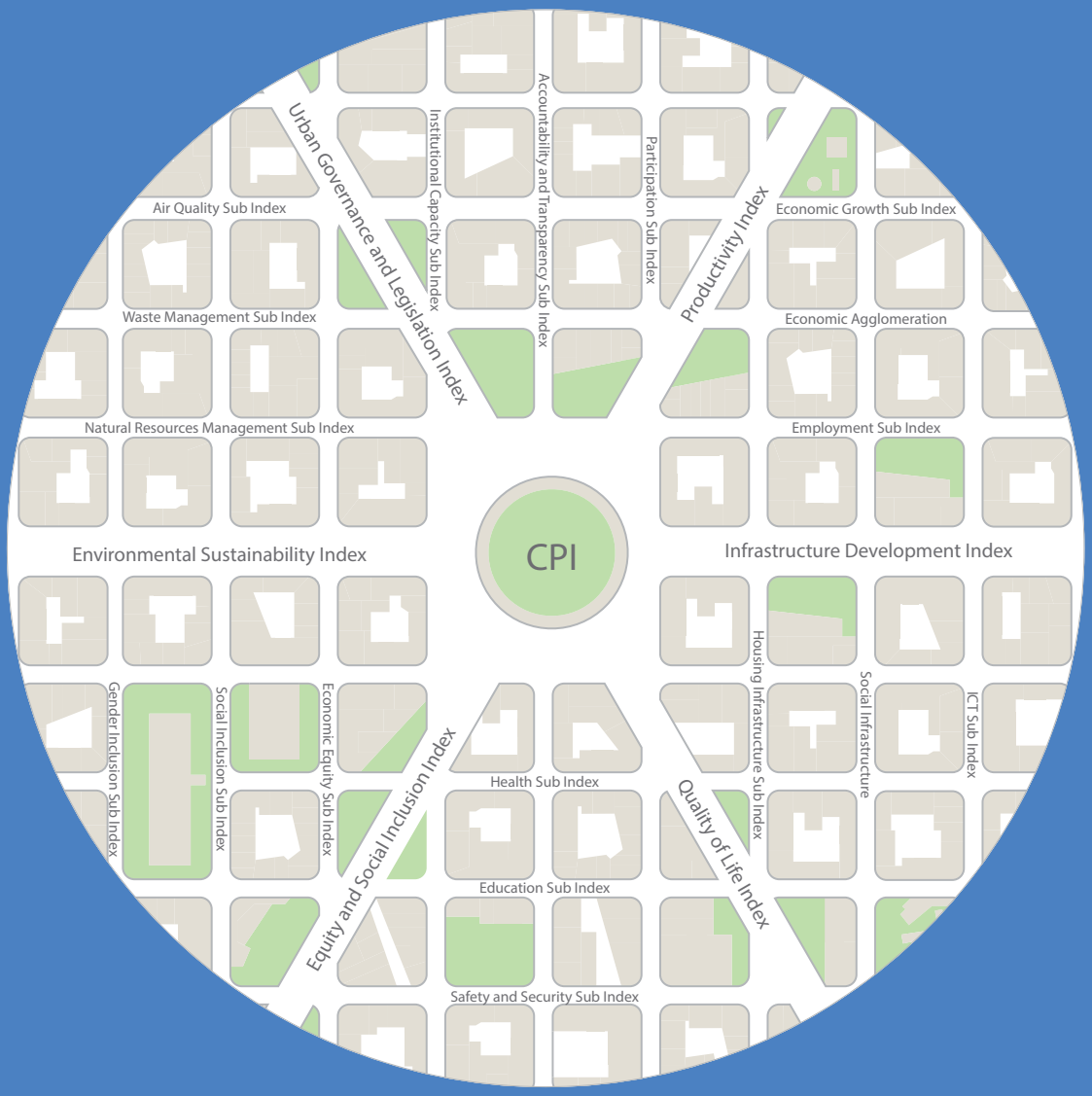
MEASUREMENT OF CITY PROSPERITY
Methodology and Metadata



UN HABITAT
FOR A BETTER URBAN FUTURE

DATA FOR SUSTAINABLE DEVELOPMENT

Cities have emerged as the focus for change and the venue where policies are realized. They have been able to forge new linkages among actors and offer innovative solutions, with the potential to be part of national agendas, and to influence regional and global development.[1] Cities have been catalysts of productivity, technology and infrastructure development, including institutional arrangements that contribute to the enhancement of equity, social inclusion and quality of life.

The outcome document of the United Nations Conference on Sustainable Development, entitled *"The future we want",* recognizes that if well planned and developed, cities can promote economically, socially and environmentally sustainable societies.[2]
However, poor planning, the absence of effective governance and legal frameworks, fragile institutions, low capacity of local authorities, and the lack of a sound monitoring mechanism, diminishes the possibility to promote long-term sustainable urban development. Evidently, there is an urgent need to put in place a global monitoring mechanism, which is adaptable to national and local levels. This would provide a general framework that allows cities, countries, and the international community to measure progress and identify possible constraints, thus pre-empting unintended development.[3]

The Report of the Sustainable Development Solutions Network that supports the Sustainable Development Goals indicates that "data and metrics are essential for development goals to be met[4]". They enable cities to make correct decisions on the best policies to adopt, and assist in tracking changes, whilst systematically documenting their performance at the outcome level. This is fundamental towards achieving higher levels of urban prosperity and sustainable urban development for all.

"Data needs improving" – stresses the report A World that Counts, prepared as part of the Data Revolution efforts of the UN system[5]. Despite considerable progresses in recent years, whole groups of people are not being counted and important aspects of people's lives and city conditions are still not measured[6]. For people, this can lead to the denial of basic rights, and for the city, the likelihood that they are not taking full advantage of the transformative potential which urbanization offers.

Too often, existing city data is not adequately detailed, documented and harmonized, or worse, it simply is not available for a whole host of critical issues relating to urban growth and development. This obviously greatly impacts the quality of decision-making. However, cities can and must do better than this.

Sao Paulo, Brazil © Giulia Lavagna

[1] UN-Habitat (2012), State of the World's Cities Report 2012: Prosperity of Cities.

[2] United Nations (2012), The Future We Want.

[3] UN-Habitat (2014), Urbanization and Sustainable Development: Towards a New Urban Agenda

[4] Sustainable Development Solutions Network (2014), Indicators and a monitoring framework for SDGs: Launching a data revolution.

[5] UN (2014) A World that Counts: Mobilizing the data revolution for sustainable development, www.undatarevolution.org

[6] Text adjusted from the same report

1. CONCEPTUALIZING PROSPERITY

In 2012, UN-Habitat created the City Prosperity Index (CPI) as a tool to measure the sustainability of cities. This tool is accompanied by a conceptual matrix, the Wheel of Urban Prosperity.
The City Prosperity Index was developed after UN-Habitat conducted surveys in 54 cities from the developing world, to conceptualize prosperity and identify its most critical components. Experts from, Asia, Africa, Arab countries and Latin America agreed that a prosperous city integrates 6 critical dimensions:

1) productivity;
2) infrastructure development;
3) quality of life;
4) equity and social inclusion;
5) environmental sustainability and;
6) governance and legislation.

Accordingly, it was unanimously agreed that prosperity implies success, wealth, thriving conditions, well-being as well as confidence in the future and opportunities for all. Further, prosperous cities offer a profusion of public goods, allowing for equitable access to 'commons' and the development of sustainable policies.

