *"A Sustainable city, or Eco-city (also 'Eco-city') is a city designed with consideration of environmental impact, inhabited by people dedicated to minimization of required inputs of energy, water and food, and waste output of heat, air pollution – CO_2, methane, and water pollution"* (Wikipedia, 2013);

- *"The concept of 'Green City' or 'Green Development' is not new. Previously couched within the term 'sustainable development,' it seeks to integrate environmental, social, and economic considerations within city's development processes. A Green City or Green Development is an extension of this concept but is understood within the frame of a city's actions and how these actions contribute to a city or urban area advancing as green and sustainable. Green Development considers how to improve and manage the overall quality and health of water, air, and land in urban spaces; its correlation with hinterlands and wider systems; and the resultant benefits derived by both the environment and residents"* (Lewis, 2015).

Author	Year	Term	Keywords
Roseland	1997	Eco-city, Sustainable community	Multidimensionality – Responsible society
Kahn	2006	Green City	High environmental performance – Human well-being – Responsible society
UNEP	2011	Green City	Human well-being – High environmental performance – Responsible society
ELCA	2011	Green City	High environmental performance – Human well-being – Multidimensionality
Wikipedia	2013	Sustainable city, eco-city	High environmental performance, Responsible society
Lewis	2015	Green City, Green development	Multidimensionality -High environmental performance – Societal action – Responsible policy

The "Green City" theme has been influenced from movements of different origin, such as social ecology, green movement, and bioregionalism (Roseland, 1997), which contributed to its multidimensionality. Currently, the "Green City" concept is defined as an extension of sustainable development in the urban context (Lewis, 2015) and represents the architectural model of the future, where the urban structures are compatible with the environment and life quality (ELCA, 2011). The objectives of a "Green City" are to have a low ecological impact, to be resilient in the face of natural disasters, to have a low risk of major infectious disease outbreaks (Kahn, 2006), to reduce chemical and physical hazards; to develop high quality urban environments for all; to minimize transfers of environmental costs to areas outside the city, and to ensure progress towards sustainable consumption (UNEP, 2011). In this context the society has an important role to play as it is only through "green" behavior, i.e., through minimizing the required inputs of energy, water and food, and reducing waste output, air pollution, CO_2, methane, and water pollution (Wikipedia, 2013), that these important goals will be achieved.

All definitions bring the *environmental dimension* of a Green City to the foreground. Moreover, *human responsibility* to use and organize natural resources in order to prevent environmental pollution clearly emerges. For this reason, society has an important role within a "Green City": political and social choices influence the environmental performance. The third key aspect, which is highlighted in some "Green City" definitions, is *human well-being:* a city resilient to natural disasters, to the risk of major infectious disease outbreaks and with a low pollution, is synonymous with a healthy and safe city (tab.1). Well-being, this way, is conceived as closely related to socio-environmental resilience.

The "Green City," therefore, is a multidimensional concept which involves economic, environmental and social aspects. A synthetic definition would read, more or less, as follows:

A "Green City" is a city that takes responsible political and societal action in order to achieve high environmental quality, which by itself contributes to human well-being.

2. Indicators to evaluate "Green Cities"

When looking at indicators that are already proposed, a key question is whether they respond adequately to a "Green City" definition.

Various indicators were used to create a "Green City" index by some European and global institutions. In this study we analyzed the most important indicators used in three different European rankings – European Green City Index, European Green Capital Award, Urban Ecosystem Europe – and a global indicator dashboard – SDG 11 – which might be used index- or ranking-wise in the future.

2.1. Urban Ecosystem Europe (2006 – 07)

2.1.1. Aim and Scope

The Urban Ecosystem Europe (UEE) tool is the result of collaboration between DEXIA, an international banking group, and Ambiente Italia, a research consultancy and creator of the tool. The declared aim of UEE was to consolidate a periodical reporting system that offers local governments a voluntary assessment of their urban environmental quality. UEE has been endorsed by several city networks, such as ICLEI Climate Alliance and Union of the Baltic Cities, and is based upon a policy framework comprising the Thematic Strategy on the Urban Environment, the Leipzig Charter and the Aalborg Commitments (Berrini & Bono, 2007).

The Leipzig Charter on Sustainable European Cities is a document of the Member States, drawn up with the broad and transparent participation of European Stakeholders (European Union, 2007). The Aalborg Commitments are collective commitments deriving from the Aalborg Charter, an urban environment sustainability initiative approved by the participants at the first European Conference on Sustainable Cities & Towns in Aalborg (Denmark) and inspired by the Rio Earth Summit's Local Agenda 21 plan (Aalborg Charter, 1994).

UEE was conducted for the first time in 2006 (in English and Italian), analyzing the urban environments in 26 large European cities from 13 European countries. The exercise was repeated in 2007, involving 32 European cities representing 16 countries. The second application contained improvements on the quality and availability of data.

In total, 32 local governments applied the tool and 18 of them participated on both occasions. Germany was represented with five cities; Finland, Denmark, Italy and Spain with three each; France, Belgium, Great Britain and Sweden competed with two cities each; and one city was either Latvian, Czech, Austrian, Albanian, Cypriotic, or Greek. This means that 11 cities belonged to Northern Europe (including Great Britain), ten to the central area, nine to the south and two to East Europe. 12 of the urban areas considered had more than one million inhabitants; five of these exceeded two million. Most competitors were medium sized EU cities, varying between 150,000 and 750,000 inhabitants. Data collected mainly refer to 2006 and 2007 and were provided by cities' local governments through questionnaires and direct email/phone contacts. European database has mainly been considered as a way to cross check the quality of data sent by cities or as a reference for the data interpretation or to integrate few data missing for some cities (Berrini & Bono, 2007).

2.1.2. Indicators

The UEE assessment was based on a questionnaire that comprised 25 indicators. The indicators were derived from the Aalborg Commitments and aggregated into six main themes (Berrini & Bono, 2007; Joas et al., 2014). A specific category was assigned to each indicator in order to make UEE indicators comparable with other indices. In the subsequent list, these categories appear in italics and brackets.

