DIVAIRCITY

The power of Diversity & Inclusion for Climate Neutral Cities

Diversity & Inclusion Green Cities Index

and

Diversity & Inclusion Geospatial Maps

Deliverable 2.5

Lead beneficiary: UniverCities

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List of Acronyms

Acronym	Meaning
AB	Advisory Board
CA	Consortium Agreement
DoA	Description of Actions
D&IGCI	Diversity and Inclusion Green City Index
D&IGSM	Diversity and Inclusion Geospatial Map
GA	Grant Agreement
GeA	General Assembly
ICT	Information and Communication Technologies
PC	Protected Categories
PCU	Project Coordination Unit
WP	Work Package

Executive Summary

City authorities often have difficulties in ensuring that their decision-making process and selection of interventions don't have unintended negative consequences on citizens. These consequences can occur when they use a single perspective to examine a local challenge – for example, seeing high urban vehicle traffic as solely an infrastructural issue, ignoring its impact on local health, and in such a way that leads to lower traffic intensity but worse health outcomes. This single mindedness often disproportionately affects the more disadvantaged members of single-mindedness.

There is no index or tool in the literature that connects, through a systemic approach, the nexus between social inclusion, environment and health in cities.

This work designs an index that helps city policy makers and citizens to understand how their city performs according to the DivAirCity project's principles. These principles reflect the broader project's goals around seeing urban interventions from a holistic perspective, incorporating health, social inclusion and the environment.

A mechanism for this index is selected to balance rigour with easy interpretability. This includes a hierarchical approach to handling missing data and scoring data quality.

The index will be made available to global end users through an online web tool. The user journeys and example data visualisations have also been designed to support the development of the tool.

An example of how the index will work in practice is available in the Appendix, demonstrating the combination of a range of data sets into a useable score for cities that are partners in the DivAirCity project as well as around the globe. The data collected and processed to create this index example is also made available.

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1 Introduction

1.1 Background

The Diversity & Inclusion Green Cities Index (D&I GCI) and Diversity & Inclusion Geospatial Maps (D&I GM) are two tools developed during the H2020 DivAirCity project, meant to be used by city policy makers and action takers as well as be made available to the public.

The Diversity and Inclusion Green City Index (later referred to as the Index) is one of five outputs delivered by the project. It is meant to be a tool that encapsulates the core values and findings of the DivAirCity project and would exist beyond the project's lifespan.

The ambition of the Index is to serve as an extension of the project's findings, values, and perspective. Allowing cities globally to benefit from a holistic standpoint that the five participating cities enjoy.

The development of this Index included an extensive research phase that looked at comparable indexes from different fields and how they work. Most of them provide valuable insight into their topic area. However, they are usually designed solely to include data from a single domain such as health, environment, societal challenges or economics. This stands in contrast to the D&I GCI as this project is based on understanding the multifaceted nature of urban challenges, existing data gaps, and under-representing vulnerable protected categories (identified as vulnerable categories according to the UN definition). This drove the development of the Perspectives and Clusters approach used in the index to tackle the three main challenges areas identified by the project:

- Inclusion - Social inclusion vs discrimination
- Health - Health and well-being of people
- Environmental - Climate change and air pollution in cities

The Index was developed as a scalable, global tool, working with existing data frameworks and beyond. This challenge meant that, unlike most city-level indexes, it could not be shaped to live within one region, like Umbria's Region Equity Index, or country as The English Indices of Deprivation. Our Index included a data quality component to account for the lack of uniform, central data collection at the city level across countries and continents. This allows the Index to be inclusive of cities that need more resources and/or awareness to achieve better data collection standards, helping align the Index with the project's values of inclusivity from the very core of its design.

1.2 Objectives

The 'Diversity & Inclusion Green Cities Index' and 'Diversity & Inclusion Geospatial Maps' activities aim to create a usable and scalable tool to be made available to users in cities after the lifetime of the DivAirCity project. It is built considering the five DivAirCity cities and other global cities outside the project. The objectives of D&I Green Cities Index and D&I Geospatial Maps focus on creating a convenient tool for cities to explore the data representing key factors in successful urban interventions: social inclusion, health and environment, ultimately leading to them enacting more successful urban interventions. Users will benefit from this holistic perspective on urban change and connect them to other tools and best practices developed during this project.

This document provides the specification and learnings from the development of the D&I GC Index, an overview of the included KPIs, approaches for handling data quality, designs for the publicly accessible tool and discussion for future development considerations. The document also outlines how the continued development of a tool that would allow local governments to learn about successful urban interventions elsewhere in the world, see best practices shared by other cities and generate benchmark assessments of their own city to inform their own policy and plans.

1.3 Relation to other tasks and WPs

Being one of the final outcomes of the project, the D&I Green Cities Index and the GD&I Geospatial Maps are built on the findings of other Work Packages and feed into the work carried out through other tasks.

With regards to WP 2 *("Digital Innovation and D&I Data Management Framework"*), the D&I Green Cities Index constitutes a tool to assess the performance of cities and urban areas vis-à-vis the lenses of DivAirCity. The Index not only builds on the work carried out under Task 2.1 (*"Definition of the KPIs and monitoring metrics for DivAirCity")* and the indicators identified for the monitoring of the project, but also addresses the data gaps which emerged during that Task and, more generally, from WP 2. Similarly, with regards to the D&I Geospatial Maps, they build on the indicators identified in Task 2.1, as they aim to provide a visual and geolocated representation of the impacts of the intervention.

Moreover, as discussed in Section "Calculation of the Index", one of the objectives of the Index is to promote good data collection at local level from cities authorities. To this end, the design of the Index was based on the data structure developed Task 2.2 and ethical code of conduct developed in Task 2.3.

With respect to WP 3 *("Participatory engagement and people driven framework"),* WP 4 *("Urban Living Labs")* and WP 6 *("Monitoring and assessing the impact of the pilot interventions"),* the Geospatial Maps will contribute to showcasing the impacts and the results of the interventions by visually showing the geographical variation of selected KPIs after the implementation of the NBS designed through the co-creation activities.

It is expected that, due to the granularity of data available, the Index will not be the right tool to highlight the changes brought about by the planned intervention. However, the D&I Green Cities Index does reflect the assessment methodology used to evaluate the impact of the interventions, namely through the focus on social, health, economic and environmental aspects. Moreover, the Index provides useful guidance in understanding the relation and the connections between such aspects. Therefore, the intention is for the Index to be used in the future as a tool to support the design of future interventions in the five projects cities and in other urban areas, thus relating with the scalability and replication efforts of WP 8 *("Twinning, scalability and internationalisation").*

2 Methodology

The Index is based on the central tenets of the DivAirCity project, which deals with systemic issues arising from conventional city governance and data collection. These problems require an unconventional approach provided by the experts, participants, structures and interventions that are part of this project. The Index is intended to be self-sufficient and exist outside the lifetime of this project. To this end, and in light of the design and research work for this Index, it became apparent that to be a valuable tool for city action-makers, its design and processes would need to integrate into existing, imperfect, real-world systems to be effective.

The development process of this Index started with the research of the existing indexes like Global Peace by Vision of Humanity, Urban Health Index (UHI) for Lambeth and Southwark by Impact on Urban Health, OECD Better Life Index and others[1]. The approach and structure of these indexes was carefully looked at. The KPIs of the most relevant ones were analysed and put into a comparative table alongside the KPIs developed for the DivAirCity project (see the document "DivAirCity pilot cities data sources and their acquisition framework"). Results were looked at through the lenses of Maslow's Theory of Motivation to ensure that no important aspects were left out, which led to the inclusion of more indexes into the research.

Looking into the existing indexes, it was clear the lack of Indexes which deal with topics relevant to the project. The first element which emerged, as previously indicated, is the lack of a systemic index at urban level applicable globally[2]. By mapping the existing indexes, it was then possible to assess the specific indicators and data such indexes used in their structure.

At the centre of our approach is the handling of the variability of available data. Most existing publicly accessible data sets have not been generated with the definitions of the DivAirCity project KPIs in mind and therefore may not accurately represent the concept that this project needs. Often when this happens, sufficiently similar data sets are substituted. The key is having a systematic approach to determining what "sufficiently similar" means for any given task. This approach is described in Section 2.4.1 below.

Another related issue that emerged is the need for more high-quality data on specific topics. Without this, many important social issues stay hidden when undertaking quantitative analyses of broader city-data.

This Index aims to address both issues by developing a robust index structure that helps to make sure relevant data is consistently included (see Sections "Calculation of the index"). Also, an innovative, comprehensive approach to inconsistent and missing data was developed as a part of this Index.

[1] Research phase has also included Revaluing Parks and Green Spaces / Green Space Index by Fields in Trust; Global Cities and Future Opportunities by Catapult; The English Indices of Deprivation by UK government; World Happiness index by Sustainable Development Solutions Network; The Air Quality Life Index by Energy Policy Institute at the University of Chicago; Social Progress Index by Social Progress Imperative; Gender Equality Index by European Institute for Gender Equality

[2] We came across few great systematic indexes like *Urban Health Index (UHI) for Lambeth and Southwark by Impact on Urban Health* or *Umbria's Region Equity Index,* but they all to some extend contained a set of KPIs that are only applicable regionally making them unusable for cities out set regions.

2.1 Index structure

One of the critical tasks in creating the Index was to ensure it had a consistent and systematic approach to combining KPI data. This meant it had to generate an all-encompassing measure of city performance, sharing the values at the centre of DivAirCity as a project.

Indexes are built to quantify a particular question at hand. For example, the Index of Multiple Deprivation[3], produced initially by the Social Disadvantage Research Group at the University of Oxford, quantifies deprivations that groups of people are experiencing. These questions are answered thoroughly with all the data that is directly related to the index's purpose.

However, a more wide-reaching approach is needed when ranking the overall state of a country or city. The Urban Health Index (UHI) for Lambeth and Southwark[4] in London categorises its key performance indicators (KPIs) into three groups: basic human needs, the foundation of well-being, and opportunity. This approach is inspired by the Social Progress Index, which separates the KPIs by their importance to human survival and prosperity. However, this allows for scenarios where a place fails to provide essential conditions for human well-being but can provide opportunity. It becomes apparent once this approach is used on a smaller scale in the country where the Social Progress Index score seems broadly consistent. On the other hand, human needs are a priority, and the Urban Health Index has few cases where certain city districts can still score well on opportunity while simultaneously failing on basic human needs. For example, the London Borough of Southwark has ranked 61/68 in human needs and 68/68 in the foundation of well-being while having an 18/68 spot in opportunity[5]. It could be explained by the role of a country or regional programs and regulations largely outside city's or district's control. Since the need for action would be on a higher legislative level, this makes a given index less actionable and more reflective of the larger context. Another question is the validity of the opportunity score for the most vulnerable categories: does the opportunity matter if people struggle to satisfy their basic needs?

