

## Article

# What Cities Want to Measure: Bottom-Up Selection of Indicators for Systemic Change toward Climate Neutrality Aligned with Sustainable Development Goals (SDGs) in 40 European Cities

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**Abstract:** Cities are taking action to respond to climate change by designing and implementing sustainable solutions which provide benefits and challenges to citizens. Measuring the progress and effects of such actions at the urban level, beyond mere greenhouse gas (GHG) emissions quantification, is still an emerging research area. Based on data from the 40 European cities belonging to 20 pilot city programmes within the EU-funded NetZeroCities (NZC) project, cities' selections and preferences for indicators for assessing their climate actions are analysed in relation to the Sustainable Development Goals (SDGs). This study provides bottom-up evidence of cities' selection of non-GHG indicators through different levers of change, including participatory governance and social innovation, for assessing progress and the co-benefits of actions toward climate neutrality taken at the urban level. The resulting list of indicators, classified according to the SDGs, provides evidence of cities' priorities and can be utilised by cities' climate transition teams and also by researchers, as it highlights gaps and opportunities compared to extant literature.

**Keywords:** climate-neutral cities; social impact; Sustainable Development Goals (SDGs); Design for Transition; assessment; citizen engagement



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## 1. Introduction

The implications of climate change [1] underscore the urgency of addressing the threats it poses through systemic and measurable climate action. Data-supported or evidence-based climate action, despite being a relatively new concept, is arguably a best practice for cities to support their paths to climate neutrality today [2,3]. Greenhouse gas (GHG) indicators provide crucial information and evidence for policymakers, public administrations, and politicians to support and communicate climate action. A focus on GHG outcomes alone, however, has proven insufficient for understanding complex systems, since they do not consider contextual factors [4] that influence behaviour, stakeholders' acceptance of and involvement in solutions [5], climate justice awareness [6], location-specific awareness, training and capacity building [7], and ecosystems for systemic change [8]. Moreover, climate action and environmental governance have been conventionally top-down interventions across global contexts, and the effectiveness of climate actions has essentially been focused only on the measurement of Greenhouse gas (GHG) emission reductions [9]. However, this approach in isolation is not sufficient for tackling the systemic complexities of the current climate crisis [10,11]. Technological innovation, considered one of the primary drivers necessary to reduce GHG emissions, is proving to be insufficient for addressing the complexities of today's socio-technical systems [11–13] and behavioural norms [14,15].

Ulpiani and Vettors [16] analysed a questionnaire completed by 362 cities (including cities analysed in this study) regarding their express interest in the European Mission for 100 Climate-Neutral and Smart Cities by 2030 and presented a comprehensive account of the associated risks and barriers that these European cities are currently facing, indicating

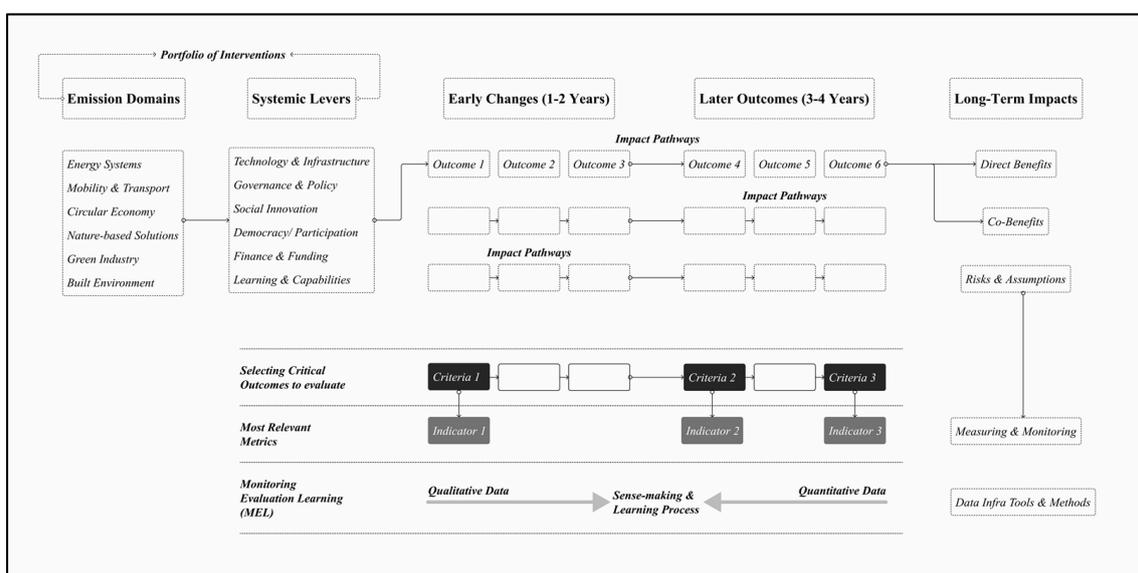
the relative lack of available literature with regard to the non-technical aspects of the transition to climate neutrality. The present study responds to this call to action and builds on cross-disciplinary perspectives in the wider domain of sustainable development, specifically in the European context, such as the role of culture, artistic expression, and creativity in sustainable urban transformations [17], which is testimony to the growing consensus towards the adoption of a multi-dimensional systemic approach. The agendas of large-scale climate initiatives, policies, and multi-level governmental organisations reflect the relevance of this systemic approach [18,19], namely the EU Mission “Climate Neutral and Smart Cities”, which includes the NZC project.

The transformative potential of new categories of innovation is gaining recognition as a means of bridging the gap in systemic climate action and comprehensive environmental governance. Recent developments in research and practice show a gradual adoption of systemic climate action strategies among cities that employ nature-based solutions [20], Urban Green Infrastructures [21], and bottom-up approaches towards climate neutrality [6] such as social innovation [11,12,22] and citizen engagement [23] to support stakeholders’ involvement in the transition [24]. However, the promising potential of such approaches cannot be described through GHG indicators alone, requiring cities to evaluate outcomes of actions toward climate neutrality with indicators beyond GHG measures [25], such as co-benefits or indicators of behavioural change, as well as process indicators such as collaboration and partnerships for the goal [2,24,26].

Despite this need, the academic literature provides scarce systematic support for cities aiming to deploy a systemic approach beyond GHG indicators to monitor the progress and outcomes of actions taken to reach climate neutrality, such as measures to assess health and well-being [27,28], citizens’ engagement [23] with climate action, the involvement of citizens in policy making and public institutions [29,30], or the development of public–private partnerships for sustainability [31,32]. On the other hand, the Sustainable Development Goals (SDGs) [33] provide a well-known, widely utilized, and suitable framework to classify such indicators. Scholars recently began deploying this approach, highlighting the need to establish a connection between climate action and other SDGs to ensure a broader focus on the actions’ accountability [34]. Even if SDG targets are primarily centred around developing contexts, Sompolska-Rzechuła et al. [35] already examined the climate–well-being linkages through SDGs and presented the diverse implementations of SDG3 (“Good Health and Well-Being”) and SDG13 (“Climate Action”). However, the ambitious 1.5 target established in the Paris Agreement [26] not only highlights the need for reductions in GHG emissions (SDG13) and the need to promote “good health and well-being” (SDG3) but also points towards considering systemic societal transformations [13,22] with Pro-Environmental Behaviour (PEB) among citizens [5,36]. Sachs et al. [37] discuss the gap in the common understanding among stakeholders on how the implementation of SDGs can be organised and propose a systemic policy approach with six transformations aimed towards SDG achievement. In another study, Wuebben et al. [38] propose bottom-up alliances between citizen science and energy communities through SDGs and present the relevance of SDG7 (“Affordable and Clean Energy”), SDG11 (“Sustainable Cities and Communities”), SDG13 (“Climate Action”), and SDG17 (“Partnerships for the Goals”). The paradigm shift [39] in climate action arguably signals the need to measure climate neutrality by incorporating broader indicators of change. Yet, the knowledge of cities’ perspectives on what is considered relevant to measure at the urban level to assess the progress and outcomes of their city’s climate action has not been thoroughly investigated.