Local Action for Health and Natural common goods

1. Air quality: PM_{10} concentrations (*Air quality*)
2. Air quality: NO_2 concentrations (*Air quality*)
3. Noise map and noise reduction plan (*Acoustic Environment*)
4. Domestic water consumption (*Water*)
5. Inhabitants served by water treatment plants (*Water*)

Responsible consumption and lifestyle choices

6. Electric consumption variation (*Energy*)
7. Amount of municipal waste produced (*Waste*)
8. Municipal waste processed according to differentiated refuse collection schemes (*Waste*)
9. Green public procurement procedures and purchasing (*CO_2*)

Planning, design and Better mobility, less traffic

10. Passengers travelling on public transport within the urban area (*Transport*)
11. Underground and tram lines in the urban area (*Transport*)
12. Number of registered cars (*Transport*)
13. Cycle paths and lanes availability (*Transport*)
14. Public green areas availability (*Green areas and land use*)

Local to global: Energy and Climate change

15. Setting of an energy Balance and a CO_2 reduction target (*CO_2*)

16. Solar power generation in public buildings (*Buildings*)
17. Inhabitants connected to a district heating system (*Buildings*)
18. Climate and energy saving policies (*Energy*)

Vibrant, Sustainable Local Economy and Social equity, justice and cohesion

19. Demographic and old age dependency (*Health and Safety*)
20. Female employment (*Equity*)
21. Population qualified at highest level of education (*Education*)

Local Management towards sustainability and Governance

22. EMAS and ISO 14001 certification of public authorities (*CO_2*)
23. Level of implementation of Agenda 21 processes (*CO_2*)
24. Electorate voting in city elections (*Participation*)
25. City representatives who are women (*Equity*)

2.2. European Green City Index (2009)

2.2.1. Aim and Scope

The European Green City Index (EGCI) was a research project conducted by the Economist Intelligence Unit (EIU) and supported by Siemens. It strove to assess and compare the environmental impact of Europe's major cities; more specifically, it assessed the Green City Index of 30 leading European cities that belong to 30 European countries, using 30 individual indicators per city (Economist Intelligence Unit, 2012).

The EGCI differs from other tools in that it is not based or reliant on voluntary submissions from local governments; EGCI is the result of independent research using available sources, such as national statistical offices and local governments. Where gaps in data existed, the EIU produced estimates using national averages (Joas et al., 2014). Data were collected over the period February to August 2009. Most of them are associated with the year 2007, which was

the latest year available for most indicators given the time needed to collect, record and publish official data (Economist Intelligence Unit, 2012).

The EGCI is part of a wider work in which the same partners calculated a Green City index, but using different indicators, for Germany, Asia, Latin America, North America, Africa, Australia and New Zealand.

The index takes into account 30 individual indicators per city which cover eight categories:

1. CO_2
2. Energy
3. Buildings
4. Transport
5. Water
6. Waste and land use
7. Air quality
8. Environmental governance

In the first two categories, ten out of the 30 cities did not measure the full amount of energy consumed in their city or the associated CO_2 emissions. These cities only calculated how much energy is consumed from electricity, gas and district heating, but on average, such data only account for approximately 70% of the total energy consumption, particularly because the liquid fuels used in the transport sector are missing.

However, as part of their Kyoto commitments, all countries included within the study must report national data on energy consumption across all sources, as well as associated CO_2 emissions, so it was possible to retrieve missing data from these reports.

The goal of the index is to allow key stakeholder groups, such as city administrators, policymakers, infrastructure providers, environmental non-governmental organizations (NGOs), urban sustainability experts, and citizens, to compare their city's performance against others overall, and within each category (Economist Intelligence Unit, 2012).

2.2.2. Indicators

The EGCI comprises 17 quantitative indicators measuring how a city is currently performing, e.g. energy consumption and recycling rate, and 13 qualitative indicators assessing cities' environmental aspirations, e.g. commitments to reduce CO_2 emissions or to increase share of renewable energy (tab. 2). The quantitative indicators were "normalised" on a scale of 0 to 10, where 10 points were assigned to cities that met or exceeded certain criteria of environmental performance. For this purpose, benchmark targets were chosen from international or European directives. Where no targets existed, the cities were scored instead using a min-max calculation, where the score is the standard deviation from the mean, with the best city scoring 10 points and the worst scoring 0 points. The qualitative indicators were scored by EIU analysts based on concrete actions, strategies and targets have been adopted and set by cities. The qualitative indicators were scored on a scale of 0 to 10, with 10 points assigned to cities that met or exceeded the check-list of criteria. The index is composed of aggregate scores of all the underlying indicators. The index is first aggregated by category and finally, overall, based on the composite of the underlying category scores. To create the category scores, each underlying indicator was aggregated according to an assigned weighting. The scores for each category were then rebased on a scale of 0 to 10. Finally, all category scores were added together and the index results were expressed as percentage (Economist Intelligence Unit, 2012).

List of categories, indicators and their weightings

Category	Indicator	Type	Weighting	Description	Normalisation technique
Co₂	CO₂ emissions	Quantitative	33%	Total CO_2 emissions, in tonnes per head.	Min-max.
	CO₂ intensity	Quantitative	33%	Total CO_2 emissions, in grams per unit of real GDP (2000 base year).	Min-max; lower benchmark of 1,000 grams inserted to prevent outliers.
	CO₂ reduction strategy	Qualitative	33%	An assessment of the ambitiousness of CO_2 emissions reduction strategy.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
Energy	Energy consumption	Quantitative	25%	Total final energy consumption, in gigajoules per head.	Min-max.
	Energy intensity	Quantitative	25%	Total final energy consumption, in megejoules per unit of real GDP (in euros, base year 2000).	Min-max; lower benchmark of BMJ/€GDP. Inserted to prevent outliers.
	Renewable energy consumption	Quantitative	25%	The percentage of total energy derived from renewable sources, as a share of the city`s total energy consumption, in terajoules.	Scored against an upper benchmark of 20% (EU target).
	Clean and efficient energy policies	Qualitative	25%	An assessment of the extensiveness of policies promoting the use of clean and efficient energy.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
Buildings	Energy consumption of residential buildings	Quantitative	33%	Total final energy consumption in the residential sector, per square metre of residential floor space.	Min-max.
	Energy-efficient buildings standards	Qualitative	33%	An assessment the extensiveness of cities`energy efficiency standards for buildings.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
	Energy-efficient buildings initiatives	Qualitative	33%	An assessment of the extensiveness of efforts to promote energy efficiency of buildings.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
Transport	Use of non-car transport	Quantitative	29%	The total percentage of the working population travelling to work on public transport, by bicycle and by foot.	Converted to a scale of 0 to 10,
	Size of non-car transport network	Quantitative	14%	Length of cycling lanes and the public transport network, in km per square metre of city area.	Min-max. Upper benchmarks of 4 km/km² and 5 km/km² inserted to prevent outliers.
	Green transport promotion	Qualitative	29%	An assessment of the extensiveness of efforts to increase the use of cleaner transport.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
	Congestion reduction policies	Qualitative	29%	An assessment of efforts to reduce vehicle traffic within the city.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.