DivAirCity project was built on the understanding that problems and opportunities in the city are not distributed equally in a city and aims to give voice to the underrepresented and primarily excluded from traditionally collected data. These data gaps are a core and systematic failure of established practices in data collection and decision-making. The ambition of this Index is to establish a new way of thinking about cities and inspire action that would benefit cities that are frequently overlooked. Our Index is working in an imperfect wider set of systems that need fundamental changes to fix the existing data gaps. However, these issues won't disappear soon and so a robust system that ensures cross-checking across different data sets to capture a complete picture, was developed.

2.2 Perspectives

During the project thus far, importance of cities managing the nexus between these triple threats was confirmed:

- Environmental - Climate change and air pollution in cities;
- Societal - Social inclusion vs discrimination;
- Health - Health and well-being of people.

[3] https://www.gov.uk/government/collections/english-indices-of-deprivation
[4] https://urbanhealth.org.uk/insights/data/urban-health-index-uhi-for-lambeth-and-southwark
[5] "Urban Health Index (Lambeth & Southwark)"

However, conventional assessment methods focus on limited data sources, allowing systemic failures to go unnoticed until emergencies like the COVID-19 pandemic arrive. To mitigate this, the idea of the so-called Perspectives was introduced.

The idea of Perspectives in the context of this Index means choosing KPIs corresponding to the three threats: health, societal, and environmental (see examples of this approach in the following sections). The systematic approach of the index is designed to assess each city through these three perspectives. This idea allows us to give the Index a robust structure that will ensure a comprehensive analysis of the current data circumstances, identify its failures (see Section Calculation of the index), and ensure future development and evolution.

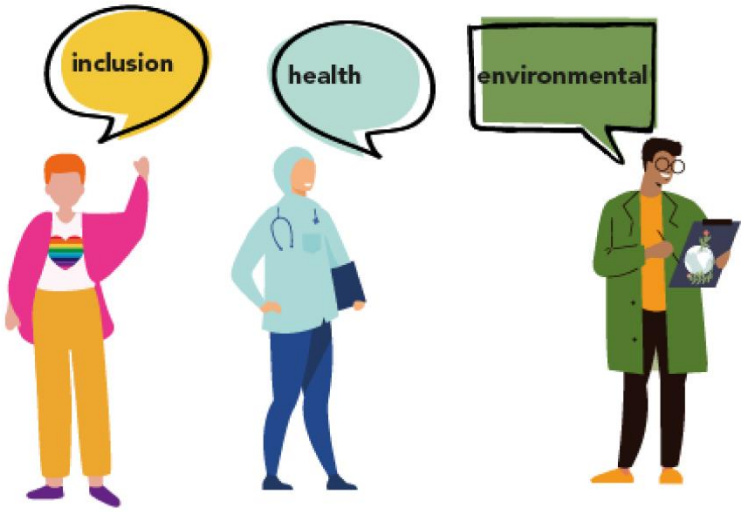

Figure 1. All factors of life in cities included in the Index are explored from three different Perspectives.

2.3 Clusters and subclusters

One of the critical design considerations of this Index is its **actionability**. Regarding the structure, this meant that not only should it inform the audience of the overall state of the city but also help identify weaknesses and strengths of the city and allow governing bodies to set their priorities accordingly. The DivAirCity project focuses on the nexus between people, places, peace, economic growth, and its impact on air quality and decarbonisation. These four core domains follow the World Health Organisation's framework for Healthy Cities, which were agreed to be used as main clusters during project partner discussions.

These clusters represent core domains a city could improve. Each of the four clusters is easily understandable by city action-maker with regards to what improvement initiative would be needed to better it:

- ***People*** - a cluster that relates primarily to the social policies of the city.
- ***Place*** - descriptive of city planning policies and the current physical environment.
- ***Peace*** - is meant to give us an understanding of the quality of law enforcement, speaking to the fundamental right of safety and security.
- ***Economic Growth*** - relates to the opportunity of citizens to participate in economic activity in the city sustainably.

This division helps to encourage the interpretation of the results, focus on action rather than assessment and target the audience responsible for a given area of action.

This division is further broken down into subclusters. It can be seen as a series of questions for each cluster. ***People*** cluster is described in three subclusters that could also be seen as questions:

- ***Equality*** - Is the city supporting equality and social inclusion?

This sub-cluster is meant to screen the city for systematic inequalities present, as the belief that life in the city is only as good as the life of the most vulnerable is at the centre of the project.

- ***Physical Well-Being*** - Are people living a healthy life in the city?

It is included to reinforce the importance of the city's role in keeping its citizens in their best health.

- ***Education*** - Are people receiving education and having easy access to information?

This cluster explores whether all children have fair and equal access to quality education, enabling them to develop to their full potential and promoting lifelong learning opportunities for all.

The inclusion of education as a separate sub-cluster is linked DivAirCity project emphasis on citizen engagement and civic participation. This sub-cluster includes both formal education and access to information through modern communication technologies (this is motivated by the use of technology to lower air pollution and decarbonisation).

Different versions were considered during the development phase, such as the inclusion of basic living standards. However, this cluster was made redundant since parts of it could be answered in other clusters/sub-clusters like place-housing.

The cluster of ***places*** is meant to access the cities' physical environment. It is composed of these clusters:

- ***Air Quality*** - How clean is the air in the city?

The problem of air pollution is at the project's core and is included thoroughly throughout the *Environmental Perspective.* However, the inclusion of it as a separate cluster creates a place for a much more focused approach to the question.

- ***Housing*** - Does the city provide the possibility of good living conditions and shelter?

The COVID-19 pandemic highlighted the importance of this cluster for quality of life in the city. This sub-cluster is crucial in accessing housing provision, quality and safety in the city. It also represents people's access to the most basic standards of dignified living.

- ***Streets & Mobility*** - Is the city allowing for the comfortable and safe movement of people?

Providing easy, safe and sustainable travel options in cities is key to ensuring all vulnerable categories can access services and amenities fairly/inclusively.

- ***Green Spaces*** - How well developed is the city's green infrastructure?

Through improved air and water quality, buffering of noise pollution and mitigation of impacts from extreme events, urban green spaces can reduce environmental health risks associated with urban living as well as provide mental health benefits.

The Peace* and *Economic growth cluster does not have a sub-cluster division in this index version. This data is usually understood at the local level, and the contribution of the Index going deeper into it would be small. For these clusters, the Index is focused on giving a different lens to these topics focusing on the values of DivAirCity.

2.4 Key Performance Indicators

Each cluster and subcluster is analysed from 3 different perspectives, creating a matrix like the one seen below (Figure 2). This structure gave the Index an excellent starting point for KPIs selection as it helps to ensure a broader perspective on each topic independent of future changes.

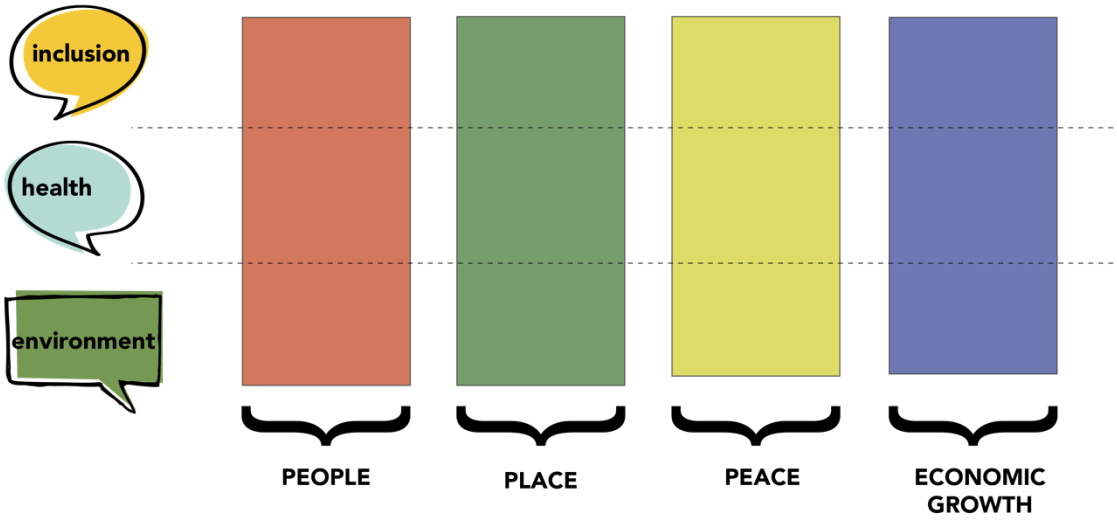

Figure 2. The Index Perspectives and Clusters

However, it is vital to establish a baseline approach to selecting KPIs and outline topics that should be covered for each part of the matrix and general criteria for KPIs selection.

2.4.1 Criteria of selection

When selecting KPIs for each part of the matrix, they had to follow these criteria:

- ***Relevant and reflective of the question at hand***

This was ensured by referencing KPIs with other selected indexes and internal discussions.

- ***Output KPIs***

When talking about KPIs, there are the ones that measure Input, such as legislation and budget spent, and output, which measures the impact of it. Cautious of the differences in definitions between inputs from city to city globally, it was decided to build the Index based on output KPIs.

- ***Actionable at a city level***

Since this Index is designed with city action-maker in mind, a guideline was established to include only issues that could be solved or influenced on a city level.

- ***Publicly available data samples***

Data collected by big, well-established organisations such as United Nations, World Health Organization and others is prioritized to ensure that the definitions used are compatible between countries and continents to ensure the universality of the Index.

2.4.2 People Cluster

2.4.2.1 Equality

The question for this sub-cluster is: Is the city allowing for equality and social inclusion? This speaks to the most fundamental KPIs directly related to vulnerable categories and the discrimination they face.

This included relevant KPIs screening for:

- Violation of basic rights.
- Systemic issues disproportionately experienced by vulnerable protected categories.
- Societal acceptance of vulnerable protected categories.

This sub-cluster is supposed to focus on core aspects of the life of vulnerable protected categories. This data is conventionally not collected as they are underrepresented at all levels of governing. This discrepancy created a significant gap in research on what data is essential to highlight vulnerable categories concerns, especially at the city level. Things like acceptance, safety concerns, and discrimination related explicitly to protected categories are seldom collected at the country level, let alone at the city.

A limited number of KPIs from the indexes consulted specifically relate to vulnerable protected categories. Issues of gender equality are usually covered in terms of pay equality and hours worked, as well as hours worked. Fewer indexes included metrics that track issues of concern for other protected groups.

One index that includes a significant metric focused on minorities, gender equality, freedom and discrimination is the Social Progress Index by the Social Progress Imperative. However, these metrics do not appear in the smaller-scale index that draws inspiration from it, Urban Health Index (UHI) for Lambeth and Southwark.