This study aims to analyse cities’ selection of indicators for assessing the progress and outcomes of the actions of their Pilot Cities Programmes aimed at climate neutrality according to the SDGs. The results provide evidence of cities’ priorities in terms of what they find relevant to measure. For this purpose, indicators selected by 20 of the first batch of Pilot Cities (cohort 1) taking part in the EU-funded NetZeroCities (NZC) project are analysed and classified. NetZeroCities is a Horizon 2020 project, supporting the European Union’s Mission of “100 Climate-Neutral and Smart Cities 2030” [2] and The European

Green Deal [40]. The project aims to support Mission Cities and Pilot Cities with tools, resources, expertise, and a platform for collective knowledge sharing in their path to achieving climate neutrality. The NetZeroCities project proposes a systemic approach to innovation. Pilot cities are required to report greenhouse gas (GHG) emissions and are additionally invited to measure the outcomes of their actions in terms of co-benefit indicators. Cities submit a pilot programme description in which they outline the actions they plan to undertake and the indicators they plan to use for assessing progress, both in terms of GHG emissions (mandatory) as well as non-GHG indicators (optional, including process indicators and co-benefits). The NZC theory of change framework (also called the “impact pathways”) [41,42] defines seven emission domains (vehicles and transport, electricity consumption, non-electricity energy consumption, industrial processes, land use, and multi-sector waste) and six systemic levers: (1) technology and infrastructure, (2) governance and policy, (3) social innovation (SI), (4) democracy and participation, (5) finance and funding, and (6) learning and capabilities. With this structure (Figure 1), cities can define and measure the performance of their climate actions.



**Figure 1.** The NetZeroCities theory of change [41].

The NZC project’s pilot cities are required to submit documentation containing, among several other requirements, a description of their actions as well as their selection of indicators. The cities are provided with a standardised set of 36 indicators which include 12 GHG emissions indicators and 24 non-GHG emissions indicators (see Table 1 and Appendix A, Table A1). In addition, the cities can propose their own customised indicators which are suitable for their specific pilot actions.

In this study, we extrapolate indicators provided by the 20 pilot cities of the first cohort of the NZC project, classify them according to SDGs, and analyse their frequencies to derive insights into cities’ priorities in terms of the SDGs. This study provides a novel contribution by analysing bottom-up evidence from several cities in terms of their SDG priorities in relation to actions toward climate neutrality. Secondly, the resulting analysis provides a comprehensive list of non-GHG indicators, classified according to SDGs that can potentially be applied by all cities in the world. The results also provide directions for future academic research regarding cities’ priorities in terms of measurable SDG impact, highlighting gaps in the extant literature.

**Table 1.** The NetZeroCities standardised indicators set for pilot city projects [41,43].

	<b>Emission/Impact Domain</b>	<b>Subdomain</b>	<b>Indicator</b>	<b>Suggested Unit of Measurement</b>
1	Greenhouse gas (GHG) emissions	Total GHG emissions	Total greenhouse gas emissions per year	t CO <sub>2</sub> equivalents/year
2	Greenhouse gas (GHG) emissions	Stationary energy	GHG emissions per year from stationary energy per year	t CO <sub>2</sub> equivalents/year
3	Greenhouse gas (GHG) emissions	Transport	GHG emissions from transport per year	t CO <sub>2</sub> equivalents/year
4	Greenhouse gas (GHG) emissions	Waste	GHG emissions from waste per year	t CO <sub>2</sub> equivalents/year
5	Greenhouse gas (GHG) emissions	Industrial processes and product use	GHG emissions from industrial processes and product use per year	t CO <sub>2</sub> equivalents/year
6	Greenhouse gas (GHG) emissions	Agriculture, forestry, and land use (AFOLU)	GHG emissions from agriculture, forestry, and land use per year	t CO <sub>2</sub> equivalents/year
7	Greenhouse gas (GHG) emissions	Grid-supplied energy	GHG emissions from grid-supplied energy per year	t CO <sub>2</sub> equivalents/year
8	Greenhouse gas (GHG) emissions	Energy consumption	Change in the total energy consumption per year	kWh/year
9	Greenhouse gas (GHG) emissions	Energy efficiency	Change in energy efficiency over the lifetime of the project	%
10	Greenhouse gas (GHG) emissions	Share of renewable energies	Change in the energy mix over the lifetime of the project	%
11	Greenhouse gas (GHG) emissions	Carbon capture and residual emissions	Amount of permanent sequestration of GHG within city boundary	t CO <sub>2</sub> equivalents/year
12	Greenhouse gas (GHG) emissions	GHG emissions	Change in the greenhouse gas emissions per sector during the lifetime of the project	t CO <sub>2</sub> equivalents/year
13	Public health and environment	Air quality	Improved air quality	Highest annual mean of PM2.5 concentration recorded [ $\mu\text{g PM}_{2.5}/\text{m}^3$ ]
14	Public health and environment	Noise	Reduction in noise pollution	% of population exposed to avg. LDEN > 55dB (annual average)
15	Public health and environment	Health	Improved physical and mental well-being	Likert scale; 5 scales to be determined in local survey
16	Public health and environment	Quality of life	Perceived change in the quality of life	Likert scale; 5 scales to be determined in local survey
17	Social inclusion, innovation, democracy, and cultural impact	Citizen and Community Participation	Improved citizen participation	# of citizens engaged through the Pilot activities
18	Social inclusion, innovation, democracy, and cultural impact	Capacity of the public administration	Improvement in skills and awareness	# of public officers trained through the Pilot activities
19	Social inclusion, innovation, democracy, and cultural impact	Social cohesion	Affordability of housing and energy	% of disposable household income spent on housing and energy

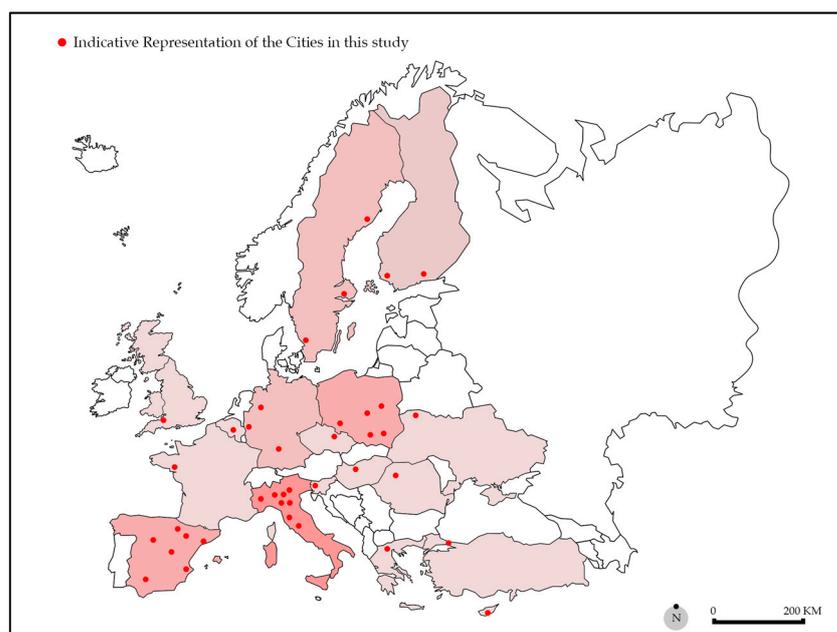
Table 1. Cont.