Table 2: European Green City Index indicators. This index is the only one to explicitly state the indicator type: qualitative or quantitative.

Source: Economist Intelligence Unit, 2012

Water	Water consumption	Quantitative	25 %	Total annual water consumption, in cubic metres per head.	Min-max.
	Water system leakages	Quantitative	25 %	Percentages of water lost in the water distribution system.	Scored against an upper target of 5 %.
	Wastewater treatment	Quantitative	25 %	Percentages of dwelings connected to the sewage system.	Scored against an upper benchmark of 100 % and a lower benchmark of 80 %.
	Water efficiency and treatment policies	Qualitative	25 %	An assessment of the comprehensiveness of measures to improve the efficiency of water usage and the treatment of wastewater.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
Waste and land use	Municipal waste production	Quantitative	25 %	Total annual municipal waste collected, in kg per head.	Scored against an upper benchmark of 300 kg (EU target). A lower benchmark of 1,000 kg inserted to prevent outliers.
	Waste recycling	Quantitative	25 %	Percentage of municipal waste recycled.	Scored against an upper benchmark of 50 % (EU target).
	Waste reduction and policies	Qualitative	25 %	An assessment of the comprehensiveness of measures to reduce the overall production of waste, and to recycle and reuse waste.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
	Green land use policies	Qualitative	25 %	An assessment of the comprehensiveness of policies to contain the urban sprawland promote the availability of green spaces.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
Air quality	Nitrogen dioxide	Quantitative	20 %	Annual daily mean of NO_2 emissions.	Scored against a lower benchmark of 40 ug/m³ (EU target).
	Ozone	Quantitative	20 %	Annual daily mean of O_3 emissions.	Scored against a lower benchmark of 120 ug/m³ (EU target).
	Particulate matter	Quantitative	20 %	Annual daily mean of PM_{10} emissions.	Scored against a lower benchmark of 50 ug/m³ (EU target).
	Sulphur dioxide	Quantitative	20 %	Annual daily mean of SO_2 emissions.	Scored against a lower benchmark of 40 ug/m³ (EU target).
	Clean air policies	Qualitative	20 %	An assessment of the extensiveness of policies to improve air quality.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
Environmental governance	Green action plan	Qualitative	33 %	An assessment of the ambitiousness and comprehensiveness of strategies to improve and monitor environmental performance.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.

	Green management	Qualitative	33%	An assessment of the management of environmental issues and commitment to achieving international environmental standards.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.
	Public participation in green policy	Qualitative	33%	An assessment of the extent to which citizens may participate in environmental decision-making.	Scored by Economist intelligence Unit analysts on a scale of 0 to 10.

2.3. European Green Capital Award (since 2010)

2.3.1. Aim and Scope

The European Green Capital Award (EGCA) was launched in 2008 as a policy tool of the Commission's Directorate General for the Environment to promote and improve the quality of urban environments. BMThe EGCA tool is based on the Thematic Strategy on Urban Environment and encourages local governments across Europe to adopt a more integrated approach to urban management. Since 2010, one European city has been selected each year as the European Green Capital.

The EGCA was originally adopted by 15 European cities (Tallinn, Helsinki, Riga, Vilnius, Berlin, Warsaw, Madrid, Ljubljana, Prague, Vienna, Kiel, Kotka, Dartford, Tartu & Glasgow) and the Association of Estonian cities on 15 May 2006 in Tallinn, Estonia. Their green vision was translated into a joint Memorandum of Understanding (Tallinn Memorandum) establishing an award to recognize local efforts to improve the environment, economy and quality of life in cities.

The objectives of the EGCA are: rewarding cities that have a consistent record of achieving high environmental standards, encouraging cities to commit to ongoing and ambitious goals for further environmental improvement and sustainable development, and providing a role model to inspire other cities and promote best practice and experiences in all other European cities (European Commission, 2016).

The tool is used yearly since 2010 to encourage cities to improve the quality of urban life by emphasizing the environmental aspect of urban planning. EU member states, European Economic Area countries and EU member state candidate countries are

eligible to apply for the award (Joas et al., 2014; European Commission, 2016). The EGCA tool is voluntary and does not provide any funds to support the initiatives of participating local governments. Cities can apply for the EGCA award online, via an online application form available in three languages (English, French and German). The evaluation process for applications is a two-tier process lasting approximately five months and involving a peer review by a panel of international experts (one main evaluator and one co-evaluator) for each indicator (12), who are appointed from EGCA at the exit of the call. In the first stage the experts evaluate cities participating in the competitions and select three to four cities which are then invited to submit their application. In the second stage the evaluators assign a score for each indicators and the city with the highest overall score will win the competition.

2.3.2. Indicators

The EGCA evaluation criteria are based upon three objectives:

1. "Greenest city": the relative environmental performance of participating cities.
2. "Implementation of efficient and innovative measures."
3. "Communications and networking": cities are required to develop an ambitious communication strategy and program of actions and events as part of their applications; if awarded the title, the city must implement this program (European Commission, 2016).