1.1 Dimensions of Prosperity

These components became the six dimensions of the City Prosperity Index which are conceptualized as follows:

- **Productivity** – a prosperous city contributes to economic growth and development, generating income, employment and equal opportunities that further provide adequate living standards for the entire population.
- **Infrastructure development** – a prosperous city deploys the infrastructure, physical assets and amenities – adequate water, sanitation, power supply, road network, information and communications technology, etc. – required to sustain both the population and the economy, and provide better quality of life.
- **Quality of life** – prosperous cities provide amenities such as social services, education, health, recreation, safety and security required for improved living standards, enabling the population to maximize individual potential and to lead fulfilling lives.
- **Equity and inclusion** – a city is only prosperous to the extent that poverty and inequalities are minimal. No city can claim to be prosperous when large segments of the population live in abject poverty and deprivation. This involves reducing the incidence of slums and new forms of poverty and marginalization.
- **Environmental sustainability** – the growth of cities and their economic development do not destroy or degrade the environment; instead, the city's natural assets are preserved for the sake of sustainable urbanization.
- **Governance and legislation** – Cities are best able to combine sustainability and shared prosperity through effective urban governance and transformational leadership, deploying appropriate and effective policies, laws and regulations, and creating adequate institutional frameworks with strong local institutions and sound institutional arrangements.

1.2. A tool to measure sustainable urban development: the City Prosperity Initiative

In 2013, UN-Habitat received numerous requests from local authorities and central governments to estimate their respective prosperity indexes. Mayors and other decision-makers wanted to know how their cities feature in comparison with other cities. This included knowledge on how to improve ratings and measurements of cities towards the prosperity path, including gaining critical insights in to which programmes and policies work, and the possible impacts these actions may have.

As a result of these demands, UN-Habitat transformed the City Prosperity Index into a global initiative known as the City Prosperity Initiative. This initiative is both a metric and a policy dialogue, which offers cities from developed and developing countries the possibility to create indicators and baseline information, often for the first time. It also serves to define targets and goals that can support the formulation of evidence-based policies, including the definition of city-visions and long-term plans that are both ambitious, and measurable.

UN-Habitat's City Prosperity Initiative not only provides indices and measurements relevant to cities; it also enables city authorities, as well as local and national stakeholders, to identify opportunities and potential areas of intervention for their cities to become more prosperous. Growing and ever more complex cities and their inhabitants no longer have the option of making decisions without the benefit of international validated data and indices. This kind of informed decision-making is a prerequisite to deciding:

- Which policies to implement?
- Where to allocate public and private resources?

- How to identify setbacks and opportunities?
- How to measure what has changed?

In short, we live in a world that requires choosing the best and most sustainable options. The CPI can play a vital role in this process.

1.3 The Wheel of Urban Prosperity and the CPI

The CPI is based on the fundamental principles of human rights. It considers that urbanization, as a process, should adhere to human rights principles, while the city, as an outcome, should meet specific human rights standards that need to be measured. In this sense, access to adequate housing, water and sanitation or any other civic, cultural, economic, political and social right that are codified in many of the human rights treaties, are integral parts of the CPI indicators and metrics.
UN-Habitat's notion of urban prosperity and sustainability considers that all dimensions of city growth and development are subsumed under the six categories identified in Section 1. Likewise, these 6 dimensions metaphorically represent six different 'spokes' of the Wheel of Prosperity.

Since shared, balanced development is a crucial feature of prosperity; none of the dimensions should prevail over others, and all must be kept roughly 'equal' – for the sake of a smooth 'ride' on the path of prosperity. In practice, of course, it is rare to find a city where the six dimensions will be equal at any point in time. This is where policy interventions will be called for, as suggested graphically by the conceptual matrix of the Wheel of Urban Prosperity.

'Urban Power functions' such as urban planning, local mechanisms of regulation and control, including civil society interventions ensure that no particular dimension of prosperity gains prevalence to the detriment of the others.

Cities with low levels of prosperity feature contrasted patterns among the dimensions of prosperity. For some, the dispersion of index values across the 'spokes' reflects institutional and structural problems. For others, the six dimensions of prosperity do not converge at all, a characteristic of dysfunctional systems, institutional failures, sluggish economic growth, as well as widespread poverty and destitution.

1.4 The Wheel of City Prosperity

The 'outer rim' of the wheel - absorbs the cumulative forces transmitted through the 'spokes' – the six dimensions of prosperity. It provides direction and guides the city towards a more prosperous path. The 'outer rim' represents the local authorities' capacity to steer growth, changing the direction and the 'pace' in pursuit of sustainable urban development.

The 'spokes' of the wheel - are the six dimensions of prosperity. Often, they interact and influence each other through various, quasi-automatic linkages along the periphery or 'outer rim'. For example, as a city develops infrastructure, it will also enhance economic expansion and the quality of life. Likewise, when a city pursues pro-poor policies and equitable development, these improve productivity and environmental protection. Interactions and inter-influences between the 'spokes' can also occur at the center of the wheel, where they are more policy-determined.

The 'hub' of the wheel - brings together the urban power functions (e.g., public authorities, urban planning, civil society participation, the private sector, special local agencies of development, etc.) associated with local urban development. Accordingly, the 'hub' represents human action in all its embodiments, holding the six 'spokes' together and trying to maintain their balance and symmetry, with four interrelated roles: (i) ensuring the prevalence of public over any other kind of interest; (ii) controlling the direction, pace and momentum of the 'wheel'; (iii) ensuring balanced development of the six 'spokes' and associated synergies; and (iv) in a two-way relationship, absorbing and amortizing any 'shocks' transmitted by the 'spokes'.

1.5 The City Prosperity Index: What is different in the CPI Framework

Most indexes have been designed for national governments using country aggregates, many of which are sectoral in nature, focusing on particular dimensions of development (environment, competitiveness, governance, corruption, etc.). The CPI offers a unique and holistic view of sustainable urban development, articulating the different dimensions of city growth, in four unique ways:

1. A flexible monitoring framework. The CPI takes into account the contextual needs and particularities of cities. Although it promotes a new urbanization model that is universal (cities that are compact, resilient, socially diverse, energy efficient and economically sustainable), it recognizes the need to be adaptable to different city and country circumstances, according to diverse urbanization challenges and opportunities.

2. A framework that promotes integration. The CPI promotes integration in the implementation of a more sustainable urbanization model, in order to address the environmental, social and economic objectives of sustainability. This integration looks at the mutually reinforcing aspects of the different components of the urbanization process.
3. An innovative tool based on spatial analysis. The CPI structure provides a wealth of new analytical tools based on spatial indicators. New indicators such as urban form, public space, agglomeration economies provide clear spatial distributions that help increase value judgment and support decision making.
4. A multi-scale decision making tool. The CPI's objective is to support decision making for multi-scale levels of government ranging from national urban policies to regional and metropolitan strategies; and city-wide interventions to sub-city districts or neighborhoods. The CPI gives decision-makers the ability to make adequate and evidence-based decisions from a territorial perspective, thus articulating different tiers of government and sectoral interventions in urban areas.

1.6 An incremental approach to urban prosperity

As part of a flexible approach that intentionally leaves room for cities to respond to contextual needs, the CPI has a double function. Firstly, it serves as a platform for global comparability in which cities can assess their situation, and compare their rate and present performance with other cities worldwide. Secondly, it acts as a strategic policy tool where the data and information is adapted to local or contextual needs, and used to measure progress and identify deficiencies in the different dimensions of prosperity.

Consequently, the CPI is constructed incrementally favouring, at the basic level, the regional or global comparison and at the advanced level providing the possibility to integrate contextual aspects of cities. This incremental approach includes the potential to understand and measure cities comparative advantages, as well as policies and actions which the CPI is intended to assess. Thus, the CPI is measured according to three scenarios as depicted in the following graph:

• The Basic City Prosperity Index. This index is useful for cities that want to compare their level of development and overall performance with regards to prosperity ratings, with other cities in the regional and global arena. The Basic City Prosperity Index uses a set of commonly available indicators that exist amongst all cities, acting as a platform for regional/global benchmarking and for comparison purposes.