Inspired by our research, the desired list of indicators would include KPIs like “1.3.2 Social inclusion and diversity” developed for the DivAirCity project, which measures the number of citizens who experienced discrimination regarding ethnicity and nationality. From our research, it also emerged that child marriage is one of the issues that can be targeted and prevented locally[6].

With regards to LGBTQ+ issues, it was noted that a push for better KPIs development needs to be made since none of the existing output metrics considered in the process of our research has received wide acceptance among the experts, leaving the assessment of legislation as a benchmark for this topic. An example would be Rainbow Europe by ILGA-Europe, which is

[6] (Sundaram)

assessing European countries to protect LGBTQ+ peoples' rights and freedoms legally2. Discrimination of other vulnerable categories is also primarily measured by assessing country-level legislation, which is out of cities' control.

In many cases, inclusion and non-inclusion of these metrics are determined by what data is traditionally collected. One of the only data sets collected globally on the issue of LGBTQ+ issues, for example, is "acceptance of gays and lesbians" collected by the Gallup world poll3. This data set, alongside "discrimination and violence against minorities", is done for 103 countries by simple polling. However, the questions asked are limiting and do not include the entirety of the LGBTQ+ community, nor does it have the methodology of collecting opinions of the people in question. Gallup also does not publish this data publicly, limiting access to it for the use of the index ultimately made us look for other KPIs to include.

Table 1. People - Equality

Perspective	KPI Name	Description
Inclusion	**Proportion of women aged 20-24 years who were married or in a union by age 18**	Proportion of women aged 20-24 years who were married or in a union by age 15 (%)
	Rainbow Index[7]	Rainbow Europe – ILGA-Europe's annual benchmarking tool – comprises the Rainbow Map and Index and national recommendations. ILGA-Europe has produced the Rainbow Map and Index since 2009, using it to illustrate the legal and policy situation of LGBTI people in Europe.
Health	**Life expectancy at 60 (years)**	The average number of years that a person of 60 to 64 years old could expect to live if they were to pass through life exposed to the sex- and age-specific death rates prevailing at the time of their 60 years, for a specific year, in a given country, territory, or geographic area.
	Maternal mortality rate	Maternal deaths per 100,000 live births in women aged 10-54 years.
	Child mortality rate	Probability of dying between birth and exactly 5 years of age, expressed per 1,000 live births.
Environmental	**Share population exposed to particulate matter above 5 P.M**	Fine particulate matter (PM2.5) is the air pollutant that poses the most significant health risk globally, affecting more people than any other pollutant. Chronic exposure to PM2.5 considerably increases the risk of respiratory and cardiovascular diseases in particular. Data refer to population exposure to more than 10 micrograms/m3 and are expressed as annual averages.

The most crucial KPIs selected help to understand how the city is taking care of protecting categories.

[7] ("Rainbow Europe Map and Index 2021 - ILGA-Europe")

One of the critical concessions made is the inclusion of an input matrix (the Rainbow Index). Due to the lack of comprehensive metrics for the LGBTQ+ issue, it is included in the Index as a provisional KPI to familiarise cities with the discrimination they face and create a push for developing a more comprehensive KPI for future editions of the Index.

The most fundamental metric collected that indicates gender inequality from the social perspective, which is child marriages, is here included as it is used in multiple sources consulted, such as the Social Progress Index[8] and progress indicators of the UN and WHO[9].

Health was one of the most data-rich domains which have consulted for this sub-cluster. KPIs on life expectancy for senior citizens (at 60) and child and maternal mortality allow us to see how equal the place is regarding the health and well-being of vulnerable groups.

From the experience of the project, it was decided to include the metrics that explore how many people receive excessive air pollution, as it disproportionately affects the vulnerable categories.

2.4.2.2 Physical Well-Being

The well-being sub-cluster allows us to assess the health of people in depth. During the pandemic, it became apparent that air quality and social-economic factors played a role in the health outcomes of those affected by COVID.

This cluster includes indicators of cities' consistent work on ensuring that citizens have access to systems that allow them to live a long and healthy life. This included relevant KPIs screening for:

- Length of life
- Access to nutrition, medical care and other services relevant to physical well-being.

In this sub-cluster***, the Perspective of Inclusion*** *w*ould be the same as ***the Health perspective*** in the ***Equality sub-cluster.*** This is due to the fact that during the assessment, it was evident that the data were closely tight together with Equality in the perspective of *Inclusion,* so the same comments apply as mentioned above.

From the other perspectives, the aim was to reflect on citizens' ability to lead healthy lives by accessing health services, food and air. One of our core considerations regarding this sub-cluster is seeing a general picture of health.

An interesting indicator, such as *Access to quality healthcare*[10] used in the Social Progress Index, requires experts' opinions to derive the score, which complicates its inclusion in the

[8] (Social Progress Imperative)
[9] ("Proportion of Women Aged 20-24 Years Who Were Married or in a Union by Age 15 (%)")
[10] Defined as: Country experts' aggregated evaluation of the question, "To what extent is high quality basic healthcare guaranteed to all, sufficient to enable them to exercise their basic political rights as adult citizens?" measured on a scale of 0 to 4.
0: Extreme. Because of poor-quality healthcare, at least 75 percent (%) of citizens' ability to exercise their political rights as adult citizens is undermined.
1: Unequal. Because of poor-quality healthcare, at least 25 percent (%) of citizens' ability to exercise their political rights as adult citizens is undermined.

Index. *Perceived health*[11] is one of the KPIs eliminated in the current selection due to a lack of open sources, as seen in the Better Life Index by OECD[12].

One of the data gaps encountered is the inclusion of people from groups such as the undocumented population since the information is mainly collected through healthcare facilities ,and these groups have limited-to-no access to healthcare facilities. Research is limited, and more is required to breach this gap.

Table 2. People - Physical Well-Being

Perspective	KPI Name	Description
Inclusion	**Same as sub-Cluster Equality, perspective Health**	
Health	**Life expectancy at birth, total**	Number of years that a new-born can expect to live
	Undernourishment	(% of pop.) The prevalence of undernourishment expresses the probability that a randomly selected individual from the population consumes a number of calories that is insufficient to cover their energy requirement for an active and healthy life. The indicator is computed by comparing a probability distribution of habitual daily dietary energy consumption with a threshold level called the minimum dietary energy requirement. Both are based on the notion of an average individual in the reference population
Environmental	**Years of life lost due to air pollution**	Data on causes of death (COD) provide information on mortality patterns and form a major element of public health information.

In the current configuration, this sub-cluster helps to highlight the city's role in life expectancy and the effects of air pollution, as the discrepancy between rural and urban populations is becoming more evident[13]. Also, the metrics on undernourishment were included, as many consulted sources underscore the importance of food security in cities.

2: Somewhat equal. Because of poor-quality healthcare, ten to 25 percent (%) of citizens' ability to exercise their political rights as adult citizens is undermined.
3: Relatively equal. Basic healthcare is overall equal in quality but because of poor-quality healthcare, five to ten percent (%) of citizens' ability to exercise their political rights as adult citizens is undermined.
4: Equal. Basic healthcare is equal in quality and less than five percent (%) of citizens cannot exercise their basic political rights as adult citizens.

[11] Defined as: Share of adults reporting "good" or "very good" health

[12] ("OECD Better Life Index") https://www.oecd-ilibrary.org/sites/9870c393-en/1/1/index.html?itemId=/content/publication/9870c393-en&_csp_=fab41822851fa020ad60bb57bb82180a&itemIGO=oecd&itemContentType=book

[13] (Kyte and Wells)

2.4.2.3 Education

Education is a sub-cluster that asks: Are people receiving education and can access information? It was a significant cluster for this Index as good access to education, and information is one of the most effective methods by which a city can improve inequalities, reduce data gaps and combat air pollution. To see where the city is with this access and implementation of education, relevant KPIs were screened for:

- Education rates
- Disparities in education for protected categories
- Quality of education on health, equality and environment
- Access to information and communication technologies

This cluster is significantly linked to combating all three core threats identified by the DivAirCity project since people cannot fight what they are unaware of. Thus, the references from other indexes were used but moulding them to the project's perspective, which goes beyond a conventional understanding of educational KPIs.

Table 3. People - Education

Perspective	KPI Name	Description
Inclusion	**Graduates of tertiary education**	Educational attainment measures the share of people with a high level of education among men and women. People with tertiary education as their highest successfully completed level (levels 5–8), percentage of total 15+ population
	School enrolment, gender parity index	The absolute deviation from parity (=1) in secondary education attainment of women and men.
Health	**Premature deaths from noncommunicable diseases**	Mortality rate due to cardiovascular diseases, cancers, diabetes, and chronic respiratory diseases among populations aged 30–70 years, per 100,000 people
Environmental	**% of households with internet access**	Share of households with internet access and mobile telephone subscription

With this sub-cluster, the outlook on education was expanded to include KPIs that would give us insights into education in the city on screening and treating preventable disease, since most of the work needed for it is done on the ground in education institutions and in primary health facilities. It is also well known that there are educational inequalities which incidence of non-communicable diseases[14]. Regarding the inclusion of technology as part of the *Environmental perspective* on education, DivAirCity's approach to using cutting-edge technology in combating air pollution and encouraging decarbonisation of the cities and educational inequalities that arise from children not being able to participate in digital learning was considered.

[14] (Oshio and Kan)

2.4.3 Place Cluster

2.4.3.1 Air Quality

The air quality sub-cluster can be seen as an answer to the question: How clean is the air in the city? This question is a straightforward one for most of the indexes. However, the lens of the DivAirCity question becomes way more nuanced since it considers that the vulnerable categories are disproportionally affected by environmental issues. With this cluster, the following topics are aimed to be covered:

- How clean is the air
- How affected are the vulnerable groups
- Health costs to the population due to poor air quality

Overall, there are many good sources of data for air quality. However, the evaluation of the placement of the sensors and the frequency of data collection should be performed by the city to ensure good results.

Table 4. Place - Air Quality

Perspective	KPI Name	Description
Inclusion	**Ambient air pollution attributable disability-adjusted life years in children under 15 years (male and female)**	The burden of disease attributable to ambient air pollution can be expressed as number of deaths, death rate (both crude and age-standardized), number of disability-adjusted life years (DALYs), DALYs rate (both crude and age-standardized), and number of years life lost (YLLs). Death and DALYs rates are calculated by dividing the number of deaths or DALYs by the total population (or indicated if a different population group is used, e.g. children under 5 years, or children under 15 years). Age-standardized rates adjust for differences in population age distribution by applying the observed age-specific mortality (or DALYs) rates for each population to a standard population. The age-standardized rates can therefore be used to compare the rates of countries without being affected by the differences in age distribution from country to country. Evidence from epidemiological studies have shown that exposure to ambient air pollution is linked, among others, to the important diseases taken into account in this estimate: 1) Lower respiratory infections in general population, children under 5 years of age and children under 15 years of age; 2) Stroke in adults (25 years and over); 3) Ischaemic heart diseases in adults (25 years and over); 4) Chronic obstructive pulmonary diseases in adults (25 years and over); and 5) Trachea, bronchus and lung cancers in adults (25 years and over).
Health	**Same as Cluster People, sub-cluster Well-Being in perspective of Environment**	

Perspective	KPI Name	Description
Environmental	**Annual mean concentration of particulate matter of less than 2.5 microns of diameter (PM2.5) [ug/m3] in urban areas**	The mean annual concentration of fine suspended particles of less than 2.5 microns in diameters is a common measure of air pollution. The mean is a population-weighted average for urban population in a country.