The basis of the evaluation is a set of 12 environmental indicators which have equal weightings. The panel of experts, on the basis of the data filled in standardized questionnaire by local cities' authorities, assigns a score to each indicator (Meijering et al., 2014).

1. Climate Change: Mitigation & Adaptation
2. Local Transport
3. Green Urban Areas Incorporating Sustainable Land Use
4. Nature and Biodiversity
5. Ambient Air Quality
6. Quality of the Acoustic Environment
7. Waste Production and Management
8. Water Management
9. Waste Water Management
10. Eco-innovation and Sustainable Employment
11. Energy Performance
12. Integrated Environmental Management.

2.4. SDG 11: "Make cities and human settlements inclusive, safe, resilient and sustainable" (since 2016)

The Sustainable Development Goals (SDGs) of the United Nations (UN) are a set of 17 goals that will lead global development efforts from 2016 to 2030 (UN Statistical Commission, 2016).

These goals comprise 169 sub-targets and not only include previous Millennium Development Goal (MDG) dimensions such as poverty reduction, zero hunger, good health, but also environmental targets e. g. on water, resources, industrialization, and urbanization (Choi et al., 2016).

Goal 11, "Make cities and human settlements inclusive, safe, resilient and sustainable," was the result of efforts conducted by the global campaign for an Urban SDG since 2013. The belief of the Campaign was that the urban areas structure and dynamics require special attention considering their social, environmental and economic impact (Simon et al., 2016) but also their political role (Rivera & Lagos, 2013).

It is not yet clear whether and how the reporting on SDG 11 will plot individual cities against each other, or whether the monitoring will be aggregated at the national level (UN-Habitat, 2016). The SDG is placed within a wider framework of targets, which also explains why two of its indicators (11.5.1. and 11.b.2) are shared with other goals, namely, SDG 1 on poverty eradication, and SDG 13 on combating climate change. SDG 11 is also not bound to add up to an "index" by itself.

We can assume, however, that in one way or another the SDG 11 indicators, as they have been agreed upon at the highest level and with the participation of numerous national Statistical Offices, will play an important role in urban sustainability assessments over the next decades, and we therefore decided to include them in our review of "Green City" measurement initiatives. We assigned an indicator category to each target of SDG 11 in order to compare them with the categories proposed in the other indices. We also tried to associate a specific unit of measure to each indicator (tab. 3).

Target	Indicators	Categories	Units
(Goal 11: Make cities and human settlements inclusive, safe, resilient and sustainable)			
1. By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums	**1.1** Proportion of urban population living in slums, informal settlements or inadequate housing	◼ Buildings ◼ Equity ◼ Health ◼ Safety	-%
2. By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons	**2.1** Proportion of the population that has convenient access to public transport, disaggregated by age group, sex and persons with disabilities	◼ Transport ◼ Equity	-%

Table 3: SDG 11 indicators with the respective categories.

Source of the two first columns: UN Statistical Commission, 2016

3. By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries	**3.1** Ratio of land consumption rate to population growth rate **3.2** Percentage of cities with a direct participation structure of civil society in urban planning and management which operate regularly and democratically	▪ Green areas and land use ▪ Participation	-m²/inh -Yes/Not
4. Strengthen efforts to protect and safeguard the world's cultural and natural heritage	**4.1** Share of national (or municipal) budget which is dedicated to the preservation, protection and conservation of national cultural natural heritage, including World Heritage sites	▪ Green spaces ▪ Education	-%
5. By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations	**5.1** Number of deaths, missing people, injured, relocated or evacuated due to disasters per 100,000 people	▪ Health ▪ Safety ▪ Equity	-N°
6. By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management	**6.1** Percentage of solid waste regularly collected and with adequate final discharge with regard to the total waste generated by the city **6.2** Annual mean levels of fine particulate matter (e.g. $PM_{2.5}$ and PM_{10}) in cities (population weighted)	▪ Waste ▪ Air quality	-% -μ/m^3
7. By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities	**7.1** The average share of the built-up area of cities that is open space for public use for all, disaggregated by age group, sex and persons with disabilities **7.2** Proportion of women subjected to physical or sexual harassment, by perpetrator and place of occurrence (last 12 months)	▪ Green areas and land use ▪ Equity ▪ Health ▪ Safety	-m² -%
a. Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning	**a.1** Cities with more than 100,000 inhabitants that implement urban and regional development plans integrating population projections and resource needs	▪ Participation	Yes/Not
b. By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels	**b.1** Percentage of cities that are implementing risk reduction and resilience strategies aligned with accepted international frameworks (such as the successor to the Hyogo Framework for Action 2005–2015 on disaster risk reduction) that include vulnerable and marginalized groups in their design, implementation and monitoring	▪ Health ▪ Safety ▪ Equity	Yes/Not
c. Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials	**c.1** Percentage of financial support that is allocated to the construction and retrofitting of sustainable, resilient and resource-efficient buildings	▪ Buildings ▪ Health ▪ Safety ▪ Equity	-%

3. Analysis of "Green City" indicators

The analyzed studies' first year of publication ranges from 2007 up to 2018 for the most recent one, the European Green Capital Award. The authors of these tools are: an European governmental institution (European Commission), an international organization (United Nations), private companies with an economic profile (Economist Intelligence Unit) and with an environmental profile (Ambiente Italia) (tab.4).

The EGCA is suited to cover all the European cities with more than 200,000 inhabitants but it is the only tool in which the cities must apply themselves voluntarily; EGCI and UEE assess respectively 30 and 32 big European cities. In contrast, SDG 11 addresses in principle all cities in the world. EGCA is the tool with the largest number of indicators (56), followed by EGCI (30), UEU (25) and SDG 11 (13).

The only tools with a clear periodicity are SDG 11 and EGCA. The indicators of SDG 11 are valid until 2030, while those of EGCA are annually redefined, starting with the year 2010. The EGCA however, doesn't analyze the same cities because these must apply voluntary and the winner city cannot candidate for a period of ten years after they held the European Green Capital title. It may be mentioned that UEE Europe was conducted twice, but the second time with a more complete tool and with a higher number of cities; for this reason, it offers no comparability.