• The Extended City Prosperity Index. This index is a more advanced version of the basic model. Its main function is the integration of more indicators that are not commonly available in all cities: hence comparability is not its primary objective. The availability of local information and the particular characteristics of the city determine the profusion of the indicators to use. Most of the indicators are strictly urban in nature and various have a spatial component, such as the use of public space, the economic agglomeration index and the urban form index. The Extended Index allows for a more detailed political and technical dialogue that is essential for the development of more informed public policies. This version of the index allows to document performance of the cities at the outcome level.

• The Contextual City Prosperity Index. This index is an enhancement of the extended CPI model and represents the most advanced and matured stage of the process. In addition to the basic and extended indicators, a certain number of variables are integrated, including indicators that are derived from the policies and actions recently or currently implemented in the city. From this perspective, The Contextual Index plays a role as a performance measurement. Its primary functions is to monitor local initiatives and projects that are needed to implement the city's vision in order to achieve shared prosperity and sustainable development.

2. COMPUTATION OF THE CITY PROSPERITY INDEX

The CPI is constituted by six dimensions. Each dimension is integrated by a series of sub-indices or sub-dimensions, which in turn include numerous indicators that allow for the calculation of the specific index. In this sense, the CPI produces six sub-indices related to the six 'spokes' of prosperity: productivity, infrastructure, quality of life, equity and inclusion, environmental sustainability and governance and legislation. The aggregation of these six sub-indices generates a consolidated value that represents the CPI.

As indicated, the CPI can be produced in its basic, expanded or contextual version. Taking into account the characteristics of the CPI previously described, the computation of the index is done through the following tasks:

a) Variable standardization
b) The construction of a weighting scheme
c) Aggregation of the composite index

2.1 CPI: Dimensions, sub-dimensions and Indicators

The following tables present the overall integration of the CPI with its dimensions and sub-indices and indicators at the Basic and Extended levels.

Productivity Index (P)	1. Economic Strength Sub Index (ES)
	2. Economic Agglomeration (EA)
	3. Employment Sub Index (E)
Infrastructure Index (ID)	1. Housing Infrastructure Sub Index (HI)
	2. Social Infrastructure (SI)
	3. ICT Sub Index (ICT)
	4. Urban Mobility Sub Index (UM)
	5. Urban Form Sub Index (UF)
Quality of Life Index (QOL)	1. Health Sub Index (H)
	2. Education Sub Index (E)
	3. Safety and Security Sub Index (SS)
	4. Public Space (PS)
Equity and Social Inclusion Index (ESI)	1. Economic Equity Sub Index (EE)
	2. Social Inclusion Sub Index (SI)
	3. Gender Inclusion Sub Index (GI)
	4. Urban Diversity Sub Index (UD)
Environmental Sustainability Index (ES)	1. Air Quality Sub Index (AQ)
	2. Waste Management Sub Index (WM)
	3. Sustainable Energy Sub Index (WE)
Governance and Legislation Index (UGL)	1. Participation Sub Index (P)
	3. Municipal Finance and Institutional Capacity (MFIC)
	4.Governance of Urbanization (GU)

CITY PROSPERITY INITIATIVE INDEX INDICATORS		
DIMENSION	SUB-DIMENSION	INDICATOR
PRODUCTIVITY (P)	1. Economic Strenght (EG)	1.1 City Product per capita
		1.2 Old Age Dependency Ratio
		1.3 Mean Household Income
	2. Economic Agglomeration (EA)	2.1 Economic Density
		2.2 Economic Specialization
	3. Employment (E)	3.1 Unemployment Rate
		3.2 Employment to Population Ratio
		3.3 Informal Employment
INFRASTRUCTURE DEVELOPMENT (ID)	1. Housing Infrastructure (HI)	1.1 Improved Shelter
		1.2 Access to Improved Water
		1.3 Access to Improved Sanitation
		1.4 Access to Electricity
		1.5 Sufficient Living Area
		1.6 Population Density
	2. Social Infrastructure (SI)	2.1 Physiscian Density
		2.2 Number of Public Libraries
	3. Information and Communication Technology (ICT)	3.1 Internet Access
		3.2 Home Computer Access
		3.3 Average Broadband Speed
	4. Urban Mobility (UM)	4.1 Use of Public Transport
		4.2 Average Daily Travel Time
		4.3 Length of Mass Transport Network
		4.4 Traffic Fatalities
		4.5 Affrodbaility of Transport
	5. Urban Form (UF)	5.1 Street Intersection Density
		5.2 Street Density
		5.3 Land Allocated to Streets
QUALITY OF LIFE (QOL)	1. Health (H)	1.1 Life Expectancy at Birth
		1.2 Under-Five Mortality Rate
		1.3 Vaccination Coverage
		1.4 Maternal Mortality
	2. Education (E)	2.1 Literacy Rate
		2.2 Mean years of Schooling
		2.3 Early Childhood Education
		2.4 Net enrollment rate in higher education
	3. Safety and Security (SS)	3.1 Homicide rate
		3.2 Theft rate
	4. Public Space (PS)	4.1 Accessibility to Open Public Areas
		4.2 Green Area per Capita

EQUITY AND SOCIAL INCLUSION (ESI)	1. Economic Equity (EE)	1.1 Gini Coefficient
		1.2 Poverty Rate
	2. Social Inclusion (SI)	2.1 Slums Households
		2.2 Youth Unemployment
	3. Gender Inclusion (GI)	3.1 Equitable Secondary School Enrollment
		3.2 Women in Local Government
		3.3 Women in Local Work Force
	4. Urban Diversity (UD)	4.1 Land Use Mix
ENVIRONMENTAL SUSTAINABILITY (ES)	1. Air Quality (AQ)	1.1 Number of monitoring stations
		1.2 PM2.5 Concentration
		1.3 CO2 Emissions
	2. Waste Managment (WM)	2.1 Solid Waste Collection
		2.2 Waste Water Treatment
		2.3 Solid Waste Recycling Share
	3. Suitable Energy (SE)	3.1 Share of Renewable Energy
URBAN GOVERNANCE AND LEGISLATION (UGL)	1. Partecipation (P)	1.1 Voter Turnout
		1.2 Access to Public Information
		1.3 Civic Partecipation
	2. Municipal Financing and Institutional Capacity (MFIC)	2.1 Own Revenue Collection
		2.2 Days to Start a Business
		2.3 Subnational Debt
		2.4 Local Expenditure Efficiency
	3. Governance of Urbanization (GU)	3.1 Land Use Efficiency

Table 1 City Prosperity Index Indicators

3. VARIABLE STANDARDIZATION

Variable standardization transforms a variable from its original measurement unit into a dimensionless measure that ranges between 0 and 100. From this transformation, a broad and varied range of variables (measures that are originally formed in different units and scales) can be included in the CPI index. Standardization also accounts for the fact that there is a direct relationship between the variable and the CPI. Hence, a larger variable value will correspond with an increase in the index and better prosperity.

The section below presents different approaches to standardization. Each variable within the CPI is treated using just one form of standardization. For each standardization approach, an example is given to provide clarity. Figure 4 below presents a flowchart of the process for determining the appropriate variable standardization approach.