For this sub-cluster, KPIs in the current version cover all the perspectives well. However, for future versions, in the perspective of Inclusion the current KPI would preferably be replaced by *Proportion of children living in areas with high air pollution*, which would measure the number of children living in neighbourhoods with pollutant concentrations above the levels of the current air quality standards.

2.4.3.2 Housing

Housing is a sub-cluster that encompasses the question: Does the city provide the possibility of good living conditions and shelter? This sub-cluster encompasses questions surrounding some of the most basic human needs:

- Access to housing
- Quality of housing
- Access to water and sanitation
- Access to basic comfort

One of the things found in the process is that homelessness is not commonly collected, and the definition of homelessness greatly varies across nations. Also, despite being part of the Urban Health Index for Lambeth and Southwark and the Better Life Index, data on overcrowding rates are not readily available.

Another data considered to be included as a part of this sub-cluster is the energy efficiency of buildings. It was not included as the practical aspect of collecting these data globally seems impossible due to the significant variation in measurement practices.

Table 5. Place - Housing

Perspective	KPI Name	Description
Inclusion	**Drinking water, sanitation and hygiene in households by country**	Risk-weighted prevalence of populations using unsafe or unimproved water sources, as measured by the summary exposure value (SEV) for unsafe water (%)
	Homeless population estimates	Percentage of population experiencing homelessness
Health	**Mortality rate attributed to household and ambient air pollution, age-standardized**	Mortality rate attributed to household and ambient air pollution is the number of deaths attributable to the joint effects of household and ambient air pollution in a year per 100,000 population. The rates are age-standardized. Following diseases are taken into account: acute respiratory infections (estimated for all ages); cerebrovascular diseases in adults (estimated above 25 years); ischaemic heart diseases in

Perspective	KPI Name	Description
		adults (estimated above 25 years); chronic obstructive pulmonary disease in adults (estimated above 25 years); and lung cancer in adults (estimated above 25 years).
	Mortality rate attributed to exposure to unsafe WASH services	Deaths attributable to unsafe water, sanitation and hygiene focusing on inadequate WASH services, expressed per 100,000 population. Death rates are calculated by dividing the number of deaths by the total population. Evidence from epidemiological studies have shown that exposure to unsafe water, sanitation and hygiene habits is, among others, directly linked to diarrhoeal diseases and intestinal nematode infections and other diseases. Repeated diarrhoea episodes are linked to protein-energy malnutrition. In this estimate, only the impact of diarrhoeal diseases, intestinal nematode infections, and protein-energy malnutrition are taken into account. The included diseases are the WASH-attributable portions of diarrhoea (ICD-10 code A00, A01, A03, A04, A06-A09), intestinal nematode infections (ICD-10 code B76-B77, B79) and protein-energy malnutrition (ICD-10 code E40-E46).
Environmental	**Usage of clean fuels and technology for cooking**	The proportion of population primarily using clean cooking fuels and technologies for cooking
	Access to electricity	The percentage of the population with access to electricity

In its current state, this sub-cluster presents a mix of data that would showcase any concerns the most vulnerable could have with housing in the city. It screens for access and quality to sanitary facilities in death counts and household availability to cover housed and under-housed populations.

2.4.3.3 Streets & Mobility

This sub-cluster asks: Is the city allowing for the comfortable and safe movement of people? Streets and mobility are aspects of the city that cannot be underestimated as they determine citizens' access to its infrastructure and amenities. Streets and transportation have to be screened for:

- Walkability
- Safety
- Public Transport connection

One of the biggest challenges with this sub-cluster was finding a KPI that would consistently reflect the walkability of cities. Examples of such metrics could be the Walkability[15] metrics developed in the previous deliverables. However, open sources of data were found on the

[15] ("Most Walkable Cities in the United States, Canada, and Australia on Walk Score")

topic. One of the promising sources discovered during the research phase is a tool called Walk Score. It analyses walking routes to different essential amenities, urban density, and block length using publicly available data and user-generated ones for their walkability score. However, it is currently only available in North America. These sources also provided a complex Transit score[16] and a Biking score. Public transportation and biking in the city are essential aspects of mitigating air pollution and carbon emissions. However, regarding biking, more nuances must be put into the KPI with a perspective on the vulnerable categories, not unfairly disadvantaged cities that had to prioritise other forms of transportation due to their topography, climate and others. In cities with hilly topography and/or climate extremes, biking would require people to be in optimal physical conditions, or/and use an electric bike. Both issues make biking inaccessible to many people that fall into the vulnerable protected categories.

Table 6. Place - Streets & Mobility

Perspective	KPI Name	Description
Inclusion		
Health	**Number of road traffic deaths in a year**	Estimated number of deaths due to road traffic fatal injury in the specified year
Environmental	**Percentage Access to Public Transport**	The proportion of the population that has convenient access to public transport disaggregated by age group, sex, and persons with disabilities. This indicator is computed as the estimated share of urban population who can access a public transport stop within a walking distance of 500 meters (for low-capacity public transport systems e.g., buses) and/or 1000 meters (for high-capacity public transport systems e.g. trains, ferries) along the street network. Only mapped public transport stops are included in the analysis, which may include both formal and informal stops.

The perspective of Inclusion is one part of the unreferenced matrix. This is due to the lack of available sources that would consistently indicate a place's pedestrian walkability, satisfying the basic assumptions of this Index (see section 3.1 Index design criteria). The number of road traffic death is a KPI that was quite a distinct metric for judging cities' priorities for pedestrians, since VisionZero is proving that no road fatalities is an achievable goal even in big cities like Oslo[17]. Another KPI affecting people's ability to use city streets freely is Feeling safe at night. However, since it is also related to the general crime level, it was included in the Peace cluster.

2.4.3.4 Green Spaces

The green spaces sub-cluster answers the question: How well developed is cities' green infrastructure? Green spaces are an essential part of the city's structure, and when well done, they can target issues like air pollution, urban island heat effect and much more. This sub-cluster covers data:

[16] ("Transit Score Methodology") https://www.walkscore.com/transit-score-methodology.shtml
[17] ("What Is Vision Zero?")

- Amount of green spaces
- Citizens' access to green areas.
- Urban heat island effects
- Excessive mental health issues in the population[18]

Concerning this sub-cluster, ensuring it goes beyond measuring the percentage of the land area designated as green space was essential. Green space quality and accessibility are critical factors impacting the city. Well-planned and executed green infrastructure can be a nature-based solution that can serve as a basis for sustainable development for many years. This consideration was a guiding factor in selecting indicators for the sub-cluster.

Data for this cluster was quite accessible through Copernicus and other similar sources. However, processing this data could have been more intensive and significantly limits its use.

Table 7. Place - Green Spaces

Perspective	KPI Name	Description
Inclusion	**Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities**	Data on a) the estimated share of urban areas allocated to streets, b) estimated share of urban areas allocated to open public spaces c) estimated share of urban areas in both streets and open public spaces, and d) estimated share of urban population within 400 meters walking distance along the street network to an open public space.
Health	**Estimated population-based prevalence of depression**	Number of persons with depressive disorder (major depressive disorder/depressive episode or dysthymia) in the last year. Major depressive disorder / depressive episode involves symptoms such as depressed mood, loss of interest and enjoyment, and decreased energy; depending on the number and severity of symptoms, a depressive episode can be categorized as mild, moderate, or severe
Environmental	**Leaf Area Index**	The Leaf Area Index is defined as half the total area of green elements of the canopy per unit horizontal ground area. The satellite-derived value corresponds to the total green LAI of all the canopy layers, including the understory which may represent a significant contribution, particularly for forests. Practically, the LAI quantifies the thickness of the vegetation cover.
	Share of Green Areas in urban centres	% of green areas in urban centres
	Summertime daytime urban heat island: difference in land surface temperature between the build-up area and its surroundings	Measure of the temperature differences in the city

[18] Barton and Rogerson ("The Importance of Greenspace for Mental Health")

This sub-cluster has a great combination of KPIs in the current version. However, in the future, the development index might benefit from including KPIs that would measure the comfort, safety and accessibility of green spaces for vulnerable groups precisely.

2.4.4 Peace Cluster

The cluster of Peace is answering a fundamental question: How safe is the city? Upholding law and order is a crucial task of the local governments as it is the backbone of city prosperity. This cluster is looking at the following:

- General safety and security of a place
- Crime rates that especially sensitive to vulnerable protected categories
- The subjective feeling of safety

Safety is a very complex topic. There are many parts to consider to give a complete picture of the situation, including all the different crime statistics and security data. Regarding safety and security, the vulnerable are often targets of violence and hate crimes that often underreported. It is estimated that close to 9 out of 10 hate crimes alone are not included in the official statistic[19]. The aspect of safety hidden in official statistics is the perception of safety. The same city can be dramatically differently accessible to men and women due to the perception of safety. This aspect is often missing in indexes; however, as it is linked to increased stress, it can be seen as a health factor for citizens[20].

Table 8. Peace Cluster

Perspective	KPI Name	Description
Inclusion	**Violent sexual crimes recorded**	Amount of Violent sexual crimes recorded by population
Health	**Feeling safe at night**	Share of people declaring that they feel safe when walking alone at night in the city or area where they live
Environmental	**The Global Peace Index (Safety and Security)**	Part of the index that evaluates the internal peace and security in each country

In the current selection, after much consideration, the internal peace component of the Peace Index was included as a stand-in to understand the objective peacefulness of a place. This is motivated by a general lack of crime statistics openly available and a desire to make comprehensive assessments, even if it comes with the limitation of using the index as a KPI. Assessment of violent sexual crimes is included in this cluster due to the severity of their effects on inspiring fear for the vulnerable population, particularly women.

2.4.5 Economic Growth Cluster

The economic growth cluster focuses on the question: How prosperous is life in the city? Economic prosperity in a city plays a crucial role in determining the quality of life. It gives

[19] (Brzozowski and Fox)
[20] (Polko and Kimic)

people opportunities to better their lives and improve their living standards. Economic prosperity also enables people to invest in their education, health, and well-being. This cluster looks at economic growth and prosperity from the perspective of sustainability and inclusion covers:

- The ability of people to provide for oneself
- Good employment
- Ability to access opportunity
- Ability to participate in economic activities sustainably.