	<b>Emission/Impact Domain</b>	<b>Subdomain</b>	<b>Indicator</b>	<b>Suggested Unit of Measurement</b>
20	Social inclusion, innovation, democracy, and cultural impact	Digitalisation	Improved acceptance of digital solutions	total # of users per digital solution
21	Social inclusion, innovation, democracy, and cultural impact	Social innovation	Number of participative activities implemented per stakeholder group	total # of counselled activities
22	Social inclusion, innovation, democracy, and cultural impact	Scientific or Communication Outreach of the project	Scientific publications, social campaigns, etc.	total # of scientific publications
23	Social inclusion, innovation, democracy, and cultural impact	Upscaling and replication	Number of follow-up projects or districts	total # of follow-up projects
24	Economy	Investment in R&I	Improved investments in climate change action	EUR invested over the lifetime of the pilot project
25	Economy	Skilled jobs and employment	Newly created sustainable jobs	total # of newly created jobs
26	Economy	Technological readiness	Number of solutions suggested for implementation in local strategies	total # of implemented solutions over the lifetime of the project
27	Economy	Local entrepreneurship and local businesses	Creation of start-ups, accelerators, or tech innovation	total # of start ups created during the lifetime of the project
28	Economy	Increase in efficiency	Savings in working time achieved	Working hours/per year saved
29	Economy	Revenues generated	Revenues generated by the project	total EUR during the lifetime of the project excluding funding
30	Resource efficiency	Waste management and efficiency	Urban waste reduction; biowaste recovery	% of recycled domestic waste of the total domestic waste generation
31	Resource efficiency	Circular economy	Re-use of material during construction or renovation	% of recycled construction material of the total construction material used in the process
32	Resource efficiency	Water management	Improved water management	Household water consumption [l/capita/day]
33	Resource efficiency	Land use management	Improved land use management practices (e.g., urban greening)	m <sup>2</sup> of public green space/inhabitant
34	Biodiversity	Urban forestry plantation and improved plant health	Percentage of tree canopy within the city	% of the municipal area
35	Biodiversity	Non-invasive species and pollinators	Change in the number of species of birds in built-up areas	% of change in species
36	Biodiversity	Ecological habitat connection	Structural connectivity of green spaces	Degree of physical (“structural”) connectivity between natural environments within a defined urban area

## 2. Empirical Information Sources and Methods

### 2.1. Empirical Information Sources

This study systematically analyses all indicators selected by cities belonging to the first cohort of pilot cities of the NZC project—Bristol (U.K.), Budapest (Hungary), Cluj-Napoca (Romania), Istanbul (Turkey), Kozani (Greece), Kranj (Slovenia), Lahti (Finland), Leuven (Belgium), Liberec (Czech Republic), Limassol (Cyprus), Malmö (Sweden), Nantes (France), Rivne (Ukraine), Turku (Finland), and Umeå and Uppsala (Sweden)—and those selected by the cities in the following four multi-city pilot projects: 7 Spanish cities under the pilot project titled “Urbanew”, 9 Italian cities under the pilot project titled “LetsGOv”, 5 Polish cities under the project “NEEST”, and 3 German cities of the project “Co-lab” (information on these specific pilot projects is available online at <https://netzerocities.eu/pilot-cities-cohort-1-2022/>). Figure 2 shows a map that visually locates all the above-mentioned cities. The pilot cities were provided with a standardised set of 36 indicators, including 12 GHG indicators (such as the “total Greenhouse gas emissions per year”) and 24 non-GHG indicators (such as “Improved citizen participation” in the area of participatory governance) [2,42] (Table 1). In addition, the cities could provide their own indicators, which resulted in 127 customised indicators in total for the analysed cities [43]. It is important to note that this study solely analyses the selection of proposed indicators as, currently, no data have been submitted by the pilot cities; thus, we only have information on the preliminary selection of indicators the cities are planning to utilise to assess their pilot programme actions (which are subject to change in consecutive rounds of refinement and data submissions).



**Figure 2.** Geographical locations of all the pilot cities analysed.

For the purpose of this study, the primary goal is to analyse the standardised indicators set (Appendix A, Table A1) and the list of customised non-GHG indicators proposed by the Pilot Cities Programmes in relation to the SDGs (Appendix B, Table A4).

### 2.2. Methods

The analysis of the indicators of the NZC Pilot Cities Programme in relation to the SDGs was conducted by extracting the set of standardised and customised indicators and computing the frequency of occurrence of each one (Section 2.2.1), which is the total count of the number of times each indicator was selected by the cities for their pilot

projects. Secondly, the indicators were classified according to the SDGs and further analysed according to the categorisation approach discussed in Section 2.2.2.

### 2.2.1. Compilation of Indicators

The compilation of the indicators was carried out in two steps: the frequency of occurrence of each indicator (as selected by the cities based on their interventions) was recorded for the set of 36 standardised indicators (including the 12 GHG and 24 non-GHG indicators) provided for the pilot cities participating in the NetZeroCities project (Table 1, Appendix A, Table A3).

For the set of customised indicators proposed by the cities based on the specific requirements of their pilot programmes, 127 indicators were extracted from the documentation submitted by the 20 Pilot Cities Programmes and compiled as a list (Appendix B, Table A4). Since the customised indicators differ on a city-by-city basis, indicators with similar characteristics were grouped into 12 different thematic categories (Table 2). The grouping was first conducted independently by each author and then finalised through a communal discussion. This categorisation is aimed at assessing the current trends in climate action undertaken by neutral-to-be European cities.

**Table 2.** Thematic clusters of customised indicators proposed by cities and related corresponding standardised indicators (when available).

S.No.	Thematic Groups of Customised Indicators	Corresponding Clusters of Standardised Indicators
1	Bottom-up approaches, participation, and involvement (people, neighbourhood, and company and government channels)	Number of participative activities implemented per stakeholder group; improved citizen participation
2	Awareness building, training, knowledge sharing, and capacity building	Improvement in skills and awareness
3	Satisfaction and self-efficacy	Improved physical and mental well-being
4	Unique/city-specific	-
5	<b>Policy and regulatory indicators *</b>	-
6	Economic and financial indicators	Improved investments in climate change action
7	<b>Behavioural indicators *</b>	-
8	New ventures and businesses	Number of follow-up projects of districts
9	Technology-based solutions	Number of solutions suggested for implementation in local strategies
10	Publication	Scientific publications, social campaigns, etc.
11	<b>Operations, decision making, and reporting indicators *</b>	-
12	Air quality and CO <sub>2</sub> e reduction	Improved air quality

\* The thematic clusters in bold are indicators that have been listed by multiple cities but are not related to any of the standardised indicators.