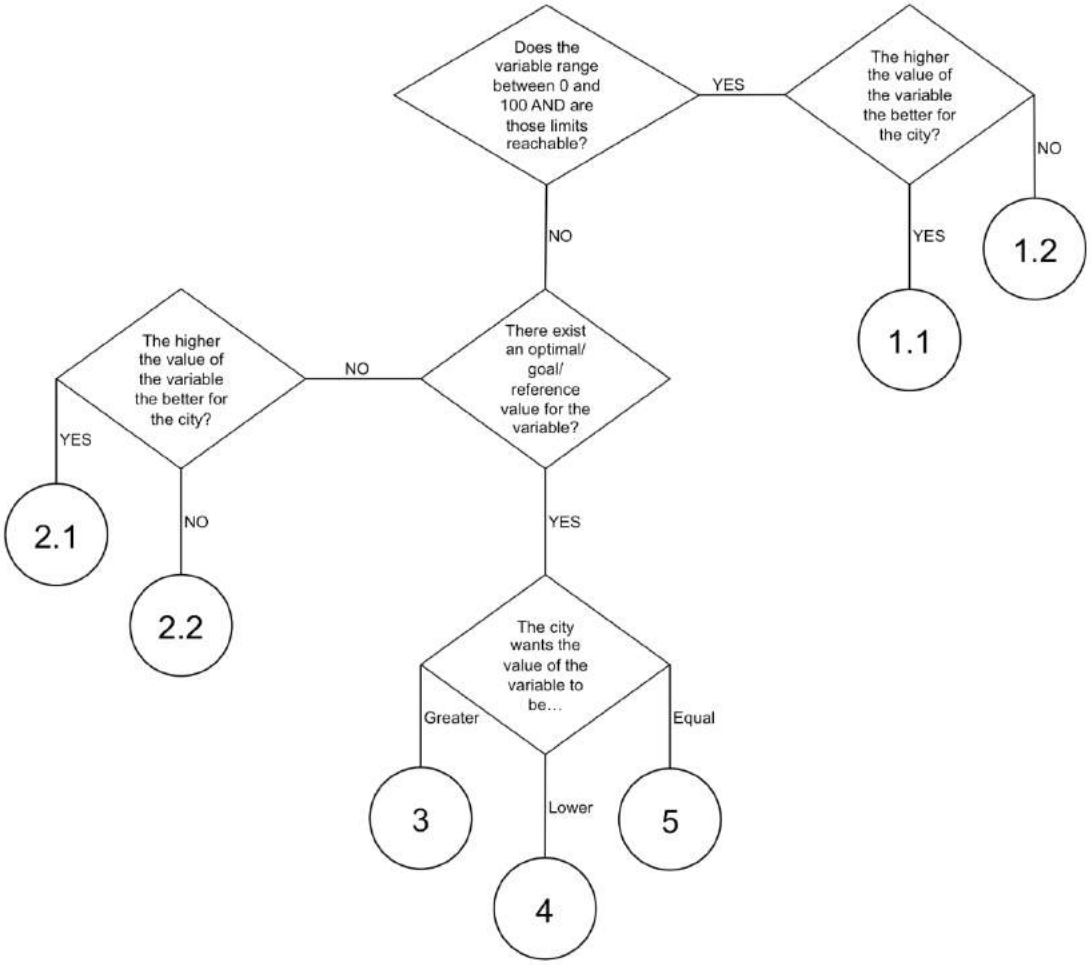


Figure 1 Variable standardization decision-making process

3.1. Standardization: Not required (1.1)

Variable X does not need to be standardized when it meets the following requirements:

- It is bounded between 0 and 100
- Both values can feasibly be reached. This condition is important, as there are variables that, despite being bounded between 0 and 100, are unlikely to reach these extreme values (e.g., the percentage variable of Renewable Energy Consumption is bounded between 0 and 100 and can easily reach the zero value, but it cannot as easily reach a value of 100). In such cases, the alternative standardization approach described below must be applied.
- There is a direct relationship between the variable and the CPI.

When these requirements are met, the following equation is used:

$$X^{(S)} = X$$

Example: The Infrastructure Development dimension includes the Housing Infrastructure sub-dimension. One variable that belongs to this sub-dimension is Access to Electricity, which is measured as the percentage of homes in a city that are connected to this public service. A higher service coverage percentage is thus expected to correlate with greater city prosperity. Furthermore, cities can have no electricity coverage or complete electricity coverage. Therefore, this variable is directly added to the index without undergoing any transformation.

3.2. Simple Reversion (1.2)

This standardization approach differs from that presented in section 1.1, as variable X is inversely related to the CPI. In these cases, the variable must be inversed to guarantee the direct relationship condition between the variable and the CPI. This inversion has the following form:

X is the observed value of the variable and $X^{(S)}$ is its standardized value. Then

$$X^{(S)} = 100 - X$$

Example: The Social Equality and Inclusion dimension includes the Economic Equality sub-dimension. One variable within this sub-dimension is the Poverty Rate, which is measured as a percentage. Although the variable varies between 0 and 100, it has an inverse relationship with the CPI because an increase in the Poverty Rate will generate lower prosperity levels in the city. Thus, to ensure that the direct relationship condition is achieved, the variable is introduced into the CPI as $X^{(S)} = 100 - Poverty\_Rate$;

thus, a higher $X^{(S)}$ value correlates with a higher CPI.

3.3. Direct classic standardization (2.1)

Variable X requires direct classic standardization when there is evidence that its measurements move, with high probability, within a determined range and that there is a direct relationship between the variable and the CPI. In these cases, the following standardization approach is used:

Let X be the observed value of the variable and let $X^{(S)}$ be its standardized value. Then:

$$X^{(S)} = 100\frac{X - Min(X)}{Max(X) - Min(X)}$$

Where, $Max(X)$ and $Min(X)$ are the maximum and minimum values observed for X, respectively.

If a city has an X value that is greater than $Max(X)$, the value assigned via standardization will be 100. If a city has an X value lower than $Min(X)$, the value assigned via standardization will be 0.

Requirements: X , $Max(X)$ and $Min(X)$. In some cases, maximum and minimum values are calculated based on the transformed variable using ln(x) or X(1/k) operators to guarantee more symmetrical distributions and superior outlier identification.

Example: The Quality of Life contains dimension includes the Health sub-dimension. One variable of this sub-dimension is Life Expectancy at Birth, which is measured in years. According to the World Bank (2014), in 2012, Life Expectancy at Birth varied from 45.33 years (Sierra Leone) to 83.48 years (Hong Kong SAR). Thus, a city with a Life Expectancy at Birth value of 77.08 years will have the following standardized value:

$$X^{(S)} = 100\frac{77.08\,years - 45.33\,years}{83.48\,years - 45.33\,years} = 83.22$$

Please note that this operation eliminates the measurement units of the variable and that the value obtained ranges between 0 and 100.

2.4. Reversed classic standardization (2.2)

This standardization approach differs from the approach described in section 2.1 in that variable X is inversely related to CPI. In these cases, the following standardization technique is used:

Let X be the observed value of the variable and let $X^{(S)}$ be its standardized value. Then

$$X^{(S)} = 100\left(1 - \frac{X - Min(X)}{Max(X) - Min(X)}\right)$$

where $Max(X)$ and $Min(X)$ are the minimum and maximum observed values of X , respectively. If a city has a value of X that is greater than $Max(X)$, the value assigned via standardization will be 100. If a city has a value of X that is less than $Min(X)$, then the value assigned via standardization will be zero.

Requirements: X , $Max(X)$ and $Min(X)$. In some cases, maximum and minimum values are calculated based on the transformed variable using ln(x) or X(1/k) operators to guarantee more symmetrical distributions and superior outlier identification.

Example: The Environmental Sustainability dimension includes the Air Quality sub-dimension. One variable within this sub-dimension is CO2 Emissions, which is measured in CO2 metric tonnes per capita. According to the World Bank (2014), the average minimum and maximum values for this variable from 2008 to 2010 were 0.01 and 44.20 metric tonnes, respectively. Thus, a city with 1.44 metric tonnes of emissions will have the following standardized value:

$$X^{(S)} = 100\left(1 - \frac{1.44\text{ metric tonnes} - 0.01\text{ metric tonnes}}{44.20\text{ metric tonnes} - 0.01\text{ metric tonnes}}\right) = 96.76$$

Please note that this operation eliminates variable measurement units and that the value obtained ranges between 0 and 100.