This cluster gives insight into the ability of people to live a prosperous life, providing for their needs and participating in the economy without compromising the planet. In composing this cluster, it was essential to look past commonly used economic metrics like GDP per capita as it often is ineffective for places with significant wealth disparity.

Table 9. Economic Growth

Perspective	KPI Name	Description
Inclusion	**Unemployment, female**	The proportion of unemployed women in the total of female labour force (modelled ILO estimate)
	Gini Coefficient[21] of inequality at disposable income level after taxes and transfers	Gini Coefficient of inequality at disposable income level after taxes and transfers by city or region per year
	Long hours in paid work	Percentage of employees usually working 50 hours or more every week
Health	**Unmet need for contraception**	Unmet need for contraception is the percentage of fertile, married women of reproductive age (15-49) who do not want to become pregnant and are not using contraception.
Environmental	**Municipal waste recycling rate**	Percentage of municipal waste that is being recycled or composted

[21] The Gini index, or Gini co-efficient, measures income distribution across a population.

Perspective	KPI Name	Description
	Energy Transition(renewable)	Renewable energy is defined as the contribution of renewables to total primary energy supply (TPES). Renewables include the primary energy equivalent of hydro (excluding pumped storage), geothermal, solar, wind, tide and wave sources. Energy derived from solid biofuels, bio gasoline, biodiesels, other liquid biofuels, biogases and the renewable fraction of municipal waste are also included. Biofuels are defined as fuels derived directly or indirectly from biomass (material obtained from living or recently living organisms). This includes wood, vegetal waste (including wood waste and crops used for energy production), ethanol, animal materials/wastes and sulphite lyes. Municipal waste comprises wastes produced by the residential, commercial and public service sectors that are collected by local authorities for disposal in a central location for the production of heat and/or power. This indicator is measured in thousand toe (tonne of oil equivalent) as well as in percentage of total primary energy supply.

This cluster, including the Gini coefficient, provides a more nuanced picture of the level of inequality in the distribution of income or wealth by taking into account the differences in income or wealth between all individuals in the population. It focuses on female unemployment, often linked to a lack of flexible employment, affordable childcare and prejudice. In addition, long work hours worked is also something that hurts parents and other caregivers predominantly. The environmental perspective on prosperity is composed of cities responsible attituded to lobbying and allowing people to use renewable energy sources at a city level and recycle their waste responsibly.

3 Calculation of the index

To create an indexing mechanism that delivers the objectives of this work package, the following design criteria were established and laid out the assumptions made to justify our approach.

3.1 Index design criteria

These criteria were established from a combination of best practice from other similar indexes and the broader ethos of the DivAirCity project.

1. Values for the same indicator should be directly comparable. This means that all data values for a given indicator should use the same definition and have been collected in similar ways.
2. Adding new cities should not change the scores of existing cities. This means that as data for additional cities becomes available, it does not affect previous readings of the index.
3. The indicator aggregations and index scores should be easily explainable. This means that there are no black box steps in calculating the index and it uses the simplest mathematical operations possible.
4. A user should be able to get useful and actionable insight from the index.
5. Indicators should be sufficiently sensitive to change so that the impact of interventions is at least theoretically possible.
6. The index output should encourage collaboration and cooperation rather than competition.
7. The scores should not penalise cities that do not have data for all indicators, but the quality of data used to create scores should be summarised and shown to the user alongside the index output.
8. Using the index should promote good data collection practice by highlighting the value of high-quality data sets and gaps in current data availability.
9. The index will be based on the assumptions given in Section 3.2.
10. The index uses the data hierarchy described in Section 3.3 to ensure a reliable and consistent assessment.

3.2 Index assumptions

It is important to note the assumptions made when finalising the design of the index mechanism, as these are often choices or points that could change as the project develops.

Assumption 1: For the index to be useful, it must have coverage of all the data clusters and perspectives.

Assumption 2: The index must be able to characterise a city specifically, rather than just give a national picture.

Assumption 3: At a bare minimum, the index must be applicable to the 5 project cities.

Assumption 4: It must be possible for other cities (Europe, outside Europe) to collect data consistent with that used in the index and be able to use it with the same indexing mechanism.

Assumption 5: Each perspective is as important as each other and should equally contribute to the final index output.

Assumption 6: Clusters do not have to be equally weighted and are used solely for grouping together related indicators.

Assumption 7: The Geospatial maps component of the Work Package will deal with communicating the impact of specific planned urban interventions and tell a story with available data about those projects, focusing on circumstances before, during and after the intervention.

3.3 Index method

For each indicator, a value to use in the index for each city is selected. Depending on data availability, the most specific value from a data set will be taken, according to the following data specificity hierarchy:

Data specificity hierarchy:

- Level 1: A recent, measured value for that city using a DivAirCity definition and collection method.
- Level 2: A recent, measured value for that city, using a sufficiently similar definition and collection method.
- Level 3: A recent, modelled value for that city, using a sufficiently similar definition and respectable modelling method.
- Level 4: A value for that country using a DivAirCity definition and collection method
- Level 5: A value for that country using a sufficiently similar definition and collection method.
- Level 6: There is no data.

The raw values taken from the source data sets may be represented in many ways in their original form. To allow us to combine them consistently, those values will then be transformed according to these principles:

- Representation: All values for an indicator should have the same representation, e.g., a value between 0 and 1. Where values in source data sets are not represented in this way, they should be changed consistently and so that no information is lost. For example, "3.4 child mortalities per 100,000 live births" -> "0.034% of live births resulted in child mortality" => value of 0.034. Once all values are consistent, they can be linearly scaled for display to users if that's more accessible, e.g., x100 for percentages.
- Depending on the distribution of values for that indicator, the values may need to be normalised to make them comparable to other cities and keep them as sensitive to change as is possible. For example, if across all cities in the index they have values for the Walkability indicator that range between 5% - 20%, to mix-max scale the values can be chosen:

$$\overline{x} = \frac{(x - \min(X))}{(\max(X) - \min(X))}$$

Equation 1

  - where X is the distribution of values across all cities, x is the value for one city specifically and $\overline{x}$ is the normalised value.
  - However, if the distribution of X changes (i.e., through adding more cities that have values outside the initial range), the scores would need to change for all

cities – this may not be desirable as it is inconsistent with design criteria 2 above.

- For some values originally represented as absolute counts (for example "Population with primary reliance on clean fuels and technologies for cooking in millions"), these must be turned into a proportion by using another number to make them comparable across cities. For example, the number of gigawatts of power created from renewable sources in a city can be contextualised by dividing it by the total number of gigawatts created in that city. It then represents a proportion, that can be transformed into a value between 0 and 1.

Indicator combination

The overall mechanism consists of a weighted linear combination. As different indicators have different "optimal" values, they must first be categorised.

Categorise each metric of value n must be added to be one of:

1. Metric to be maximised (m_+)
2. Metric to be minimised (m_-)
3. Metric to be kept to the mean average (m_μ) (*unused in this instance of the index*)

These values are then normalised in line with the approach above to scale them to the range $0 \leq m \leq 1$.

If the simple approach of equally weighted indicators throughout the index is taken, then an index score f_s is given by the sum of the normalised values:

$$f_s = \sum \overline{m}_+ + \sum \overline{m}_- + \sum \overline{m}_\mu$$

Equation 2

If, however, it needs to weight indicators individually (and if there is a rationale for such a weighting), then it simply multiplies each indicator by its weight:

$$f_w = \sum W_{j_+} \times \overline{m}_{+_{j_+}} + \sum W_{j_-} \times \overline{m}_{-_{j_-}} + \sum W_{j_\mu} \times \overline{m}_{\mu_{j_\mu}}$$

Equation 3

where the W_{j_+} is the set of weights for category 1 metrics, W_{j_-} is the set of weights for category 2, and W_{j_μ} is the set for category 3.

This will result in an overall weighted score for each city, which can be scaled to a desired output range, for example 0 – 100 which may be more easily interpretable by end users of the index.

Ranking

Each city's score can be linearly ordered to produce a rank. However, overemphasising relative 'performance' by rank should be avoided as it can mislead users by implying that there is an equal difference between ranks, differentiated only by their order, which could hide what could be a high variation in scores.

Instead, comparison of indicator values should be encouraged, and groups of them via indicator groups like perspectives and clusters. This would allow users to explore and understand the complete picture of their city with respect to the indicators and the relationships between them.

3.4 Data quality score

Data Specificity

Using the hierarchical approach to handling data gaps means it should be possible to calculate a value for every city. However, it should be able to communicate to users when scores are primarily generated from values from lower down the data quality hierarchy. This means when the index score is presented, a data quality score should be shown alongside it.

For the set of indicators M, each $m \in M$ has a data specificity score s_m where:

$$s_m = \frac{6 - v_m}{5}$$

Equation 4

… where v_m is the value from the 6-level specificity hierarchy.

Example:

For the city of Orvieto, the water sanitation indicator uses data collected in Orvieto using DivAirCity definitions:

$$s_m = \frac{6 - 1}{5} = 1$$

For the city of Potsdam, the tertiary education indicator uses country-level data using DivAirCity definitions:

$$s_m = \frac{6 - 4}{5} = 0.4$$

Data Freshness

Also, for the set of indicators M, where each $m \in M$ has a year y associated with its most recent value for that indicator. This then informs the data freshness score f_m where:

$$f_m = \frac{\max\{w - (y_{ref} - y),\ 0\}}{w}$$

Equation 5

y_{ref}: a reference year representing the most recent year it's theoretically possible to have a value for. This could be the current or previous year.

w : window size within which data is considered fresh, measured in years, with the end of the window being y_{ref}.

The score linearly grades between 0 and 1 such that recent data (at y_{ref}) scores 1 and data w years old scores 0 and data older than that also scores 0.

Example:

For an indicator on access to clean water, the most recent value available is from 2018. Its freshness score, assuming the most recent year data could be available $w = 2022$, with a window size of $w = 10$ years would be:

$$f_m = \frac{\max\{10 - (2022 - 2018), 0\}}{10} = \frac{\max\{10 - 4,0\}}{10} = \frac{6}{10} = 0.6$$

Whereas, in an example where that same indicator's most recent value was from 2010, its freshness score would be:

$$f_m = \frac{\max\{10 - (2022 - 2010), 0\}}{10} = \frac{\max\{10 - 12,0\}}{10} = \frac{0}{10} = 0$$

Combined Data Quality Score

Freshness and specificity are chosen to be equally important. Therefore the combined data quality score for an indicator m is given by:

$$q_m = \frac{s_m + f_m}{2}$$

Equation 6

Data quality score for all indicators

The overall score for all indicators, when all metrics contribute equally to the final score, is then given by:

$$Q_M = \frac{\sum q_m}{|M|}$$

Equation 7

Where $|M|$ the total number of indicators in the set M.