### 2.2.2. Classification with SDGs

All indicators were classified according to the SDGs; the classification was conducted by two authors independently and by a research assistant following an investigator triangulation method [44]. A discussion was organised to solve cases in which a different SDG was attributed by different coders, and all cases were solved with unanimous agreement. The

coding of each indicator with the most relevant SDGs was based on the thematic selection criteria mentioned in Appendix A, Table A2.

$$\text{Total Frequency of SDG, } f = \sum_{i=1}^n \left( \frac{\text{Indicator Frequency of Occurrence}_i}{p_i \times \text{Total sum of all indicator occurrences}} \right)$$

where  $n$  is the total number of indicators,  $p_i$  is the total number of SDGs selected for the  $i$ -th indicator, and Indicator Frequency of Occurrence $_i$  is the frequency of occurrence for the  $i$ -th indicator.

The SDGs were then ranked from the highest to the lowest frequency of occurrence for the standardised indicator set, as shown in Table 3.

**Table 3.** Ranked order of SDGs in terms of their frequencies of occurrence for the NZC standardised indicators.

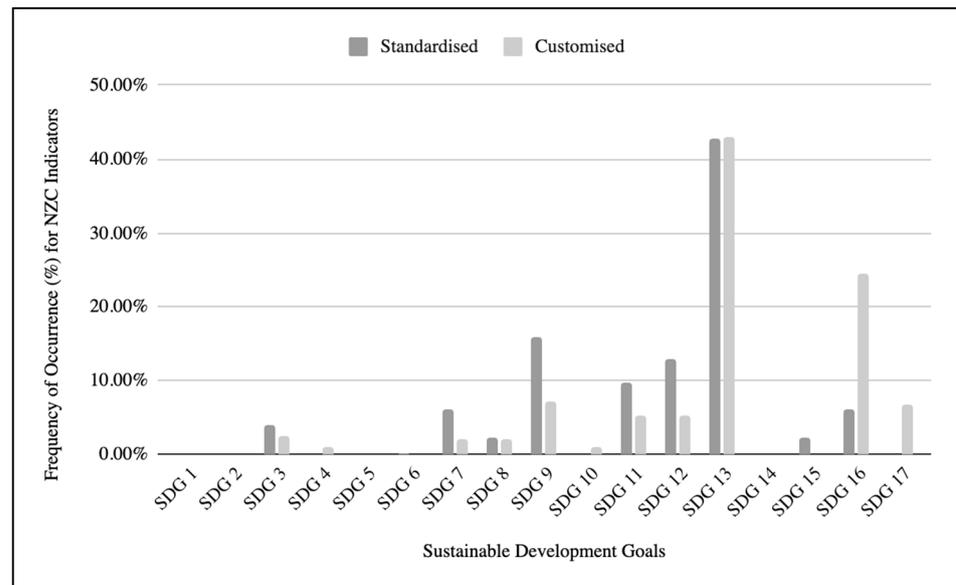
Rank	SDG	Frequency of Occurrence, $f$ (Expressed as a %)
1	SDG13—Climate Action	42.80%
2	SDG9—Industry, Innovation, and Infrastructure	15.90%
3	SDG12—Responsible Consumption and Production	12.80%
4	SDG11—Sustainable Cities and Communities	9.60%
5	SDG7—Affordable and Clean Energy	6.10%
6	SDG16—Peace, Justice, and Strong Institutions	6.10%
7	SDG3—Good Health and Well-being	4.00%
8	SDG15—Life on Land	2.30%
9	SDG8—Decent Work and Economic Growth	2.30%
10	SDG6—Clean Water and Sanitation	0.10%

For the customised indicator set, however, since each indicator is essentially unique to the particular pilot interventions, such an analysis is neither feasible nor useful. Hence, each indicator was attributed a primary SDG and a secondary and tertiary SDG when needed.

The total number of occurrences of the SDGs for each level of relevance (i.e., primary, secondary, and tertiary) were separately computed and then ranked from the highest to the lowest frequency of occurrence for the customised indicator set, as shown in Table 4. The results are visualized as bar charts (Figure 3).

**Table 4.** Ranked order of SDGs in terms of their frequencies of occurrence for the NZC customised indicators.

Rank	SDG	Frequency of Occurrence (Expressed as a %)
1	SDG13—Climate Action	43.10%
2	SDG16—Peace, Justice, and Strong Institutions	24.50%
3	SDG9—Industry, Innovation, and Infrastructure	7.20%
4	SDG17—Partnerships for the Goals	6.70%
5	SDG12—Responsible Consumption and Production	5.30%
6	SDG11—Sustainable Cities and Communities	5.30%
7	SDG3—Good Health and Well-being	2.40%
8	SDG7—Affordable and Clean Energy	2.00%
9	SDG8—Decent Work and Economic Growth	2.00%
10	SDG10—Reduce Inequalities	1.00%
11	SDG4—Quality Education	1.00%



**Figure 3.** Frequencies of occurrence (%) of SDGs for standardised and customised indicators combined.

### 3. Results

#### 3.1. Standardised Indicators and SDG Occurrence Frequency Rankings

The frequency of occurrence of the SDGs was calculated from the selection of standardised indicators in the analysed pilot cities of the NZC project, providing insights into the current trends in climate actions adopted by the 40 European cities considered in this study. Table 3 shows the frequencies of occurrence of 10 relevant SDGs, ranked from the highest to the lowest frequency of occurrence. While it may be regarded as an expected outcome for SDG13 (Climate Action) to emerge as the most frequently occurring SDG, the order of the rest of the list reveals a unique set of insights.

SDG9 (Industry, Innovation, and Infrastructure) is the second highest ranked, with 15.90% of indicators relating to this goal, closely followed by SDG12 (Responsible Consumption and Production; 12.80% of selections) and SDG11 (Sustainable Cities and Communities; 9.60% of selections). Tracing back these SDGs to the frequency of occurrence of the specific indicators of the standardised set (Appendix A, Table A1), it is seen that a large number of cities have selected indicators from the impact domain “Social Inclusion, Innovation, Democracy and Cultural Impact”. In particular, 16 out of the 20 pilot city projects selected the indicator (17) “Improved Citizen Participation” (categorised under the sub-domain Citizen & Communities Participation) and the indicator (18) “Improvement in Skills and Awareness” of public administration (categorised under the sub-domain Capacity of the Public Administration). Moreover, other indicators in the same domain also show a considerable rate of selection (more than 6 out of 20 pilot projects), including indicator (20) “Improved acceptance of digital solutions”, indicator (21) “Number of participative activities implemented per stakeholder group”, and indicator (23) “Number of follow-up projects or districts”. This analysis highlights that, besides mandatory GHG indicators, European cities are showing an inclination towards selecting optional bottom-up levers for systemic change and socio-economic impact domains to focus their comprehensive climate actions, thus illustrating a pattern in their urban visions that centres around the citizenry, focusing on a flexible and accessible framework that advocates for stakeholder participation in the face of challenges to deep decarbonisation [45].