2.5. Standardization with minimum objective (3)

Some variables include a minimum objective value X^* that relates to a CPI proposed by a specific international organization, according to which the city is considered prosperous. In these cases, the “Standardization with minimum objective” technique is applied using the following approach:

If the value of X does not reach the objective value, X^* , its standardized value will be less than 100, and it will decrease to the extent to which X moves to the left of X^*. Values of X that are less than 0 will have a standardized value of 0. If X reaches or exceeds the objective value, the standardized value of X will be 100. The following standardization approach is proposed:

$$X^{(S)} = \begin{cases} 0 & if \quad X < 0 \\ 100\left(1 - \left|\frac{X - X*}{X*}\right|\right) & if \quad 0 \le X < X^* \\ 100 & if \quad X \ge X^* \end{cases}$$

For X values varying between 0 and X^*, the marginal effect is constant and equals $1/X^*$.

Requirements: X, X^*

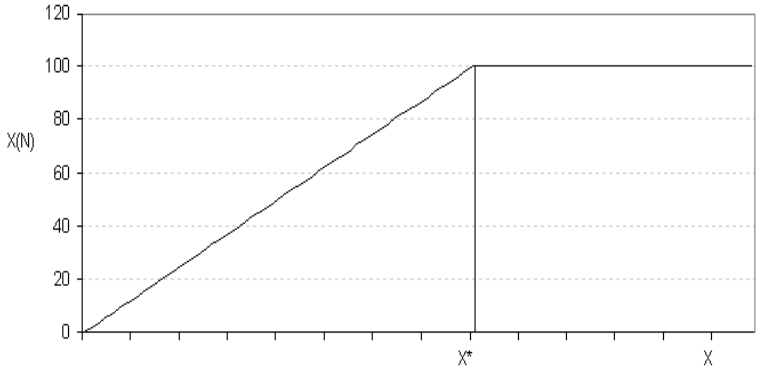


Figure 2 Standardization with minimum objective

Example: The Infrastructure Development dimension includes the Urban form sub-dimension. One variable within this sub-dimension is the Intersection Density of the city, which is measured as the number of road intersections per square kilometer. According to UN-Habitat (2013), an objective value of X^* =100 intersections/km2 is recommended for a city. If a city includes X =50 intersections/km2, its standardized value will be

$$X^{(S)} = 100\left(1 - \left|\frac{50\,\text{int}/\,km^2 - 100\,\text{int}/\,km^2}{100\,\text{int}/\,km^2}\right|\right) = 50.00$$

Please note that this operation eliminates variable measurement units and that the value obtained ranges between 0 and 100.

2.6. Standardization with maximum objective (4)

Some variables that form the index include a maximum objective value, X* that is considered a city prosperity benchmark according to an international organization. In these cases, the "Standardization with maximum objective" procedure is applied using the following approach:

If the value of X exceeds the objective value, X^*, then its standardized value will be less than 100, and it will decrease to the extent to which X moves to the right of X^*. Values of X that are greater than $2X^*$ will have a standardized value of 0. If X is lower than or equal to the objective, then the standardized value of X will be 100. The following standardization approach is proposed:

$$X^{(S)} = \begin{cases} 0 & if \quad X \geq 2X^* \\ 100\left(1 - \left|\frac{X - X*}{X*}\right|\right) & if \quad X^* < X < 2X^* \\ 100 & if \quad X \leq X^* \end{cases}$$

For values of X between X^* and $2X^*$, the marginal effect is constant and equal to $-1/X^*$.

Requirements: X, X^*.

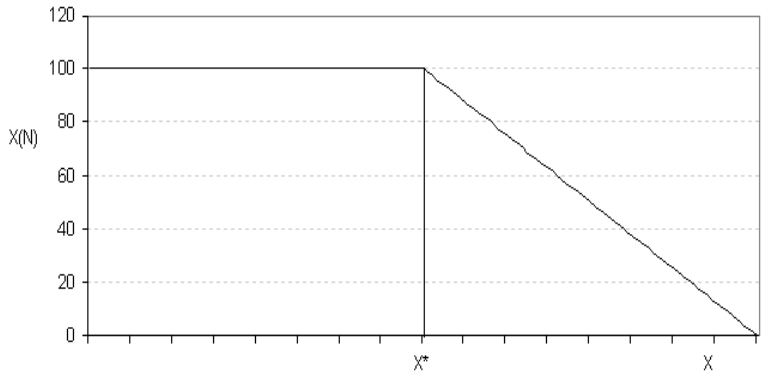


Figure 3 Maximum objective standardization

Example: The Environmental Sustainability includes the Air Quality sub-dimension. One variable of this sub-dimension is PM2.5 Concentration, which is measured in micrograms per cubic meter ($\mu g / m^3$). The World Health Organization (2011) has established a recommended objective value of no more than X^* = 10 $\mu g / m^3$ to reduce the negative health impacts. If a city reports X = 15.63 $\mu g / m^3$, the normalized value of this variable will be as follows:

$$X^{(S)} = 100\left(1 - \left|\frac{54.63\ \mu g / m^3 - \ 40\ \mu g / m^3}{40\ \mu g / m^3}\right|\right) = 63.43$$

Please note that his operation eliminates variable measurement units and that the value obtained ranges between 0 and 100.

2.7. Standardization with single objective (5)

For this class of variables, a unique objective value is proposed by an international organization according to which the city is considered prosperous. If the value of X differs from the objective value, X^*, its standardized value will be lower than 100, and it will decrease as X moves away from X^*. If X achieves the objective value, the standardized value of X will be 100. The following standardization approach is proposed:

$$X^{(s)} = \begin{cases} 0, & \text{if } X \leq \text{ or } X \geq 2X^* \\ 100\left(1 - \left|\frac{X - X^*}{X^*}\right|\right) & \text{if } 0 < X < 2X^* \\ 100 & \text{if } X = X^* \end{cases}$$

For values of X ranging between 0 and X^*, the marginal effect in growth will be constant and equal to $1/X^*$, and for values of X ranging between X^* and $2X^*$, the marginal effect will be $-1/X^*$.

Requirements: X, X^*.

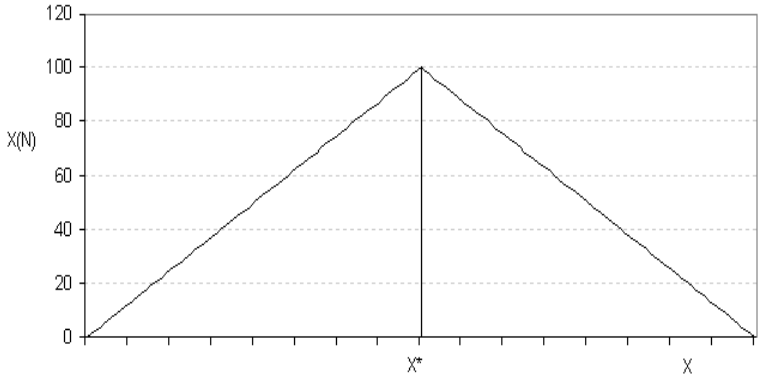


Figure 4 Single Objective Standardization

Example: The Social Equality and Inclusion dimension includes the Gender Inclusion sub-dimension. The Women in Local Government variable is included in this sub-dimension. This variable is measured as a percentage with an objective value of X^* = 50% (Mossuz-Lavau, 2005). If this variable is X = 31.32% for a specific city, then the previous procedure will generate the following standardized value:

$$X^{(S)} = 100\left(1 - \left|\frac{31.32\% - 50\%}{50\%}\right|\right) = 62.64$$

Please note that this operation eliminates variable measurement units and that the value obtained ranges between 0 and 100.

The standardization approaches described present the following advantages and disadvantages:

Advantages: Ease of interpretation, simplicity and little information required for calculations.
Disadvantages: As the variables included in the index definition are non-negative, the lower boundary of 0 included in the minimum objective and single objective standardization approaches seem appropriate for the purposes of variable standardization.
However, the upper boundary of $2X^*$ may be modified if necessary to enable a decline to zero at a slower rate.