3.5 Overviews of existing data sources

3.5.1 Country and City data

To test our approach for generating the index, out of all cities in the world, two tranches of cities were chosen to be sequentially added to the index:

Tranche 1: (Project cities)

Table 10. First tranche of cities

City	Country	UN Geoscheme Area	National Capital	Population Estimate
Aarhus	Denmark	Northern Europe	No	285 273
Bucharest	Romania	Eastern Europe	Yes	1 877 155
Castellon	Spain	Southern Europe	No	180 005
Orvieto	Italy	Southern Europe	No	20 148
Potsdam	Germany	Western Europe	No	182 112

These cities are partners in the DivAirCity Project and therefore, there is an ongoing opportunity to work with them to find the best data available for them, in addition to their key

role in shaping the index itself. The initial data set has already been collected for these cities is referenced in the Appendix.

Tranche 2: (Wider world)

Table 11. Second tranche of cities

City	Country	UN Geoscheme Area[22]	National Capital?	Population Estimate
Alexandria	Egypt	Northern Africa	No	5 263 542
Baku	Azerbaijan	Western Asia	Yes	1 116 513
Bogotá	Colombia	South America	Yes	7 674 366
Buenos Aires	Argentina	South America	Yes	2 891 082
Gaborone	Botswana	Southern Africa	Yes	208 411
Ho Chi Minh	Vietnam	South-eastern Asia	No	8 993 082
Jakarta	Indonesia	South-eastern Asia	Yes	8 540 121
Mashhad	Iran	Western Asia	No	2 307 177
Mombasa	Kenya	Eastern Africa	No	1 208 333
Nassau	The Bahamas	Caribbean	Yes	227 940
New York	USA	Northern America	No	8 804 190
Nuku'alofa	Tonga	Polynesia	Yes	22 400
Shanghai	China	Eastern Asia	No	22 315 474

The Tranche 2 cities were chosen to validate our index approach on cities outside of the project partners. The intention is to evaluate the index on cities on multiple continents (described by UN Geoscheme Areas[23]), of a range of population sizes, and with or without the status of being a capital city. By doing so, it is possible to demonstrate the potential wider applicability of the index.

The initial set of data that has already been collected for these additional cities is also referenced in the Appendix and they are also present in the Index. The primary learning from this process has been that data availability is very inconsistent and depends heavily on the cities concerned. Some data sets from international organisations have better coverage for high-income countries (e.g., recycling), some are generally inconsistent in coverage (e.g., homelessness). At the same time, some primarily economic figures, are more consistent (e.g., female employment rates, clean cooking fuel). Some data sets are only available for larger countries (e.g., measures of safety and security weren't available for the two smallest countries in the tranche). This coverage can be seen in the Index Spreadsheet referenced in the Appendix.

This exercise highlights the large challenges in acquiring consistent data for multiple cities and how these challenges multiply when extending from a solely European to a global context.

[22] https://unstats.un.org/unsd/methodology/m49/
[23] https://unstats.un.org/unsd/methodology/m49/

However, for each city in our initial two tranches of cities, descriptive statistics were acquired for each of them, both for numerical use in the index and also for display in the tool. The primary example is the current city population. Where possible, this data was acquired from global organisations like the UN or WHO. However, these data providers usually provide country or regional data and don't often have data at big city level and very rarely for small-town level. In these cases, other providers were used, including the open data geo data platform GeoNames[24], which collates such data from a range of sources. This makes data quality more difficult to assess, but it was deemed sufficient for the purposes of this index.

3.5.2 Data gaps and Quality of data

Having established an approach for evaluating, transforming and combining KPI data sets to create a score for an individual city, the next step is acquiring all required data sets and applying the index mechanism.

This entails the following steps:

1. Searching for suitable datasets
2. Acquiring access
3. Confirming data is available for use for our purpose
4. Evaluate attributes of the data set
5. Derive appropriate transformation
6. Transform and add to the index

Where city-level data cannot be found that passes these steps, the data hierarchy found in Section "Index Method" was used to progressively move through the hierarchy from most specific to least specific.

For many of the KPIs chosen in this work package, only data at a country level was found publicly. In other cases, data for only some cities was found, but not all. In this case, for the cities which didn't have city-level data, the data for that city's country was used instead.

Likewise, in some cases, only older data was available. The freshness window parameter is set to 10 years to allow us to use more of the data found. However, that does mean that for some KPIs, the impression given will be less reflective of that city today.

These compromises in data selection are all encoded in the data quality score so that each KPI for each city has a data quality score reflecting the circumstances of the source data set's specificity and freshness.

The combination of transformed KPI data, their data quality scores, and final index scores are available in the Index spreadsheet. Please see the Appendix for further details.

3.6 Worked Example

To demonstrate how to calculate an index and quality score for an individual city, this table has a subset of KPIs and their data values for the Danish city of Aarhus:

[24] https://www.geonames.org/

Table 12. Worked example

KPI	Value (x)	Units	Transformation	Transformed Value	Year	Specificity (Equation 4)	Freshness (Equation 5)
Place GreenSpaces GreenAreaShare	57.2	The proportion of vegetation to total urban area	=x/100	0.572	2020	0.8	0.8
People Wellbeing LifeExpectancyBirth	81.55122	Years	=(x-52.777)/ (85.3878-5 2.777)	0.882352457	2020	0.2	0.8
Economic Prosperity FemaleUnemployment	192.1	Thousand women 20-64	=1-((x*1000)/ total_population)	0.576895545	2021	0.8	0.9

In this data table, the raw data values are transformed into a range between and 1. For the first data set, this is simply scaling a percentage value into a value between 0 and 1. The second, this requires min-max scaling (Equation 1) with respect to the values of the other cities in the data set. For the third, the count of unemployed women between the ages of 20 and 64 is converted into a proportion of the total population (female-only population data was not available at the city level). This population value is taken from Geonames[25].

The year when the data was captured is also shown, as well as its translation into a freshness score using Equation 5. The specificity level (see Section 3.3) is also calculated using Equation 4.

With this example subset of 3 KPIs, the overall index score using equally weighted scores is calculated:

$$f_s = \frac{0.572 + 0.882352457 + 0.576895545}{3} = 0.67708267$$

The combined data quality score using equal weighting for freshness and specificity for this set is calculated:

$$q_m = \frac{0.8 + 0.8}{2} + \frac{0.2 + 0.8}{2} + \frac{0.8 + 0.9}{2} = 0.7167$$

Interpretation: The Aarhus index score is quite high according to these three example KPIs, and the data quality score is as well, mostly due to the availability of recent data, but it is dragged down by the lack of city-specific data for the Life Expectancy at Birth KPI.

To see the full calculation for Aarhus for all computable KPIs, as well as for all Tranche 1 and Tranche 2 cities, please see the Index Spreadsheet referred to in the Appendix.

[25] https://www.geonames.org/2624652/arhus.html

4 Index Tools and Outputs

4.1 Index Tool

4.1.1 Starting the user's journey

Please see this link

(https://www.figma.com/proto/XrHhMCSEZN5OU5eNBmvBpt/DivAirCity-Clickable-Prototype-Index-Tool?node-id=0%3A1) to the clickable prototype hosted on Figma and the Appendix to find the high-resolution images for all screenshots shown in this section.

The platform has been designed with a main menu divided into 5 main items:

- **Home page**
- **Index**
- **Region**
- **Geospatial maps**
- **Login**

Figure 3. Homepage (I)

The site hosts the AccessiWay[26] plugin (see the icon on the bottom), which offers dedicated paths and cutting-edge tools to make websites, web apps and mobile applications accessible.

The home page lays out the intentions of this tool, its mission and its objectives. It explains the "Vision" of the DivAirCity project and encourages collaboration and sharing of the objectives achieved and the current state-of-the-art. Cities are called to participate and become part of this network.

[26] "AccessiWay - the Web Accessibility Solution"

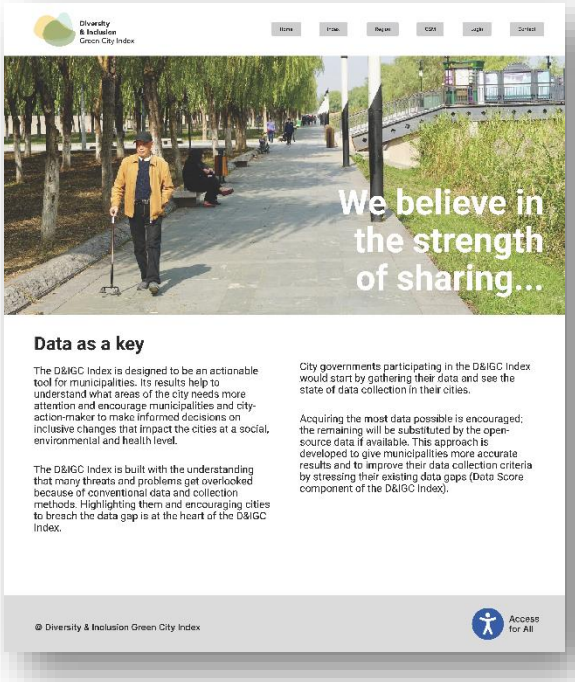

Figure 4. Homepage (II)

4.1.2 Index output

Here users can compare the index results for individual cities.

(All numbers shown in the following screenshots are placeholder values to illustrate the design and user journey. The actual index scores would be used in the finally implemented tool.)

The main screen allows users to see the "ranking" of the cities, indicated in the index and the diagram on the right shows how balanced the scores are on the index's 3 axes.

Cities ranking is scrollable to allow viewing all the cities that have participated in the index.

The meaning of the index and how it is constructed in the lower part of the web page is explained and the sources for the data used are provided. This initial data will be provided via the data platform created elsewhere in the DivAirCity project.