#### 3.2. Customised Indicators and SDG Occurrence Frequency Rankings

The coding of the customised indicators proposed by the pilot cities according to the SDGs (shown in Appendix B, Table A4, and the final ranking for the SDGs in Table 4) resulted in SDG13 (Climate Action) emerging again as the most relevant with a frequency

of 43.10%, followed by SDG16 (Peace, Justice, and Strong Institutions), with a frequency of selection of 24.50%, meaning that approximately one fourth of the indicators proposed by the cities related to strong institutions, justice, or peace (SDG16). In this bottom-up proposal of indicators by cities, SDG9 (Industry, Innovation, and Infrastructure) is still prominent, ranking as the third most selected category, with a frequency of occurrence of 7.20%, closely followed by SDG17 (Partnerships for the Goals) with a frequency of 6.70% and SDG12 (Responsible Consumption and Production) and SDG11 (Sustainable Cities and Communities), which were both selected 5.30% of the time. Other SDGs related to the indicators proposed by the pilot cities have a frequency below 2.40% and include SDG3 (Good Health and Well-being), SDG7 (Affordable and Clean Energy), SDG8 (Decent Work and Economic Growth), SDG10 (Reduce Inequalities), and SDG4 (Quality Education).

Compared to the SDGs associated with the standardised indicators presented in Section 3.1, the frequencies of occurrence of SDG16 and SDG17 for the customised indicators are interestingly higher: when cities proposed their own indicators, 24.50% of indicators belonged to SDG16 (Peace, Justice, and Strong Institutions), while in the standardised indicators set, SDG16 appeared only 6.10% of the time, suggesting that cities need more indicators related to strong institutions, justice, and peace. SDG17 (Partnerships for the Goals) is not included in the standardised indicators set, but cities have self-selected indicators related to it with a frequency of 6.70%.

In the case of the customised indicators, there is a high number of indicators that are unique or project-specific; however, a high frequency of occurrence (see Appendix B, Table A4) was observed for the thematic groups “*Bottom-up Approaches, Participation and Involvement (People, neighbourhood, company and govt. channels)*”, with 22 corresponding indicators proposed by the cities for their pilot projects, and “*Awareness Building, Training, Knowledge Sharing and Capacity Building*”, with 17 corresponding indicators proposed by the cities for their pilot projects. This finding shows the inclination of cities to experiment with bottom-up approaches towards climate neutrality, similar to the trend observed in the analysis of the standardised indicators. However, it is noteworthy that some of the thematic areas evolving out of cities’ proposed indicators are not captured in the standardised set. These novel thematic areas include *Policy and Regulatory Indicators, Behavioural Change Indicators and Operations, and Decision Making and Reporting Indicators* (Table 2).

These results provide relevant insights into the climate action indicators that cities are not obliged to report and yet find necessary to measure and evaluate based on their priorities.

#### 4. Discussion

The key outcome of the analysis of the indicators through the framework of the SDGs is that it outlines emerging patterns that shape the trends of the climate actions currently undertaken by 40 European cities belonging to 20 pilot projects (Figure 2). It also sheds light on what cities are interested in measuring to gauge the progress of their climate actions, as seen especially for the customised indicators. Classifying indicators aimed at assessing progress toward climate neutrality with the SDGs provides novel insights that can shape the understanding and the narrative of the current trends in the climate actions undertaken by cities. While there may be no surprise that SDG13 (Climate Action) emerged as the most relevant SDG, the high occurrence of SDG9 (Industry, Innovation, and Infrastructure), SDG12 (Responsible Consumption and Production), and SDG11 (Sustainable Cities and Communities) for the standardised indicators point at a common focus among cities towards interventions related to non-GHG indicators, essentially interventions centring around their citizenry. Interestingly, these results show consistency with another recent study which focused on monitoring climate neutrality through SDGs, namely the referenced study conducted by Ciambra et al. [46], wherein it was found that SDGs 7, 11, 12, and 13 have emerged as the primary SDGs associated with (GHG-focused) climate neutrality indicators taken into consideration for the case of Madrid (Spain). For the customised indicators (those freely selected by cities), the high occurrence of SDG16 (Peace, Justice,

and Strong Institutions; 24.50%), SDG9 (Industry, Innovation, and Infrastructure), SDG17 (Partnerships for the Goals), and SDG11 (Sustainable Cities and Communities) also suggests a focus on systemic climate action through climate policy and regulations, participatory governance, bottom-up approaches, and awareness building (Figure 3).

In summary, this study gauges the inclinations of European cities beyond the realms of GHG indicators towards more systemic and inclusive, citizen-centric approaches, navigated through systemic levers of change such as participatory governance, social innovation, policy and regulations, and awareness and capacity building, thereby bringing forth a novel transdisciplinary systemic perspective [47] towards assessing climate actions by highlighting the social components of holistic climate action in European cities.

## 5. Conclusions

The SDGs associated with the standardised and customised indicators of the NZC Pilot Cities Programme present a comprehensive landscape of the trends in the climate actions undertaken by European cities' frontrunners in climate action. The 17 SDGs have long served as time-bound targets for cities to measure the five Ps—Prosperity, People, Planet, Peace, and Partnership [37]. However, they can also be valuable and appropriate in the specific context of climate action evaluation and reporting [33,37]. The uniqueness of this study is found in the bottom-up inputs provided by the cities' administrators who are at the forefront of fostering climate actions. Hence, the study contributes a realistic and timely perspective for the emerging body of literature in this interdisciplinary domain based on evidence from the convergence of current practices and cities' needs. However, readers should be aware of the study's limitations: the NZC project is focused on the European context; nonetheless, indicators' insights can be beneficial for cities worldwide with adaptation. It is also noteworthy to acknowledge the varying levels of preparedness of specific cities or multi-city projects participating in the NZC project: certain indicators might be suitable depending on the city's readiness level or the scope of the specific pilot programme.

In conclusion, this study makes three key novel contributions. Firstly, it provides a comprehensive list of the most relevant indicators for assessing climate neutrality projects according to 40 European cities. Such a list of indicators has both pragmatic and academic relevance, enriching the extant literature on climate action assessment at urban and regional levels. Secondly, this study lays the foundation for future theoretical research on systemic innovation for climate neutrality at the urban level, showing that the cities, which were only required to report GHG emissions, selected optional indicators related to SDG16 (Peace, Justice, and Strong Institutions) in 24.50% of cases. Thirdly, it shows that the SDGs are a suitable impact assessment framework for cities to deploy for framing and reporting on climate actions to further enhance cities' pathways toward climate neutrality through systemic and holistic assessments of progress and impacts which include innovative governance, citizen participation, awareness, behaviour, social aspects, and partnerships.

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## Appendix A

**Table A1.** NZC standardised indicators with their frequencies of occurrence in the indicators selected by the 20 pilot city projects of the NZC project [43]. “#” indicates Number and is directly extracted from the original source data.