The categories present in *all* the tools are "Transport," "Air quality," "Waste." The "CO_2," "Energy," and "Water" categories are analyzed in all the tools except SDG 11, while "Green spaces" was assessed in all the studies except in EGCI. The category "Building" was assessed by all tools except EGCA. The category "Acoustic environment" was analyzed only in EGCA and UEE. Finally, only in UEE and SDG 11 we can find social indicators: "Education," "Equity," "Safety," "Health" and "Participation" (tab.4). This latter finding is remarkable because in our review of "Green City" definitions, we had found that social well-being had been an important normative aim inherent to the concept.

	Periodicity	Author	Cities	Indicators
				Tot	Category	N° Quant.	N° Qualit.
Urban Ecosystem Europe	(2006) 2007	Ambiente Italia	Europe/ 32	25	**Air quality**, Acoustic Environment, Water, Energy, **Waste**, **Transport**, Green areas and land use, Building, CO_2, Health, Equity, Education, Participation	21	4
European Green City Index	2009	Economist Intelligence Unit	Europe/ 30	30	CO_2, Energy, Building, **Transport**, Water, **Waste** and land use, **Air quality**	17	13

Table 4: Methodological characteristics of tools. The categories highlighted with bold font are present in all the indicess.

Source: own figure

Urban Ecosystem Europe	(2006) 2007	Ambiente Italia	Europe/ 32	25	**Air quality**, Acoustic Environment, Water, Energy, **Waste**, **Transport**, Green areas and land use, Building, CO_2, Health, Equity, Education, Participation	21	4
European Green City Index	2009	Economist Intelligence Unit	Europe/ 30	30	CO_2, Energy, Building, **Transport**, Water, **Waste** and land use, **Air quality**	17	13
European Green Capital Award	Since 2010	European Commission (DG Environment)	Europe/ cities with more than 200,000 inhabitants	56	Climate Change, **Local Transport**, Green Urban Areas, Nature and Biodiversity, **Air quality**, Quality of Acoustic Environment, **Waste**, Water, Waste Water, Eco-innovation, Energy, Environmental management	52	3
SDG 11	2015– 2030	United Nations	World	13	Building, Transport, Air quality, Waste, Green areas and land use, Education, Equity, Safety, Health, Participation	10	3

Due to the difference in criteria and methodology, the four indicator systems are not directly comparable. Some of them establish target values, some do not; some offer periodicity, some do not; and so on. But if blended together, they do cover the essential dimensions of our pre-established Green City definition. That's why we attempt to inductively select the indicators based on (1) coherence and (2) recurrence (common to two or more of the reviewed indices). We think that by doing so, we will be able to cover the three core dimensions of our definition. While doing this, we will divide the quantitative from the qualitative indicators. The latter, as we shall see below, are mainly used to assess the environmental policy of cities but due to the lack of a unit of measure they are not comparable. Therefore, the qualitative indicators are linked to the "societal and political action" dimension.

We believe that the quantitative indicators of the "environmental quality" and "human well-being" dimensions can not only offer a measure for "Green City" performances, but at the same time also assess the effectiveness of the "societal and political action." On the basis of the two aforementioned selection criteria, the review shows 13 categories of indicators that play a role when evaluating the degree of "greenness" of cities:

1. CO_2;
2. Air quality;
3. Energy;
4. Buildings;
5. Transport;
6. Water;
7. Waste;
8. Green areas and land use;
9. Acoustic Environment;
10. Health and Safety;
11. Education;
12. Equity;
13. Participation.

3.1. Quantitative indicators

Quantitative indicators are used to describe the three "Green City" dimensions (tab. 5–6–7). In the "environmental quality" dimension – in line with the origins of the "Green City" term and with the focus of the present Working Paper – we find the largest number of indicators. These indicators allow assessing the environmental performances of cities in eight categories: CO_2, Energy, Buildings, Transport, Water, Waste, Air quality and Green areas and land use (tab.5). We will briefly present them and make a few comments in the next sub-section, followed by even more sketchier remarks on the other two dimensions in sections 3.1.2 and 3.1.3.

3.1.1. Environmental Quality

Green City	Environmental Quality		
Category	**Indicator**	**Unit**	**Index**
CO_2	1. CO_2 emissions	Tones per head	EGCI
	2. CO_2 intensity	Grams per unit of real GDP	EGCI
	3. CO_2 Emissions/capita	t CO_2/inh	EGCA
	4. Total CO_2 emissions	t CO_2/year	EGCA
	5. Total CO_2 emissions per MWh electricity consumed	Total CO_2/MWh electricity	EGCA
	6. Energy Balance and CO_2 reduction target	t/inh-%	UEE
Energy	1. Energy consumption	Gigajoules per head	EGCI
	2. Energy intensity	Megajoules per unit of real GDP	EGCI
	3. Renewable energy consumption	Terajoules	EGCI
	4. Electric consumption variation	%	UEE
Buildings	1. Energy consumption of residential buildings	Gigajoules per square meter	EGCI
	2. Solar power generation in public buildings	kW	UEE
Transport	1. Proportion of buses that are low emission	%	EGCA
	2. Use of non-car transport	% of population	EGCI
	3. For all journeys under 5km, proportion of these journeys undertaken by car, public transport, bicycle, foot and other	%	EGCA
	4. Passengers travelling on public transport	%	UEE
	5. Numbers of registered cars	car/100 inh	UEE
	6. Number (and percentage of total) of electric vehicles owned by the municipality	N°-%	EGCA
Water	1. Waste recycling	%	EGCI
	2. Percentage of household waste sent to landfill/for thermal treatment or similar recovery	%	EGCA
	3. Percentage of urban solid waste regularly collected and with adequate final discharge with regard to the total waste generated by the city	%	SDG 11
	4. Municipal waste production	Kg per head	EGCI-EGCA-UEE
	5. Percentage of organic waste collected separately	%	EGCA
	6. Percentage of recycled household/packaging waste	%	EGCA
	7. Amount of Household Waste generated per capita	Kg/capita	EGCA
	8. Municipal waste, differentiated collection	%	UEE

Table 5: Environmental quality indicators.