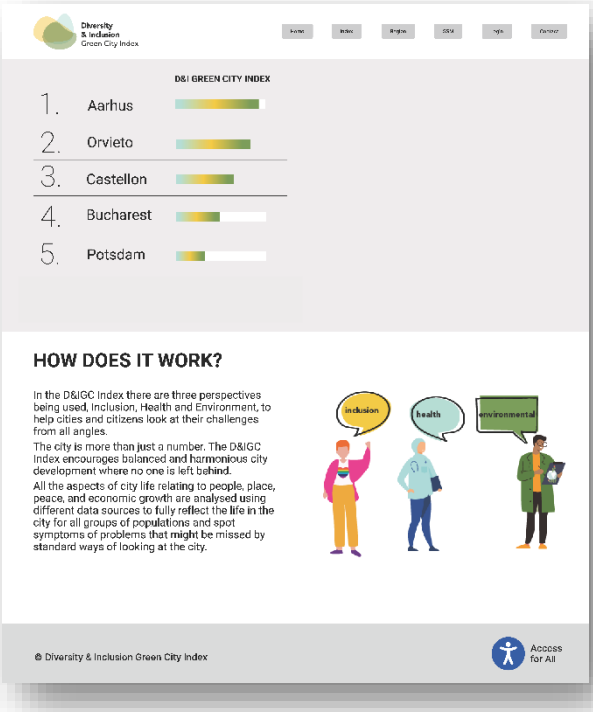

Figure 5. Index score page (I)

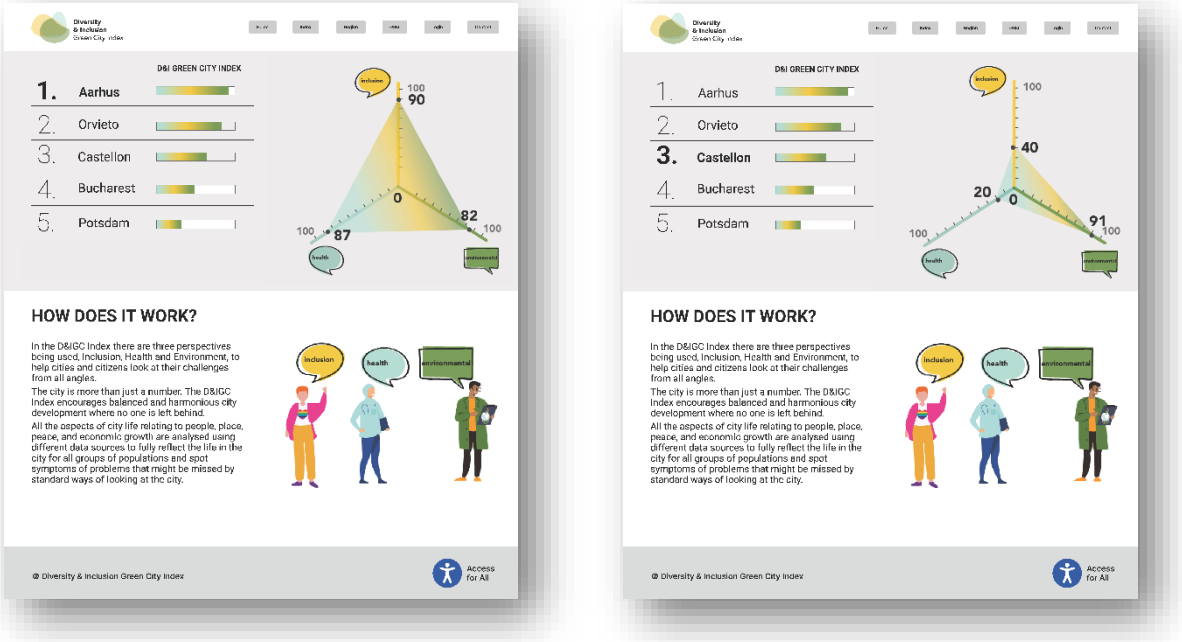

Figure 6. Index score page (II)

4.1.3 Regions and their cities

This section provides a geographic and visual narrative for each city in the index.

From the globe map it will be possible to immediately view all the cities belonging to the index identified by the score achieved.

In the lower part of the page the index is explained, how it works and the methodology with which it was designed and calculated.

All the main indicators are visualized (country by country or city by city).

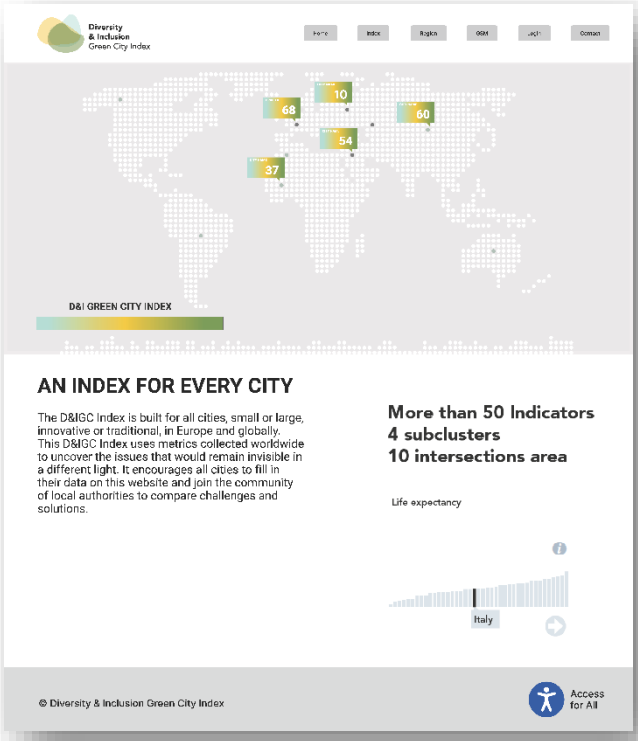

Figure 7. Regions page

4.2 Geospatial maps show casing urban interventions

This section of the tool showcases the impact assessment of projects in the 5 DivAirCity pilot cities, using measured data captured before and after the intervention, to help users understand the change that came about during the project.

The data specification and processing methods for the underlying data used in this part of the tool will be undertaken in T2.6.

Each city is represented as "exploded" in several layers: one for each aspect related to the impact assessment visualised in a manner suitable for the underlying data.

The user will be able to select the areas in which the interventions were undertaken and see how these interventions have brought changes over time (before and after buttons).

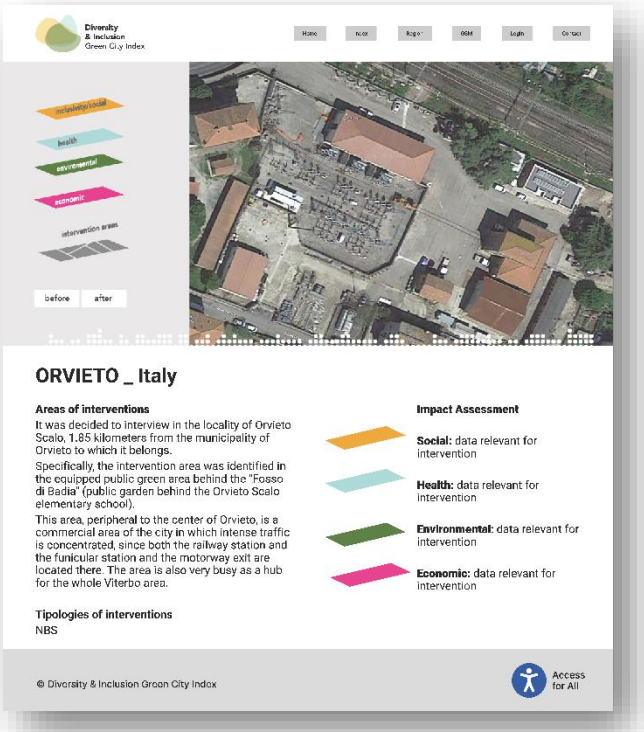

Figure 8. GSM Intervention example (I)

The lower part of the web page is dedicated to a visual case study of the activity done to support the design of future interventions elsewhere.

For each city, it will be possible to view the pre- and post-intervention (by clicking on it),

area by area (by clicking on the icon), for the 4 levels (economic, environmental, health, social).

The lower part of the web page is dedicated to a visual report both pre- and post-intervention (mainly with the aim of giving context to the graphed data and making it feel real to users).

The specific KPIs and data used in this tool section will be determined by the KPIs monitored by the intervention project.

The key for this section is that any change due to the intervention is communicated clearly and in terms that make the most sense for that specific project.

Hypothetical example intervention:

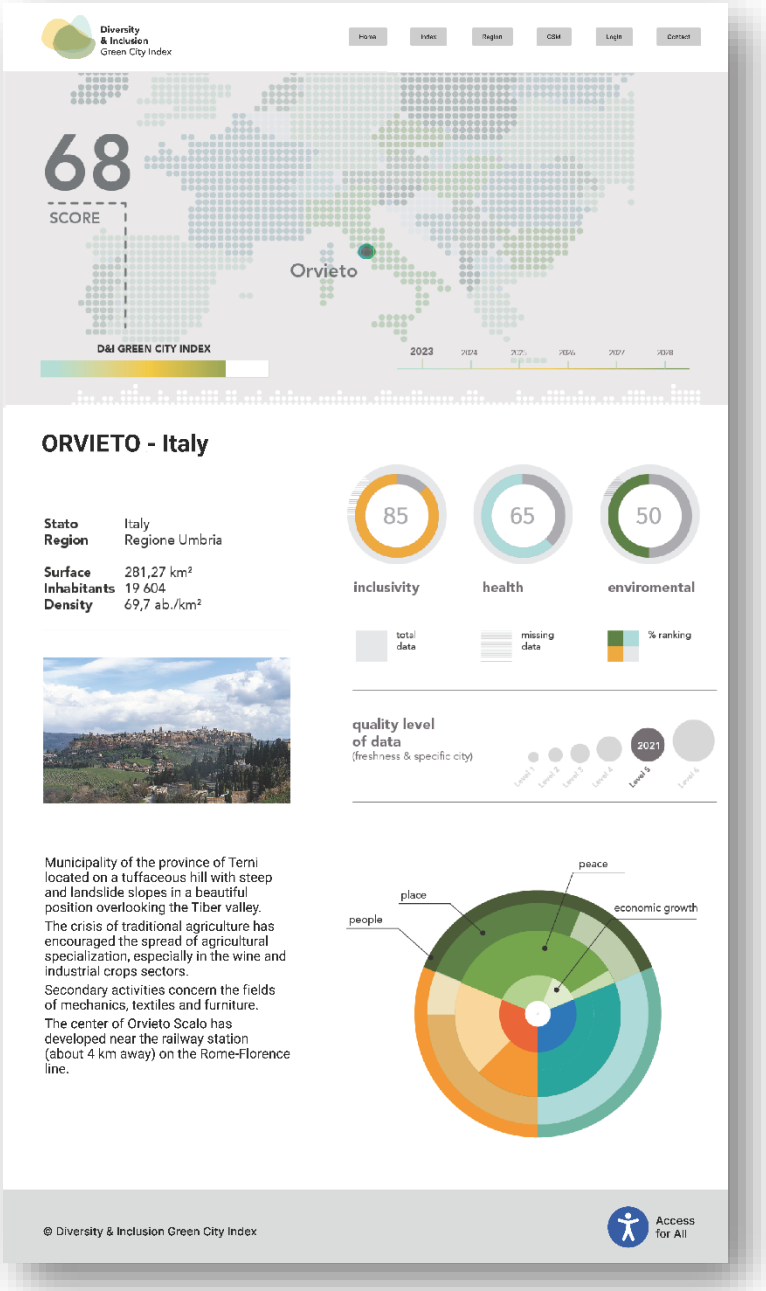

Figure 9. GSM Intervention (II)

Due to local road and space planning, there is little opportunity for vegetable growing at home in a particular neighbourhood in Orvieto that currently experiences poor food security. A proposed intervention intends to turn disused public space into community gardens for neighbourhood use.