	Emission/Impact Domain	Subdomain	Indicator	Suggested Unit of Measurement	Frequency of Occurrence *
1	Greenhouse gas (GHG) emissions	Total GHG emissions	Total greenhouse gas emissions per year	t CO <sub>2</sub> equivalents/year	20
2	Greenhouse gas (GHG) emissions	Stationary energy	GHG emissions per year from stationary energy per year	t CO <sub>2</sub> equivalents/year	4
3	Greenhouse gas (GHG) emissions	Transport	GHG emissions from transport per year	t CO <sub>2</sub> equivalents/year	8
4	Greenhouse gas (GHG) emissions	Waste	GHG emissions from waste per year	t CO <sub>2</sub> equivalents/year	7
5	Greenhouse gas (GHG) emissions	Industrial processes and product use	GHG emissions from industrial processes and product use per year	t CO <sub>2</sub> equivalents/year	1
6	Greenhouse gas (GHG) emissions	Agriculture, forestry, and land use (AFOLU)	GHG emissions from agriculture, forestry, and land use per year	t CO <sub>2</sub> equivalents/year	2
7	Greenhouse gas (GHG) emissions	Grid-supplied energy	GHG emissions from grid-supplied energy per year	t CO <sub>2</sub> equivalents/year	3
8	Greenhouse gas (GHG) emissions	Energy consumption	Change in the total energy consumption per year	kWh/year	20
9	Greenhouse gas (GHG) emissions	Energy efficiency	Change in energy efficiency over the lifetime of the project	%	8
10	Greenhouse gas (GHG) emissions	Share of renewable energies	Change in the energy mix over the lifetime of the project	%	6
11	Greenhouse gas (GHG) emissions	Carbon capture and residual emissions	Amount of permanent sequestration of GHG within city boundary	t CO <sub>2</sub> equivalents/year	2
12	Greenhouse gas (GHG) emissions	GHG emissions	Change in the greenhouse gas emissions per sector during the lifetime of the project	t CO <sub>2</sub> equivalents/year	5
13	Public health and environment	Air quality	Improved air quality	Highest annual mean of PM <sub>2.5</sub> concentration recorded [ $\mu\text{g PM}_{2.5}/\text{m}^3$ ]	4
14	Public health and environment	Noise	Reduction in noise pollution	% of population exposed to avg. LDEN > 55 dB (annual average)	1

Table A1. Cont.

	<b>Emission/Impact Domain</b>	<b>Subdomain</b>	<b>Indicator</b>	<b>Suggested Unit of Measurement</b>	<b>Frequency of Occurrence *</b>
15	Public health and environment	Health	Improved physical and mental well-being	Likert scale: 5 scales to be determined in local survey	2
16	Public health and environment	Quality of life	Perceived change in the quality of life	Likert scale: 5 scales to be determined in local survey	6
17	Social inclusion, innovation, democracy, and cultural impact	Citizen and community participation	Improved citizen participation	# of citizens engaged through the Pilot activities	19
18	Social Inclusion, Innovation, Democracy and Cultural Impact	Capacity of the public administration	Improvement in skills and awareness	# of public officers trained through the Pilot activities	18
19	Social Inclusion, Innovation, Democracy and Cultural Impact	Social cohesion	Affordability of housing and energy	% of disposable household income spent on housing and energy	1
20	Social Inclusion, Innovation, Democracy and Cultural Impact	Digitalisation	Improved acceptance of digital solutions	total # of users per digital solution	10
21	Social Inclusion, Innovation, Democracy and Cultural Impact	Social innovation	Number of participative activities implemented per stakeholder group	total # of counselled activities	9
22	Social Inclusion, Innovation, Democracy and Cultural Impact	Scientific or communication outreach of the project	Scientific publications, social campaigns, etc.	total # of scientific publications	6
23	Social Inclusion, Innovation, Democracy and Cultural Impact	Upscaling and replication	Number of follow-up projects or districts	total # of follow-up projects	8
24	Economy	Investment in R&I	Improved investments in climate change action	EUR invested over the lifetime of the pilot project	8
25	Economy	Skilled jobs and employment	Newly created sustainable jobs	total # of newly created jobs	4
26	Economy	Technological readiness	Number of solutions suggested for implementation in local strategies	total # of implemented solutions over the lifetime of the project	6
27	Economy	Local entrepreneurship and local businesses	Creation of start-ups, accelerators, or tech innovation	total # of start-ups created during the lifetime of the project	1
28	Economy	Increase in efficiency	Savings in working time achieved	Working hours/per year saved	1

Table A1. Cont.

	Emission/Impact Domain	Subdomain	Indicator	Suggested Unit of Measurement	Frequency of Occurrence *
29	Economy	Revenues generated	Revenues generated by the project	total EUR during the lifetime of the project excluding funding	1
30	Resource efficiency	Waste management and efficiency	Urban waste reduction; biowaste recovery	% of recycled domestic waste of the total domestic waste generation	5
31	Resource efficiency	Circular economy	Re-use of material during construction or renovation	% of recycled construction material of the total construction material used in the process	3
32	Resource efficiency	Water management	Improved water management	Household water consumption [l/capita/day]	2
33	Resource efficiency	Land use management	Improved land use management practices (e.g., urban greening)	m <sup>2</sup> of public green space/inhabitant	3
34	Biodiversity	Urban forestry plantation and improved plant health	Percentage of tree canopy within the city	% of the municipal area	1
35	Biodiversity	Non-invasive species and pollinators	Change in the number of species of birds in built-up areas	% of change in species	1
36	Biodiversity	Ecological habitat connection	Structural connectivity of green spaces	Degree of physical (“structural”) connectivity between natural environments within a defined urban area.	0

\* Total number of times the indicator has been selected by the 20 pilot cities in the NZC project.

Table A2. Qualitative selection criteria for coding SDGs with the NZC indicators.

Selection Criteria	Inclusion Criteria
Primary Criterion: General description of the SDG and keywords	The NZC indicator description contains similar thematic areas or impact domains, impact sub-domains, keywords, and/or levers of change.
Optional Criterion: SDG targets and indicators <sup>1</sup>	The NZC indicator description matches or is similar to one or more targets and indicators of the SDG in consideration. For example, SDG 13 contains target 13.2 (Integrate climate change measures into national policies, strategies, and planning) and a corresponding indicator 13.2.2 (Total greenhouse gas emissions per year).

<sup>1</sup> This criterion was mostly used to resolve cases where different SDGs were attributed to the NZC indicator by the researchers in order to come to a common consensus.





Table A3. Cont.

#	NZC Indicator	Frequency of Occurrence	SDGs Coding	SDG Targets *	SDG Frequency of Occurrence																
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
11	Amount of permanent sequestration of GHG within city boundary	2		13.2															0.01		
12	Change in the greenhouse gas emissions per sector during the lifetime of the project	5		13.2															0.025		
13	Improved air quality	4	 	3.9, 11.6				0.01											0.01		
14	Reduction in noise pollution	1		-				0.005													
15	Improved physical and mental well-being	2		9.1				0.01													
16	Perceived change in the quality of life	5	 	3.8, 9.1, 16.6				0.015												0.015	
17	Improved citizen participation	18	  	6.b, 11.3, 16.6, 16.7														0.031		0.031	0.031
18	Improvement in skills and awareness	17	 	12.8, 13.3															0.044	0.044	