4. WEIGHTING SCHEME CONSTRUCTION

As mentioned above, the CPI (basic and extended) is defined based on six dimensions. Each dimension is defined from a collection of sub-dimensions, and each of these typically includes a distinct number of variables. Once the variables have been standardized, using the procedures demonstrated in the prior section, index construction involves defining a methodology that allows adding information from these variables to a new variable. This new variable will form an index for comparing prosperity levels between cities. We thus now describe a nested weighting scheme through which index dimension, sub-dimension and variable weights are established.

1. The weighting scheme

Existing research literature discusses various methodologies for obtaining weighting schemes (see OECD, 2008). The weighting scheme designed for the CPI follows the recommendations of Alkire and Foster (2011a,b), who presented a weighting scheme for the multidimensional poverty index. In generalizing their recommendations, the following weighting scheme is utilized:

a) Dimensions have equal weight in the index
b) Sub-dimensions have equal weight within dimensions
c) Variables have equal weight within sub-dimensions

This weighting scheme clearly reveals an assumption that all chosen dimensions are equally effectual in determining city prosperity. This assumption similarly applies to the sub-dimensions of each dimension and to the variables within each sub-dimension. There are substantive and technical reasons that justify equal weights:

- The substantive reason is in the roots of the CPI. Prosperity is all about the equilibrium between the dimensions that constitute the index. They are like the spokes of a wheel; all have the same level of importance.
- Equal weight is a common practice in building multidimensional indices (Alkire and Foster, 2011a; Alkire and Santos 2010; United Nations Development Program 1990-2013 and Angulo, 2011)
- The city is a system, all the variables in the index have some level of connection; for example, bad performance in environmental sustainability will have an impact on health indicators; or bad performance in governance may have an impact on equity and social inclusion. These interconnections between variables implies that a change in a variable will generate direct and indirect effects on the other variables, thereby creating a multiplier effect that changes depending on how critical the impacted variable is. A-priory assignment of weights may affect these multipliers effect either upward or downward.

Example: Let us assume that an index is defined from dimensions D1 and D2 and that D1 contains two sub-dimensions (S11 and S12) while D2 contains three sub-dimensions (S21, S22 and S23). Table 2 presents the weighting scheme of this index, in which each sub-dimension is determined based on a certain number of variables shown in the fifth column:

Dimension	Weight Dj	Sub-dimension	Weight of SJI within Dj	Number of variables in SJI	Variable weight within SJI
D1	1/2	S11	1/2	3	1/3
		S12	1/2	4	1/4
D2	1/2	S21	1/3	2	1/2
		S22	1/3	2	1/2
		S23	1/3	3	1/3

Table 2: Nested weights

Note that:

a) Each dimension has the same weight (1/2) in the index.
b) The two sub-dimensions of D1 are assigned the same weight (1/2) within this dimension; the three sub-dimensions of D2 are also assigned the same weight (1/3) within this dimension.

c) Each of the three variables of the first sub-dimension (D1) has the same weight of 1/3 within the sub-dimension. Similarly, the four variables of the second sub-dimension composing the first dimension are each assigned a weight of (1/4) within this sub-dimension. Likewise, the variables for the first, second and third sub-dimensions of the second dimension are assigned a weight of 1/2, 1/2 and 1/3, respectively, within this sub-dimension.

Using this scheme, Table 3 presents the index dimension, sub-dimension and variable weights.

Dim.	Weight Dj	Sub-dimension	Weight of SJI in the index	Number of variables	Variable weight in the index
D1	1/2	S11	(1/2)(1/2)=1/4	3	(1/2)(1/2)(1/3)=0.08333
		S12	(1/2) (1/2)=1/4	4	(1/2) (1/2)(1/4)=0.06250
D2	1/2	S21	(1/2) (1/3)=1/6	2	(1/2) (1/3)(1/2)=0.08333
		S22	(1/2) (1/3)=1/6	2	(1/2) (1/3)(1/2)=0.08333
		S23	(1/2) (1/3)=1/6	3	(1/2) (1/3)(1/3)=0.05556
Total	1		1		1

Table 3: Weights within the index

The last row of Table 3 demonstrates that the weighting scheme is such that:

a) The sum of the index dimension weights is 1; each dimension weighs 1/2 in the index.
b) The sum of the index sub-dimension weights is 1. The two sub-dimensions of the first dimension each weigh 1/4 in the index, while the three sub-dimensions of the second dimension each weigh 1/6 in the index.
c) The sum of the index variable weights is 1. Each of the three variables of the first sub-dimension of dimension 1 weighs 0.08333; each variable of the second sub-dimension of dimension 1 weighs 0.06250. Similarly, variables in the first, second and third sub-dimensions of dimension 2 weigh 0.08333, 0.08333 and 0.05556, respectively.

The sum of the index variable weights must be calculated to account for the number of variables present in each sub-dimension. In the example provided, the sum of the variable weights in the index = [3(1/2)(1/2)(1/3)] + [4(1/2)(1/2)(1/4)] + [2(1/2) (1/3)(1/2)] + [2(1/2) (1/3)(1/2)] + [3(1/2)(1/3)(1/3)] = 1

Using the above procedure, Table 4 shows the general weighting scheme for the CPI. It is assumed that the index is composed of six dimensions Dj; that in each dimension there are hj sub-dimensions, Sji, i=1,…, hj, j=1,…,6; and that in each sub-dimension Sji there are nji variables that define it.

$$v_{11n_{11}}$$

Table 4: CPI weighting scheme

Using this weighting scheme, the Basic and Extended Indexes are constructed.

5. INDEX CONSTRUCTION

5.1 Basic CPI Weights

Dimension	Dimension weight in the index	Sub-dimension	Sub-dimension weighting within the dimension	Number of variables in the sub-dimension	Variable weighting within the sub-dimension	Variable weighting within the dimension
PRODUCTIVITY (P)	(1/6)	1. EG	(1/3)	1.1 City Product per capita	(1/2)	(1/3)(1/2)
				1.2 Old Age Dependency Ratio	(1/2)	(1/3)(1/2)
		2. EA	(1/3)	2.1 Economic Density	1	(1)(1/3)
		3. E	(1/3)	3.1 Unemployment Rate	1	(1)(1/3)
INFRASTRUCTURE DEVELOPMENT (ID)	(1/6)	1. HI	(1/5)	1.1 Improved Shelter	(1/2)	(1/2)(1/5)
				1.2 Access to Improved Water	(1/2)	(1/2)(1/5)
		2. SI	(1/5)	2.1 Physiscian Density	1	(1)(1/5)
		3. ICT	(1/5)	3.1 Internet Access	1	(1)(1/5)
		4. UM	(1/5)	4.1 Use of Public Transport	(1/2)	(1/2)(1/5)
				4.2 Average Daily Travel Time	(1/2)	(1/2)(1/5)
		5. UF	(1/5)	5.1 Street Intersection Density	(1/3)	(1/3)(1/5)
				5.2 Street Density	(1/3)	(1/3)(1/5)
				5.3 Land Allocated to Streets	(1/3)	(1/3)(1/5)
QUALITY OF LIFE (QOL)	(1/6)	1. H	(1/4)	1.1 Life Expectancy at Birth	(1/2)	(1/2)(1/4)
				1.2 Under-Five Mortality Rate	(1/2)	(1/2)(1/4)
		2. E	(1/4)	2.1 Literacy Rate	(1/2)	(1/2)(1/4)
				2.2 Mean years of Schooling	(1/2)	(1/2)(1/4)
		3. SS	(1/4)	3.1 Homicide rate	(1/2)	(1/2)(1/4)
				3.2 Theft rate	(1/2)	(1/2)(1/4)
		4. PS	(1/4)	4.1 Green Area per Capita	1	(1)(1/4)
EQUITY AND SOCIAL INCLUSION (ESI)	(1/6)	1. EE	(1/3)	1.1 Gini Coefficient	(1/2)	(1/2)(1/3)
				1.2 Poverty Rate	(1/2)	(1/2)(1/3)
		2. SI	(1/3)	2.1 Slums Households	(1/2)	(1/2)(1/3)
				2.2 Youth Unemployment	(1/2)	(1/2)(1/3)
		3. GI	(1/3)	3.1 Equitable Secondary School Enrollment	1	(1)(1/3)
ENVIRONMENTAL SUSTAINABILITY (ES)	(1/6)	1. AQ	(1/3)	1.1 Number of monitoring stations	(1/2)	(1/2)(1/3)
				1.2 PM2.5 Concentration	(1/2)	(1/2)(1/3)
		2. WM	(1/3)	2.1 Solid Waste Collection	(1/2)	(1/2)(1/3)
				2.2 Waste Water Treatment	(1/2)	(1/2)(1/3)
		3. SE	(1/3)	3.1 Share of Renewable Energy	1	(1)(1/3)
URBAN GOVERNANCE AND LEGISLATION (UGL)	(1/6)	1. P	(1/3)	1.1 Voter Turnout	1	(1)(1/3)
		2. MFIC	(1/3)	2.1 Own Revenue Collection	(1/2)	(1/2)(1/3)
				2.2 Days to Start a Business	(1/2)	(1/3)(1/3)
		3. GU	(1/3)	3.1 Land Use Efficiency	1	1(1/3)