Source: own figure

Air quality	1. Nitrogen dioxide	$\mu g/m^3$ (EU target 40)	EGCI
	2. Ozone	$\mu g/m^3$ (EU target 120)	EGCI
	3. Particulate matters	$\mu g/m^3$ (EU target 50)	EGCI
	4. Sulphur dioxide	$\mu g/m^3$ (EU target 40)	EGCI
	5. Max Number of days per year on which EU target for ozone/PM_{10} was exceeded	Days	EGCA
	6. Number of ozone/PM_{10}/NO_2/$PM_{2.5}$ monitoring stations	N°	EGCA
	7. PM_{10}/NO_2/$PM_{2.5}$ – Max concentration recorded	$\mu g/m^3$	EGCA
	8. NO_2/$PM_{2.5}$ – Annual Average concentration	$\mu g/m^3$	EGCA
	9. Air quality: PM_{10} concentration	$\mu g/m^3$	UEE
	10. Air quality: NO_2 concentrations	$\mu g/mc$	UEE
	11. Annual mean levels of fine particulate matters in cities	$\mu g/m^3$	SDG 11
Green areas and land use	1. Land use within the city	%	EGCA
	2. Number and total area of Natura 2000 sites are located in the city or nearby	N°-ha	EGCA
	3. Number and total area of designated sites of national biodiversity importance within the city	N°-ha	EGCA
	4. Number and total area designated sites of local biodiversity importance within the city	N°-ha	EGCA
	5. Public green areas availability	m²/inh-% total area	UEE
	6. Ratio of land consumption rate to population growth rate	m²/inhabitants	SDG 11

When comparing the categories, "Air quality" is the one with the largest number of indicators; these are related to Nitrogen, Ozone, Particulate Matters and Sulphur dioxide concentrations in the atmosphere. This category is probably the most represented because air pollution is so immediately perceivable and politically pressing, but also because it is relatively easy to measure. In EGCI, SDG 11 and UEE the concentrations are expressed as annual mean; only in EGCA there are indicators that consider recorded concentration, the maximum number of days that exceed threshold values and the numbers of monitoring stations (tab.5). This greater level of detail allows assessing the air quality with greater precision but at the same time requires a lot of data, not always available.

"Water" is another category with many indicators: it assesses the domestic and total water consumption but also the percent of water lost in the distribution system and the percentage of dwellings connected to the sewage system. EGCA, furthermore, proposes some specific indicators about wastewater treatments. As mentioned above, the large number of indicators allows more accurate estimates but requires the availability of a wide array of data.

In the "Waste" category, the municipal and the household waste production is considered in kg/capita as well as the recycling efficiency and the percentage of waste adequately disposed/discharged. It is a dimension both crucial for the environmental impact and with strong elements of municipal responsibil-

ity (although, of course, also heavily influenced by national regulations and incentives, as is the case in all categories). The "Transport" category evaluates in percentage the urbanites' habits of daily travel, and individual mobility's consequences for the urban environment. It also refers to technological innovation by evaluating the proportion of buses that are low emission and electric vehicles owned by the municipality, this way measuring the efforts of public administrations as well.

The category "CO_2" assesses the emission of this greenhouse-gas expressed as total per year, per inhabitant, as intensity (grams per unit of real GDP) and in relation to electricity consumed (total CO_2/ MWh electricity) (tab.5). These different kinds of accounting permit to evaluate both the total contribution to global warming, and the energy efficiency of the cities inhabitants. In addition, the human responsibility in resource use is addressed by the relation of emission and GDP. The category does not consider carbon sinks, such as urban forests or wooden building material which increase carbon sequestration (Churkina, 2016). "Green areas and land use" are generally expressed as percent city area covered, as recreation potential for the population, or for biodiversity effects, but not for their capacity to remove

CO_2 and pollutants from the atmosphere (Grote et al., 2016). In "Green areas and land use" category we find only one indicator on land consumption through soil sealing and other processes; this issue appears, astonishingly, only in SDG 11, but in our opinion represents a very important dimension of urban environmental impact that could also be assessed using the support of national urban information systems and geospatial technologies, thereby obtaining more accurate estimates (Choi et al., 2016).

In the "Energy" category we assess the absolute consumption (Gigajoules per head), the intensity (Megajoules per unit of real GDP), the contribution of renewable energies (Terajoules), and the variability of electric consumption over the years. The latter is particularly useful for evaluating trends in the energy consumption.

The category "Buildings" partly overlaps with the one of "Energy," since the installation of small energy production sites (e.g. solar panels) and the insulation of walls and roofs (e.g. expressed as the percentage of buildings with the highest energy classes according to EU directives 2002/91 / EC and 2006/32 / EC) are clearly connected to both. However, in many cases the data availability for these indicators is insufficient.

Green City	Well-Being		
Category	Indicator	Unit	Index
Buildings	1. Inhabitants connected to district heating system	% of total population	UEE
	2. Proportion of urban population living in slums, informal settlements or inadequate housing	%	SDG 11
Water	1. Inhabitants served by water treatments plants	%	UEE
Transport	1. Size of non-car transport network	Km per square meter	EGCI
	2. Proportion of population living within 300 meters of an hourly (more frequent) public transport service	%	EGCA
	3. Underground and tram lines in the urban area	m/100 inh	UEE
	4. Cycle paths and lanes availability	m/100 inh	UEE
	5. Number of charging outlets available for cars owned privately	N°	EGCA
	6. Proportion of the population that has convenient access to public transport, disaggregated by age group, sex and person with disabilities	%	SDG 11

Table 6: Human well-being indicators. Indicators with the same color are common within two or more categories.