### Appendix B

**Table A4.** SDG coding of the NZC Pilot cities’ customised indicators.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
1	New ventures and Businesses	No. of projects.	6	SDG 9: Industry, Innovation, and Infrastructure	SDG 13: Climate Action	NA
2		Number of new business models, including tailored incentive mechanisms.		SDG 9: Industry, Innovation, and Infrastructure	SDG 13: Climate Action	NA
3		Number of exploitable results.		SDG 9: Industry, Innovation, and Infrastructure	SDG 13: Climate Action	NA
4		New businesses supported.		SDG 8: Decent Work and Economic Growth	SDG 13: Climate Action	NA
5		Development of production of locally grown food.		SDG 9: Industry, Innovation, and Infrastructure	SDG 13: Climate Action	NA
6		Products and services offered to facilitate and mainstream the adoption of a climate-friendly lifestyle.		SDG 9: Industry, Innovation, and Infrastructure	SDG 13: Climate Action	NA
7	Policy and Regulatory	Political agreement on a climate budget and climate investment plan.	11	SDG 13: Climate Action	SDG 17: Partnerships For the Goals	SDG 16: Peace, Justice, and Strong Institutions
8		Integration of the climate budget in the municipal system of governance.		SDG 13: Climate Action	SDG 16: Peace, Justice, and Strong Institutions	NA
9		Development of a reuse plan for construction materials.		SDG 12: Responsible Consumption and Production	SDG 13: Climate Action	SDG 11: Sustainable Cities and Communities
10		District- and city-level policies making use of survey results.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	SDG 16: Peace, Justice, and Strong Institutions
11		Number of climate contracts in each category.		SDG 13: Climate Action	SDG 16: Peace, Justice, and Strong Institutions	NA
12		New structure, detailed description, adoption, and realisation.		NA	SDG 13: Climate Action	NA

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
13	Policy and Regulatory	Concrete proposals for municipal regulatory reformation.	11	SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
14		Concrete proposals for climate-resilient building codes.		SDG 13: Climate Action	SDG 11: Sustainable Cities and Communities	SDG 16: Peace, Justice, and Strong Institutions
15		Legal changes for municipal regulatory reformation.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
16		Legal changes for climate-resilient building codes, new policies, innovative pilot projects containing innovation in emission domains of climate adaptation strategies.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	SDG 11: Sustainable Cities and Communities
17		Establishing CCC as an ongoing process.		SDG 17: Partnerships For the Goals	SDG 13: Climate Action	NA
18		Number of rehabilitations fostered by the project.		SDG 11: Sustainable Cities and Communities	SDG 16: Peace, Justice, and Strong Institutions	NA
19		Online platform visitors.		NA	NA	NA
20		Social spectrograph.		SDG 17: Partnerships For the Goals	NA	NA
21	Number of distinct solutions.	NA	NA	NA		
22	Unique/City-Specific	Number of imitations.	18	NA	NA	NA
23		Accelerated change towards NZC.		SDG 13: Climate Action	NA	NA
24		Levelized cost of heat (LCOH) from full-scale GHM.		SDG 7: Affordable and Clean Energy	SDG 13: Climate Action	NA
25		Actual levelized cost of heat (LCOH) after implementation.		SDG 7: Affordable and Clean Energy	SDG 13: Climate Action	NA
26		Crime rate reduction.		SDG 16: Peace, Justice, and Strong Institutions	NA	NA

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
27	Unique/City-Specific	Finalised master plan.	18	NA	NA	NA
28		BASEMIS <sup>®</sup> evaluation in 2026 for air quality and studies on housing energy performance.		SDG 7: Affordable and Clean Energy	NA	NA
29		Vote on a metropolitan climate change adaptation plan and its implementation through sectoral actions (drought, heat, etc.).		NA	NA	NA
30		Risks and opportunities identified.		NA	NA	NA
31		TomTom Index.		SDG 13: Climate Action	SDG 11: Sustainable Cities and Communities	NA
32		Number of distinct solutions.		NA	NA	NA
33		Number of imitations.		NA	NA	NA
34		Number of interventions in case organisation during the project.		SDG 13: Climate Action	NA	NA
35		Increased visibility of local action; visibility of actions.		NA	NA	NA
36		Number of RECs (Renewable Energy Communities) triggered by the project.		NA	NA	NA
37	Bottom-up Approaches, Participation, and Involvement (People, neighbourhoods, companies, and govt. channels)	Number of community engagement activities.	22	SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
38		Number of citizens participating in programme activities.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
39		No. of participants.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
40		% of all employees in each city administration partaking in educational events.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
41		Participants in project activities.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
42		Number of people reached by the project through communication actions.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
43		Improved citizen participation per city/district (estimations).		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	SDG 12: Responsible Consumption and Production
44		Number of neighbourhoods with partnerships.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
45	Bottom-up Approaches, Participation, and Involvement (People, neighbourhoods, companies, and govt. channels)	Social spectrograph.	22	SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
46		Increase in grassroots initiatives.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	SDG 16: Peace, Justice, and Strong Institutions
47		Share of employees in participating in interventions.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
48		Participation percentage—No. of stakeholders.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
49		Resident engagement in energy- and climate-conscious actions.		SDG 12: Responsible Consumption and Production	SDG 13: Climate Action	SDG 16: Peace, Justice, and Strong Institutions
50		Co-design events.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
51		Radical collaboration.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
52	Bottom-up Approaches, Participation, and Involvement (People, neighbourhoods, companies, and govt. channels)	Local Green Deals.	22	SDG 17: Partnerships For the Goals	SDG 13: Climate Action	NA
53		Citizens in campaigns.		SDG 16: Peace, Justice, and Strong Institutions	SDG 11: Sustainable Cities and Communities	SDG 13: Climate Action
54		New formats of collaboration and capacity building for action.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
55		New forms of climate activities.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
56		Amount of citizens getting interested and engaged in climate-friendly behaviour.		SDG 16: Peace, Justice, and Strong Institutions	SDG 11: Sustainable Cities and Communities	SDG 13: Climate Action
57		Citizen engagement in co-creation spaces.		SDG 16: Peace, Justice, and Strong Institutions	SDG 11: Sustainable Cities and Communities	SDG 13: Climate Action
58		Observable changes in the behaviour of citizens towards climate neutrality.		SDG 12: Responsible Consumption and Production	SDG 13: Climate Action	NA
59	Climate impact per capita of consumption.	SDG 12: Responsible Consumption and Production	SDG 13: Climate Action	NA		
60	Behavioural Indicators	Accelerated, socially peaceful change towards NZC.	11	SDG 16: Peace, Justice, and Strong Institutions	SDG 12: Responsible Consumption and Production	SDG 13: Climate Action
61		Broader acceptance of solutions.		SDG 16: Peace, Justice, and Strong Institutions	NA	NA
62		Share of citizens with eco-friendly behaviours.		SDG 12: Responsible Consumption and Production	SDG 17: Partnerships For the Goals	SDG 13: Climate Action
63		Number of users of public transport system.		SDG 12: Responsible Consumption and Production	SDG 11: Sustainable Cities and Communities	SDG 13: Climate Action

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
64	Behavioural Indicators	Research team will collect data regarding behaviour change using both objective (e.g., electronic traffic counting) and subjective (e.g., survey questionnaires and interviews) measures.	22	SDG 16: Peace, Justice, and Strong Institutions	NA	NA
65		Reduced barriers for climate-friendly citizen actions.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
66		Increased number of climate-friendly actions by citizens.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	NA
67		Improved monitoring of CO <sub>2</sub> emissions of private consumption/individual behaviour.		SDG 12: Responsible Consumption and Production	SDG 13: Climate Action	NA
68		New behavioural standards.		SDG 12: Responsible Consumption and Production	SDG 13: Climate Action	NA
69	Satisfaction and Self-Efficacy	Level of confidence in initiating and leading climate action.	7	SDG 13: Climate Action	SDG 16: Peace, Justice, and Strong Institutions	NA
70		Citizen satisfaction.		SDG 16: Peace, Justice, and Strong Institutions	SDG 3: Good Health and Well-being	NA
71		Employee satisfaction.		SDG 16: Peace, Justice, and Strong Institutions	SDG 3: Good Health and Well-being	NA
72		Degree of satisfaction and acceptance of stakeholders and decision makers on the designed guidelines.		SDG 16: Peace, Justice, and Strong Institutions	SDG 3: Good Health and Well-being	SDG 13: Climate Action
73		Level of sense of agency among stakeholders and residents.		SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action	SDG 16: Peace, Justice, and Strong Institutions