Table 5 shows the weighting scheme for the Basic CPI

5.2 Extended CPI Weights

Dimension	Dimension weight in the index	Sub-dimension	Sub-dimension weighting within the dimension	Number of variables in the sub-dimension	Variable weighting within the sub-dimension	Variable weighting within the dimension
PRODUCTIVITY (P)	(1/6)	1. EG	(1/3)	1.1 City Product per capita	(1/3)	(1/3)(1/3)
				1.2 Old Age Dependency Ratio	(1/3)	(1/3)(1/3)
				1.3 Mean Household Income	(1/3)	(1/3)(1/3)
		2. EA	(1/3)	2.1 Economic Density	(1/3)	(1/3)(1/3)
				2.2 Economic Specialization	(1/3)	(1/3)(1/3)
		3. E	(1/3)	3.1 Unemployment Rate	(1/3)	(1/3)(1/3)
				3.2 Employment to Population Ratio	(1/3)	(1/3)(1/3)
				3.3 Informal Employment	(1/3)	(1/3)(1/3)
INFRASTRUCTURE DEVELOPMENT (ID)	(1/6)	1. HI	(1/5)	1.1 Improved Shelter	(1/6)	(1/5)(1/6)
				1.2 Access to Improved Water	(1/6)	(1/5)(1/6)
				1.3 Access to Improved Sanitation	(1/6)	(1/5)(1/6)
				1.4 Access to Electricity	(1/6)	(1/5)(1/6)
				1.5 Sufficient Living Area	(1/6)	(1/5)(1/6)
				1.6 Population Density	(1/6)	(1/5)(1/6)
		2. SI	(1/5)	2.1 Physiscian Density	(1/2)	(1/5)(1/2)
				2.2 Number of Public Libraries	(1/2)	(1/5)(1/2)
		3. ICT	(1/5)	3.1 Internet Access	(1/3)	(1/3)(1/5)
				3.2 Home Computer Access	(1/3)	(1/3)(1/5)
				3.3 Average Broadband Speed	(1/3)	(1/3)(1/5)
		4. UM	(1/5)	4.1 Use of Public Transport	(1/5)	(1/5)(1/5)
				4.2 Average Daily Travel Time	(1/5)	(1/5)(1/5)
				4.3 Length of Mass Transport Network	(1/5)	(1/5)(1/5)
				4.4 Traffic Fatalities	(1/5)	(1/5)(1/5)
				4.5 Affrodbaility of Transport	(1/5)	(1/5)(1/5)
		5. UF	(1/5)	5.1 Street Intersection Density	(1/3)	(1/3)(1/5)
				5.2 Street Density	(1/3)	(1/3)(1/5)
				5.3 Land Allocated to Streets	(1/3)	(1/3)(1/5)
QUALITY OF LIFE (QOL)	(1/6)	1. H	(1/4)	1.1 Life Expectancy at Birth	(1/4)	(1/4)(1/4)
				1.2 Under-Five Mortality Rate	(1/4)	(1/4)(1/4)
				1.3 Vaccination Coverage	(1/4)	(1/4)(1/4)
				1.4 Maternal Mortality	(1/4)	(1/4)(1/4)
		2. E	(1/4)	2.1 Literacy Rate	(1/4)	(1/4)(1/4)
				2.2 Mean years of Schooling	(1/4)	(1/4)(1/4)
				2.3 Early Childhood Education	(1/4)	(1/4)(1/4)
				2.4 Net enrollment rate in higher education	(1/4)	(1/4)(1/4)
		3. SS	(1/4)	3.1 Homicide rate	(1/2)	(1/2)(1/4)
				3.2 Theft rate	(1/2)	(1/2)(1/4)

		4. PS	(1/4)	4.1 Accessibility to Open Public Areas	(1/2)	(1/2)(1/4)
				4.2 Green Area per Capita	(1/2)	(1/2)(1/4)
EQUITY AND SOCIAL INCLUSION (ESI)	(1/6)	1. EE	(1/4)	1.1 Gini Coefficient	(1/2)	(1/2)(1/4)
				1.2 Poverty Rate	(1/2)	(1/2)(1/4)
		2. SI	(1/4)	2.1 Slums Households	(1/2)	(1/2)(1/4)
				2.2 Youth Unemployment	(1/2)	(1/2)(1/4)
		3. GI	(1/4)	3.1 Equitable Secondary School Enrollment	(1/3)	(1/3)(1/4)
				3.2 Women in Local Government	(1/3)	(1/3)(1/4)
				3.3 Women in Local Work Force	(1/3)	(1/3)(1/4)
		4. UD	(1/4)	4.1 Land Use Mix	1	(1)(1/4)
ENVIRONMENTAL SUSTAINABILITY (ES)	(1/6)	1. AQ	(1/3)	1.1 Number of monitoring stations	(1/3)	(1/3)(1/3)
				1.2 PM2.5 Concentration	(1/3)	(1/3)(1/3)
				1.3 CO2 Emissions	(1/3)	(1/3)(1/3)
		2. WM	(1/3)	2.1 Solid Waste Collection	(1/3)	(1/3)(1/3)
				2.2 Waste Water Treatment	(1/3)	(1/3)(1/3)
				2.3 Solid Waste Recycling Share	(1/3)	(1/3)(1/3)
		3. SE	(1/3)	3.1 Share of Renewable Energy	1	(1)(1/3)
URBAN GOVERNANCE AND LEGISLATION (UGL)	(1/6)	1. P	(1/3)	1.1 Voter Turnout	(1/3)	(1/3)(1/3)
				1.2 Access to Public Information	(1/3)	(1/3)(1/3)
				1.3 Civic Partecipation	(1/3)	(1/3)(1/3)
		2. MFIC	(1/3)	2.1 Own Revenue Collection	(1/4)	(1/3)(1/4)
				2.2 Days to Start a Business	(1/4)	(1/3)(1/4)
				2.3 Subnational Debt	(1/4)	(1/3)(1/4)
				2.4 Local Expenditure Efficiency	(1/4)	(1/3)(1/4)
		3. GU	(1/3)	3.1 Land Use Efficiency	1	(1)(1/3)