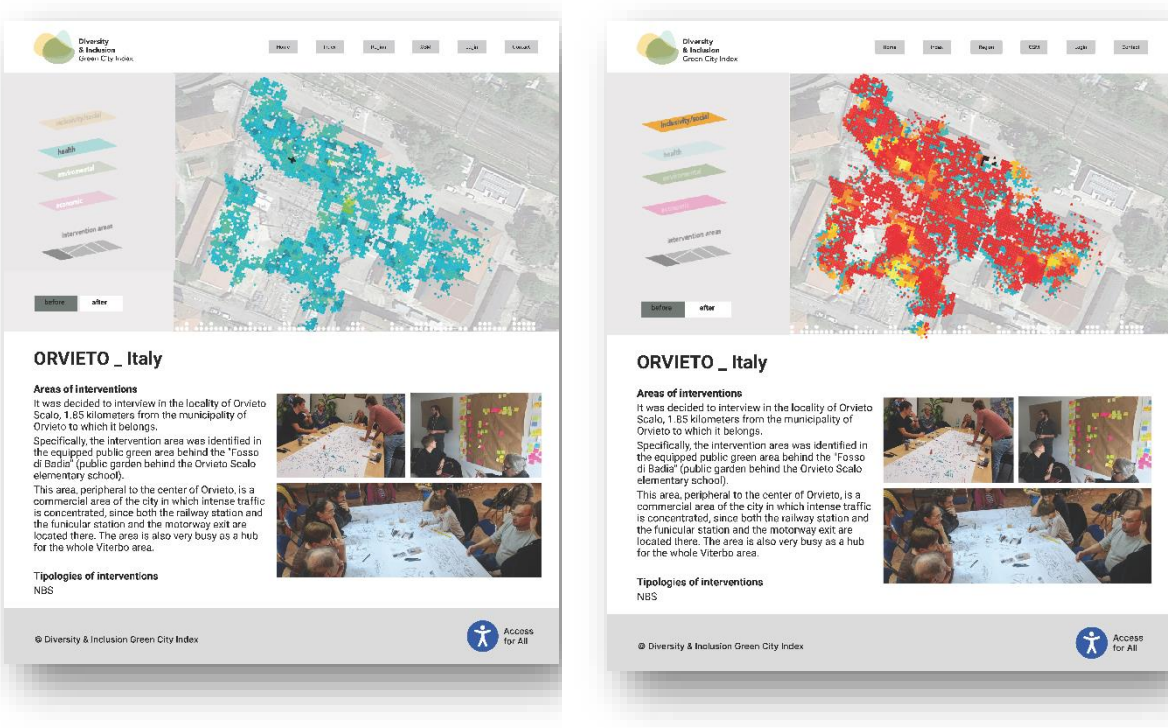

Figure 10. Example: Health layer, modelled undernourishment per dwelling, before and after

4.3 Data updating and management

An indicative proposal for a page that allows new cities that want to participate or are already part of the project to upload new or updated data.

Through a form along the lines of what is shown here, the municipality can submit missing data and information, or update data when it becomes available, improving their data quality scores.

Keeping data up to date is an essential area of functionality for the index, as it touches on the existing user journeys of data managers in city authorities, technical considerations in the backend of the online tool, and the relationship with the DivAirCity data platform.

Figure 11. Example of data form page

It will need to handle some kind of authentication and authorisation to ensure only those who are entitled to submit data are allowed to, and there will need to be a user journey designed to understand what happens to the data once it has been submitted and when and how it updates the index. These journeys could be wholly online

or a combination of online activities with offline processes supported by whoever manages the index at the time.

These questions must be addressed through user research in the Work Packages responsible for implementing the online tool.

5 Application and Impact of the D&I Green Cities Index and Geospatial Maps

This work package has designed an indexing mechanism in line with the ethos of DivAirCity and its goals, collected data for an initial version of the index, designed the journey for a user to explore and understand the content of the index as well as use geospatial maps to demonstrate change before and after urban interventions in our project cities.

The complementary roles of the index (measuring KPIs consistently across multiple cities using existing public data) and the geo-spatial maps (exploring the localised impact of an intervention) will mean users will be able to understand aspects of their city from both a general and specific, intervention-based level. This recognises the reality that there is very little, consistent, public, highly localised data for all cities in the project, let alone the wider world, that is sensitive enough to the kinds of changes an intervention might have, that would meaningfully impact the index scores. The approach taken in this work pack of separating these activities reflects this.

To translate the index calculations into a tool that end users can interact with, the work undertaken in this work package will be used as the specification and sample data set for the software design and development process elsewhere in the project.

The process should be iterative and engage end users in the development process to reduce risk and increase its ultimate value. This will require co-design, continuous user research and user testing.

Some key points remain that should be explored in that process:

- Further study into the exact needs of explicitly defined end-user groups. This will de-risk the tool development process and make it easier to communicate the value of the tool to end users.
- Exploration of how data in the tool will be maintained and expanded upon, both from a technical perspective, more importantly from a data management perspective. This will need to consider the day-to-day reality of data managers working in cities to make their involvement as seamless and as minimally burdensome as possible.
- More research into how users interpret the data quality score alongside the index score itself, to ensure that both are understood correctly.
- A blueprint to describe how insight from the index will help shape future urban interventions to make it clear and easy for end users to understand its value and how best to use it effectively.

For the index to remain relevant in future, the data used must be both:

1. kept up to date
2. expanded to include more city-specific data from around the world.

With respect to the first challenge, due to the data quality score, as time moves on, the data quality score for the same data will decrease as its freshness will decrease. This will mean that users of the tool will see quality dropping as time moves on. This is by design but does give an extra impetus to establishing an appropriate way to keep data fresh.

The people in the best position to keep data up to date are likely to be people in the city authority itself, as they are likely to have best knowledge of what data is being generated, where it is, how to acquire it and would be close enough to the DivAirCity project to know how to update the data platform. This may not always be the case, but ideally the data for each city would have a data owner of some kind who would be responsible for its upkeep.

This might require an exploration of a suitable incentive model for cities to keep their data current, to balance the required resource cost.

Similarly, regarding expanding the number of cities in the index, this is an area where clear guidance for a 'new' city will be vital, to ensure that they know exactly how to gather their city's data, transform it consistently with the existing city data and know how to import that data into the platform behind the tool. This work package document forms part of that guidance, but further work should be done to make it as accessible as possible to new data importers.

6 Appendix

Alongside this deliverable document, there are other assets that have been generated through this work package:

- **KPI Spreadsheet**
  This contains the developmental iterations of the set of indicators, including the final set (v7)
- **Data Set Collection**
  This is a location on the project could storage location that has a 'local' instance of the data sets used in the index itself. This means that the data needed is found in one place, and that allows to track the exact instance of a data set used.
- **Index Spreadsheet**
  This file has a subset of all the intended data sets included, harmonised, and the index mechanism implemented. This is where the index scores are calculated using available data.
- **Designs for Tool**
  Visual design assets that show the user journey in detail in Illustrator format. These can be used both for further user research as well as to support the tool development team.

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Core indexes used

Name	Author	Localisation	Area of Application	Intended Audience	Purpose	Number of KPIs	Frequency of Updates	Website Link	Report	Web-Tools (Maps, Visualization, Data sets)	
Social Progress Index	Social Progress Imperative	Global	Countries	General Public	Measures countries development with regards to social issues	50	Annually	https://www.socialprogress.org/	https://www.socialprogress.org/static/1aa2d19690906eb93c6cdb281e5ee68b/2020-social-progress-index-methodology.pdf	Mapping and Visualization tool	https://www.socialprogress.org/
OECD Better Life INDEX	OECD	38 OCED member countries	Countries	General Public	Measuring the well-being of societies	24	Annually	https://www.oecdbetterlifeindex.org/#/11111111151	https://www.oecdbetterlifeindex.org/media/bli/documents/ea714361-en.pdf	Visualization tool	https://www.oecdbetterlifeindex.org/#/11111111151
Gender Equality Index	European Institute for Gender Equality	27 EU memeber countries	Countries	General Public	Measuring equality between women and men	31	Annually	https://eige.europa.eu/gender-equality-index/2022/EU	https://eige.europa.eu/publications/gender-equality-index-2022-covid-19-pandemic-and-care	Visualization tool	https://eige.europa.eu/gender-equality-index/2022/EU

Name	Author	Localisation	Area of Application	Intended Audience	Purpose	Number of KPIs	Frequency of Updates	Website Link	Report	Web-Tools (Maps, Visualization, Data sets)	
Global Peace	Vision of Humanity	Global	Countries	General Public	Measure Countries Peacefulness	23	Annually	https://www.visionofhumanity.org/resources/?type=research	https://www.visionofhumanity.org/wp-content/uploads/2022/06/GPI-2022-Briefing-web.pdf	Mapping and Visualization tool	https://www.visionofhumanity.org/maps/#/
The Air Quality Life Index	Energy Policy Institute at the University of Chicago (EPIC)	Global	Countries	General Public	Measure of air particle pollution and years of life lost due to it	3+	Annually	https://aqli.epic.uchicago.edu/about/	https://aqli.epic.uchicago.edu/wp-content/uploads/2021/09/Europe-FactSheet_2022.pdf	Mapping and Visualization tool	https://aqli.epic.uchicago.edu/the-index/
Urban Health Index (UHI) for Lambeth and Southwark	Impact on Urban Health	Lambeth and Southwark (UK)	Boroughs	General Public/Decision maker	Assess the social progress of our boroughs of Lambeth and Southwark	45	Updated per-data availability	https://urbanhealth.org.uk/insights/data/urban-health-index-uhi-for-lambeth-and-southwark	https://urbanhealth.org.uk/wp-content/uploads/2021/04/Urban-Health-Index-methodology-1.pdf	Mapping and Visualization tool	https://urbanhealth.org.uk/insights/data/urban-health-index-uhi-for-lambeth-and-southwark

Name	Author	Localisation	Area of Application	Intended Audience	Purpose	Number of KPIs	Frequency of Updates	Website Link	Report	Web-Tools (Maps, Visualization, Data sets)	
The Rainbow Map and Index	ILGA-Europe	49 European countries	Countries	General Public	Review of the Human Rights Situation of Lesbian, Gay, Bisexual, Trans, and Intersex People	74	Annually	https://www.ilga-europe.org/	https://www.ilga-europe.org/report/rainbow-europe-2022/	Mapping and Visualization tool	https://www.rainbow-europe.org/