Source: own figure

Category	Indicator	Unit	Source
Green Areas and land use	1. Population density in built-up areas	%	EGCA
	2. Percentage of people living within 300m of green urban areas of any size in inner city	%	EGCA
	3. Population density for new developments	% Inhabitants per ha	EGCA
	4. The average share of the built-up area of cities that is open space for public use for all, disaggregated by age group, sex and persons with disabilities	m²	SDG 11
Acoustic Environment	1. Share of population exposed to total noise values of Lden above 55/65dB	%	EGCA
	2. Share of population exposed to total noise values of Ln above 45/55 dB	%	EGCA
	3. The percentage of citizens living within 300m of quiet areas	%	EGCA
Health and Safety	1. Demographic and old age dependency	%	UEE
	2. Proportion of women subjected to physical or sexual harassment, by perpetrator and place of occurrence	%	SDG 11
	2. Proportion of urban population living in slums, informal settlements or inadequate housing	%	SDG 11
	3. Number of deaths, missing people, injured, relocated or evacuated due to disasters per 100,000 people	N°	SDG 11
Education	1. Population qualified at highest level of education	%	UEE
Equity	1. Female employment	%	UEE
	2. Proportion of women subjected to physical or sexual harassment, by perpetrator and place of occurrence	%	SDG 11
	3. City representatives who are women	%	UEE
	4. Proportion of urban population living in slums, informal settlements or inadequate housing	%	SDG 11
	5. Proportion of the population that has convenient access to public transport, disaggregated by age group, sex and person with disabilities	%	SDG 11
	6. Number of deaths, missing people, injured, relocated or evacuated due to disasters per 100,000 people	N°	SDG 11
	7. The average share of the built-up area of cities that is open space for public use for all, disaggregated by age group, sex and persons with disabilities	m²	SDG 11
Participation	1. City representatives who are women	%	UEE

3.1.2. Human well-being

The dimension of "Human well-being" describes the degree to which the city provides appropriate environmental and social services to its inhabitants. There are nine categories: Buildings, Water, Transport, Green Areas and Land Use, Acoustic Environment, Health and Safety, Education and Equity. We tried to select the most appropriate indicators from previous studies to characterize the categories, and

several indicators are used for more than one category.

The "Equity" category hosts the largest number of indicators, which is not surprising given that justice is at the heart of sustainable development and that equity considerations rank high in people's appreciation of well-being and development. The first three indicators are about gender, one of them overlapping with "Participation" and another with "Health and Safety."

The fourth indicator is in common with "Health and Safety" and "Buildings" categories, establishing a minimum living standard. The fifth indicator also refers to "Transport," focusing on equality of access. The fifth indicator is about public space and so is partly overlapping with the "Green Areas and land use" category, its focus being, again, on equal access. The sixth and the seventh indicators are about basic needs and rights.

The "Transport" category also includes the extension and distribution of underground and tram lines, cycle paths and walking lanes per inhabitant. Furthermore, this category assesses the number of charging outlets available for cars owned privately. The availability of recreation space is also falling in the "Green areas and land use" category, which otherwise evaluates indirectly the proportion of population density in built-up areas and for new developments and the percentage of people living within 300m of green urban areas.

Other categories value the "Acoustic Environment", the access to clean "Water" and to district heating system. The demographic and old age dependency and a good "Education" are other categories in this dimension.

3.1.3. Societal and political action

There are few quantitative indicators for "societal and political action"; most of it is assessed qualitatively. This dimension of the "Green City" analyzes the role of citizens and policy in environmental and social issues. There are five categories that hold various indicators each: CO_2, Buildings, Green Areas and land use, Participation and Education. The "CO_2" category here does not focus on outcomes, but on levels of political ambition and the attention of public authorities to environmental issues. The "Buildings" presents an indicator about processes of public support for the construction and retrofitting of sustainable buildings. The "Participation" category is very conventional, insofar as it considers only formal electoral participation. From the "Green areas and land use" indicators, the first one gives credit to the existence of a "Biodiversity Action Plan", considering start and extension of the action. The second is in common with the "Education" category evaluating the percentage of money dedicated to the preservation, protection and conservation of national cultural natural heritage. Finally, "Participation" category assesses the percentage of electorate voting in city elections. The major focus on political action, however, lies on qualitative (nominal) measurements, which we are dealing with in the next section.

Green City	Societal and Political Action		
Category	**Indicator**	**Unit**	**Index**
CO₂	1. City reduction targets	%	EGCA
	2. Environmental Certification of public authorities	N°	UEE
Buildings	1. Percentage of financial support that is allocated to the construction and retrofitting of sustainable, resilient, and resource-efficient buildings	%	SDG 11
Green Areas and land use	1. Date and time horizon of your city's Biodiversity Action Plan	Year	EGCA
	2. Share of national (or municipal) budget which is dedicated to the preservation, protection and conservation of national cultural and natural heritage, including World Heritage Sites	%	SDG 11
Participation	1. Electorate voting in city elections	%	UEE
Education	1. Share of national (or municipal) budget which is dedicated to the preservation, protection and conservation of national cultural natural heritage, including World Heritage Sites	%	SDG 11

Table 7: Societal and political action indicators. Indicators with the same color fit into more than one category.

Source: own figure

3.2. Qualitative indicators

Green City	Qualitative indicators		
Category	**Indicator**	**Dimension**	**Index**
Acoustic Environment	Noise map and noise reduction plan	Societal and political action	UEE
CO$_2$	Green public procurement, procedures and purchasing		UEE
	Level of implementation of Agenda 21 processes		UEE
	Green action plan		EGCI
	Signatory of CoM		EGCA
	Aalborg Signatory		EGCA
	CO$_2$ reduction strategy		EGCI
Energy	Clean and efficient energy policies		EGCI
	Climate and Energy saving policies		UEE
Buildings	Energy-efficient buildings standards		EGCI
	Energy-efficient building initiatives		EGCI
Transport	Green transport promotion		EGCI
	Congestion reduction policies		EGCI
Waste	Waste reduction and policies		EGCI
Green Areas and land use	Green land use policies		EGCI
	Green management		EGCI
Air quality	Clean air policies		EGCI
Participation	Percentage of cities with a direct participation structure of civil society in urban planning and managements which operate regularly and democratically		SDG 11
	Public participation in green policy		EGCI
	Cities with more than 100,000 inhabitants that implement urban and regional development plans integrating population projections and resource needs		SDG 11
Health and Safety	Percentage of cities that are implementing risk reduction and resilience strategies aligned with accepted international frameworks that includes vulnerable and marginalized groups in their design, implementation and monitoring		SDG 11
Equity	Percentage of cities that are implementing risk reduction and resilience strategies aligned with accepted international frameworks that includes vulnerable and marginalized groups in their design, implementation and monitoring		SDG 11
Water	Water efficiency and treatments policies		EGCI
	Treatment level which is applied in each UWWTP: secondary or more stringent (treatment: nitrogen, phosphorus removal, disinfection)	Environmental quality	EGCA

Table 8: Qualitative indicators. Indicators with the same color are common within two or more categories.