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
74	Satisfaction and Self-Efficacy	Level of mutual appreciation.	7	SDG 3: Good Health and Well-being	SDG 16: Peace, Justice, and Strong Institutions	SDG 12: Responsible Consumption and Production
75		Degree of satisfaction and acceptance of residents affected by the actions in the project.		SDG 3: Good Health and Well-being	SDG 16: Peace, Justice, and Strong Institutions	SDG 17: Partnerships For the Goals
76	Air Quality and CO <sub>2</sub> e reduction	Improved air quality/per city/district (estimations).	2	SDG 3: Good Health and Well-being	SDG 13: Climate Action	NA
77		Avoided/reduced tonnes of carbon dioxide equivalents (CO <sub>2</sub> e) per million (SEK) investments.		SDG 13: Climate Action	NA	NA
78	Economic, Financial Indicators	Volume of investments in low-carbon development. Number of projects associated with low-carbon development.	7	SDG 13: Climate Action	SDG 9: Industry, Innovation, and Infrastructure	NA
79		Estimations in applications for funding and investments.		NA	NA	NA
80		Types and amounts of new smart green financial instruments.		SDG 13: Climate Action	SDG 9: Industry, Innovation, and Infrastructure	NA
81		socio-economic and economic development co-benefits.		SDG 8: Decent Work and Economic Growth	SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action
82		Types and amounts of new smart green financial instruments.		SDG 13: Climate Action	SDG 9: Industry, Innovation, and Infrastructure	NA
83		Incentives/work benefits offered by the employers (value/employee).		SDG 8: Decent Work and Economic Growth	SDG 16: Peace, Justice, and Strong Institutions	SDG 13: Climate Action
84		Additional income.		SDG 8: Decent Work and Economic Growth	SDG 13: Climate Action	NA

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
85	Publication	Number of articles and other publications produced thanks to the availability of the laboratory.	3	NA	SDG 13: Climate Action	NA
86		Publications about the building types.		SDG 11: Sustainable Cities and Communities	SDG 9: Industry, Innovation, and Infrastructure	SDG 13: Climate Action
87		Publications/articles about the survey results.		SDG 17: Partnerships For the Goals	SDG 13: Climate Action	NA
88	Technology-Based Solutions	New digital tools (e.g., apps) due to data openness and availability—spread to other cities.	4	SDG 9: Industry, Innovation, and Infrastructure	NA	NA
89		Number of digital tools for low-emission district design and applications.		SDG 9: Industry, Innovation, and Infrastructure	SDG 13: Climate Action	NA
90		List of technology packages/set of different solutions with financing options provided to the decision-maker.		SDG 9: Industry, Innovation, and Infrastructure	NA	NA
91		Set of prioritised solutions/most suitably integrated active and passive solutions with financing options.		SDG 9: Industry, Innovation, and Infrastructure	NA	NA
92	Operations, Decision Making, and Reporting Indicators	Awareness and ability to work across silos, formalised changes in policy, governance, organisational structure, budgets, etc.	16	SDG 17: Partnerships For the Goals	NA	NA
93		Number of updated data entries. The fact of the update.		SDG 13: Climate Action	NA	NA
94		Number of climate-related objectives in all city strategies.		SDG 13: Climate Action	NA	NA
95		Successful operational changes made.		NA	NA	NA

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
96	Operations, Decision Making, and Reporting Indicators	Number of public authorities using the platform at the national scale.	16	NA	NA	NA
97		Quality and frequency of interactions between departments.		SDG 17: Partnerships For the Goals	SDG 13: Climate Action	NA
98		A mechanism for adding new datasets in a general and efficient way. Data availability generates research and business outcomes and new ideas.		NA	NA	NA
99		Number of used innovations in the work of the city administration.		SDG 9: Industry, Innovation, and Infrastructure	SDG 13: Climate Action	NA
100		Establishment of a tool for the monitoring and reporting of GHG emissions.		SDG 13: Climate Action	NA	NA
101		Number of solutions suggested for implementation in local strategies.		SDG 13: Climate Action	NA	NA
102		No. of energy-poor households contacted by social workers through the agency.		SDG 10: Reduce Inequalities	SDG 7: Affordable and Clean Energy	NA
103		Operational associative structures.		NA	NA	NA
104		Tracking of contracts.		NA	NA	NA
105		Monitoring of operations.		NA	NA	NA
106		Sharing best practices about the platform with city networks nationally and internationally.		SDG 13: Climate Action	SDG 17: Partnerships For the Goals	NA
107		Formats of cross-departmental collaboration.		SDG 17: Partnerships For the Goals	SDG 13: Climate Action	NA

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
108	Awareness Building, Training, Knowledge Sharing, and Capacity Building	Feedback of the organized events, trainings, and webinars for the climate team.	17	SDG 13: Climate Action	SDG 16: Peace, Justice, and Strong Institutions	NA
109		Number of trained individuals beyond the pilot activity duration.		SDG 13: Climate Action	NA	NA
110		Number of the projects in buildings which energy managers were trained in.		SDG 13: Climate Action	NA	NA
111		Reduced energy consumption.		SDG 11: Sustainable Cities and Communities	NA	NA
112		Improvement in skills and awareness.		SDG 13: Climate Action	NA	NA
113		Change ambassadors.		SDG 13: Climate Action	NA	NA
114		Transfer events.		SDG 17: Partnerships For the Goals	SDG 13: Climate Action	NA
115		Improvement in skills and awareness per city.		SDG 13: Climate Action	NA	NA
116		Cities learning about deep renovation, energy retrofitting approaches, and the methodology used in the project.		SDG 13: Climate Action	NA	NA
117		Number of professionals trained.		SDG 13: Climate Action	NA	NA
118		Number of training hours.		SDG 13: Climate Action	NA	NA
119		Knowledge transfer activities.		SDG 17: Partnerships For the Goals	SDG 13: Climate Action	NA
120	Implementation reports.	SDG 13: Climate Action	NA	NA		
121	Model transferability to other cities.	SDG 13: Climate Action	NA	NA		
122	Learning materials.	SDG 13: Climate Action	SDG 4: Quality Education	NA		

Table A4. Cont.

#	Themes	Customised Indicators	Thematic Frequencies	SDG Attribution		
				Primary	Secondary	Tertiary
123		Number of experts participating in the discussions/assessment meetings/panels.		SDG 16: Peace, Justice, and Strong Institutions	NA	NA
124	Awareness Building, Training, Knowledge Sharing, and Capacity Building	Engagement of stakeholders and decision makers in guideline design processes.	17	SDG 16: Peace, Justice, and Strong Institutions	SDG 10: Reduce Inequalities	NA
125		Exchange between municipalities at regional and national level.		SDG 17: Partnerships For the Goals	NA	NA
126		Collective actions awareness events.		SDG 16: Peace, Justice, and Strong Institutions	NA	NA
127		Integration of learning methods in the format of meetings and exchanges.		SDG 4: Quality Education	SDG 17: Partnerships For the Goals	NA

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