Source: own figure

Qualitative indicators are mainly used to assess the city's environmental policies. Indeed, with the exception of an indicator for monitoring of the wastewater treatment processes, all the qualitative indicators are linked to the "societal and political action" Green City dimension. They directly appeal to politicians and administrations, by pointing at their decisions and measurements.

"CO_2" is the category with the largest number of indicators, which assesses the city's environmental strategies, both locally and internationally. This predominance makes sense with regard to quantitative assessment of environmental performance, but is somehow doubtful for qualitative assessments of policies if we think about how differently this topic appeals to immediate urban realities around the globe, e. g., in cities which rely on hydro-energy. While in this case the indicator might make some sense for

European Cities, which were in the focus of most of the analyzed indices, the differentiation caveat (Rivera, 2014) in principle applies to the usage of all the qualitative indicators in this table, and their respective categories.

In addition to this caveat which concerns the particular political usefulness 'on the ground', we have to consider that qualitative indicators do not have a specific unit of measure and for this reason are difficult to quantify and to monitor over time. They focus more on the "societal and political action" than quantitative indicators, but they do not allow to *compare* "Green City" performances – neither between different cities, nor over time – and therefore do not fully respond to our goal. In some cases, the very qualitative content of the indicators is also doubtful, as the establishment of a plan or strategy does not necessarily imply their actual relevance or implementation.

4. Monitoring multidimensional indicators

By putting the indicators proposed in the analyzed indices together, we were able to cover the three dimensions of the Green City, but could not provide complete means to measure and monitor the "Green City" performances. To clarify this incompleteness, we separated quantitative from qualitative indicators. We emphasize the fact that the qualitative indicators are somehow necessary to evaluate the "societal and political action" dimension. However, to overcome the problem of measurability, we proposed a monitoring scheme as depicted in Tab. 9. The possibility to have quantitative indicators for the "environmental quality" and "human well-being" dimensions allows not only monitoring cities performances over time, but also measuring *indirectly* the "societal and politi-

cal" dimension (tab. 9). Indeed, comparing the results of the two 'quantitative' dimensions on an annual basis will make possible to check the effectiveness of social and political action. For example, if we quantify and monitor annually the CO_2 emissions of cities, we are also able to verify if the political strategies and the social commitment impacted positively or negatively and to quantify this percentage level. If selection/ prioritizing of indicators is desirable or necessary (which will probably always be the case for reasons of manageability, data availability and so on), a proportional representation of the 13 categories should always be kept in mind. In addition, priority should be given to indicators which cover more than one category (those we highlighted with colors in the tables).

This way, we will achieve indicator dashboards which are at the same time comprehensive and synergetic. This tool can be very useful for the local but also for the national and international governance, because it allows verifying the effectiveness of political and societal choices to limit the negative impacts of the increasing urbanization.

Green City		
Societal and political action	**Environmental quality**	**Human well-being**
Quantitative and Qualitative indicators	Quantitative indicators	Quantitative indicators
Provisions	Performances	Performances
Check	Monitoring	Monitoring
	Comparison: Results	

Table 9: Monitoring scheme for Green City performances.

Source: own figure

5. Conclusions

The "Green City" term can be considered as a special case of "Sustainable development" for cities. The analysis of literature indicates that "Green City" concept has a multidimensional meaning. A "Green City" is a city that takes responsible political and societal action in order to achieve high environmental quality, which by itself contributes to human well-being.

In this paper we evaluated four indices which measure the sustainability of cities. The analysis shows that the main limitation of these indices is to not be able to monitor the city performances over time, because most of those studies were conducted only once or did not compare the same cities.

We analyzed all the indicators proposed by four indices and then we grouped these into 13 categories. The categories have been chosen based on their relevance and recurrence in two or more indices. These categories are: CO_2, air quality, energy, buildings, transport, water, waste, green areas and land use, acoustic environment, health and safety, education, equity and participation.

We separated quantitative from qualitative indicators, because the latter do not have a unit of measure and so are not measurable. These indicators, however, assess the "societal and political action" dimension more appropriately than quantitative ones (for this being the case, though, lots of attention must be paid to concrete content and local realities). For this reason, it is necessary to use quantitative and qualitative indicators in a synergetic way to evaluate the political dimension.

Putting together all the indicators, we are able to cover the three Green City dimensions. In order to overcome the problem of measurability, we propose a monitoring scheme that indirectly allows evaluating and comparing qualitative issues. More specifically, the possibility to measure and monitor the "environmental quality" and "human well-being" dimensions over time though the quantitative indicators, is related to the effectiveness of city political and societal actions. To value this relationship is very useful for policy makers because it allows verifying and correcting not only local, but also national and international policy measures, minimizing the urbanization impact on environment.

In this way we have clarified the "Green City" definition, aligning the indicators in three dimensions mentioned above, and proposed a monitoring scheme to assess and measure cities performances over time.

A further step would be to address also the smaller cities. Actually, the only data set available in the literature for this scale is the "European Green Leaf" initiative, a new competition aimed at cities and towns, with between 20,000 and 100,000 inhabitants. It is initiated and financed by the European Commission in conjunction with the European Green Capital Award. Having this development in mind, we believe that the next objective is to develop a universal index fitting cities of different sizes in order to assess the total contribution of urbanization on the environment. ▍

Acknowledgements

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