Table 6 Weighting scheme for the Extended CPI

6. INDICATORS METADATA

6.1 PRODUCTIVITY INDEX

Productivity is an economic measure of output per unit of input, at national (or even city) level. Productivity inputs include labour and capital, while the output is typically measured in GDP components.
The City Prosperity Initiative (CPI) conceptualizes a prosperous city as one that fosters economic development, and creates conditions necessary to provide decent jobs and equal opportunities for everyone, by implementing effective economic policies and sector reforms. Urban areas contribute substantially to national productivity because they concentrate economic activities, incubate talents and nurture creativity and innovation. The concentration of economic activities leads to substantial benefits and efficiency due to economies of agglomeration and scale. Agglomeration economies give cities a competitive advantage as it makes economic productivity cheaper in the densely populated areas within cities. Therefore, productivity gains are vital to any city as it would allow the city to produce more with less.
Under the CPI, the Productivity Index is estimated using three sub-dimensions, as listed below:

- Employment
- Economic Strength
- Economic Agglomeration

The indicator variables within the Productivity Index are classified below:

DIMENSION	SUB-DIMENSION	INDICATOR
Productivity Index (P)	1. Economic Strength (ES)	1.1. City Product Per Capita 1.2. Old Age Dependency Ratio 1.3. Mean Household Income
	2. Economic Agglomeration (EA)	2.1. Economic Density 2.2. Economic Specialization
	3. Employment (E)	3.1. Unemployment Rate 3.2. Employment To Population Ratio 3.3. Informal Employment

To compute the Productivity Index, at the Basic CPI level, the variables within the sub-dimensions are aggregated as follows:

PRODUCTIVITY INDEX (PI) = 1/3 [Economic Strength (ES) + Economic Agglomeration (EA) + Employment (E)]

Where:
ES = (1/2) [City Product + Old Age Dependency]
EA = Economic Density
E = Unemployment Rate

The Productivity Index can also be estimated at an Extended CPI level. To do this, aggregate the variables within the sub-dimensions as follows:

PRODUCTIVITY INDEX (PI) = 1/3 [Economic Strength (ES) + Economic Agglomeration (EA) + Employment (E)]

Where:
ES = (1/3) [City Product + Old Age Dependency + Median Household Income]
EA = (1/2) [Economic Density + Economic Specialization]
E = (1/3) [Unemployment Rate + Employment to Population Ratio + Informal Employment]

1. Economic Strength (ES) Sub-index

<table>
<tr><td>Indicator:</td><td>City Product Per Capita</td></tr>
<tr><td>Scope:</td><td>Basic CPI</td></tr>
<tr><td>Rationale:</td><td>Cities have traditionally served as economic centers and have become the primary providers of services and engines of economic growth and development. Additionally, cities currently generate over half of national economic activity worldwide (UN-Habitat, 2003). Urban production, as measured through the City Product, is an important indicator for the economic development of a city, vis-à-vis national development, and it provides information about income levels and the capacity to generate employment (United Nations, 2001). A prosperous city has to increases its City Product Per Capita in-order to achieve higher levels of economic well-being.</td></tr>
<tr><td>Definition:</td><td>The City Product Per Capita is the sum of the gross value added (wages plus business surplus plus taxes less imports), or the total final demand (consumption plus investment plus exports), relative to the city's total population.</td></tr>
<tr><td>Unit [ ]:</td><td>US$ Per Capita (2011 PPP)</td></tr>
<tr><td>Methodology:</td><td>The City Product Per Capita is calculated as the sum of the products of the national Gross Domestic Product (GDP) of each economic sector (primary, industrial and service) and the city's share of that sector's total employment, divided by total city population as shown below:
$$City\ Product\ per\ capita = \frac{\sum_{j=1}^{J} National\ Product_j * \left(\frac{city\ employment_j}{national\ employment_j}\right)}{Total\ City\ Population},$$
Where j represents the industry sector. When city employment information by sector is not available, it is possible to use census information about the employment structure.
The following table should be completed for each sector (using the most detailed categories available):
<table>
<tr><th>Sector</th><th>National Product
(1)</th><th>National Employment
(2)</th><th>City Employment
(3)</th><th>Employment Ratio
(4)=(3)÷(2)</th><th>City Sector Product
(5)=(4)*(1)</th></tr>
<tr><td>Agriculture and mining</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Manufacturing, utilities, construction</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Wholesale and retail trade, transport and communication</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Finance, insurance, real estate and business services</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Community, personal and other services</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Government</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Other</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>
The total City Product is the sum of all City Sector Products (5) converted to international dollars using the annual Purchasing Power Parity (PPP) exchange rate. This ensures comparable figures across countries.</td></tr>
</table>

Sources:	National Product by industry: available from national accounts. The classification used here is a simplified SITC standard industry classification, which is used for standard national accounting (United Nations, 2008) National and city employment: workforce statistics by economic sector. Data for this indicator are derived from living standards household surveys or labor force censuses. In case these surveys are not available, other credible surveys can be used. Population: national population censuses. Exchange rate (PPP): World Bank [1].
Benchmark:	Min = US$714.64 Per Capita, 2011 PPP Max = US$108,818.96 Per Capita, 2011 PPP Calculated from World Bank data (2014).
Standardization: 2.1	$$City\ Product\ per\ capita^{(S)} = 100\left[\frac{\ln(City\ Product\ per\ capita) - \ln(Min)}{\ln(Max) - \ln(Min)}\right]$$ $$City\ Product\ per\ capita^{(S)} = 100\left[\frac{\ln(City\ Product\ per\ capita) - 6.57}{11.60 - 6.57}\right]$$ NOTE: We use the Natural Log (ln) not only to reduce the scale of data, but also to illustrate the principle of diminishing returns. Simply put, as GDP increases the amount of returns per unit of GPD will decrease with time. Using these natural logs will not affect the overall statistical distribution of the data. Decision: $$City\ Product\ per\ capita^{(S)} = \begin{cases} 100, & If\ \ln(City\ Product\ per\ capita) \geq 11.60 \\ City\ Product\ per\ capita^{(S)}, & If\ 6.57 < \ln(City\ Product\ per\ capita) < 11.60 \\ 0, & If\ \ln(City\ Product\ per\ capita) \leq 6.57 \end{cases}$$
Limitations:	The method to calculate the City Product Per Capita assumes that mean sector labour productivity is the same for workers across regions of the country. Hence, this indicator does not consider the differences in labour productivity by sector across cities in the same country. Moreover, when census data are utilised, the indicator assumes that the sector structure has not changed between the census date and calculation date. Because the City Product Per Capita is based on GDP Per Capita, informal sector production is not considered. Therefore, the CPI will include a variable for median household income.
References:	**Bibliographic references** UN-Habitat (2003). The habitat agenda goals and principles, commitments and the global plan of action. United Nations (2001). The State of the World's Cities Report 2001. United Nations (2008). International Standard Industrial Classification of All Economic Activities. Statistical papers. Revision No 4. The World Bank (2014). World Development Indicators 1960 – 2013. [2] **URL references** [1]: http://data.worldbank.org/indicator/PA.NUS.PPPC.RF, Accessed August 10, 2014. [2]: http://data.worldbank.org/indicator/NY.GNP.PCAP.PP.KD?display=default, Accessed August 10, 2014.

Indicator:	Old Age Dependency Ratio
Scope:	Basic CPI
Rationale:	An ageing population is a common demographic pattern in many countries (especially in developed countries) where life expectancies are high and fertility and child mortality are low. The increasing share of older persons in any city presents challenges for the economic performance of cities. First, an older population implies increasing government expenditures on health and social security, which may imply higher taxes for the working population to finance pensioners. Second, an ageing population implies that fewer individuals will be able to work in the future, which affects growth, employment, savings, investment and consumption (United Nations. Dept. of Economic and Social Affairs. Population Division, 2001). A prosperous city seeks policies to maintain a healthy relationship between the younger and older residents, to avoid high levels of dependency and a decrease in future labour supply.
Definition:	The Old Age Dependency Ratio is the ratio of the total number of elderly persons (aged 65 and over) to the number of persons of working age (aged from 15 to 64) (United Nations. Dept. of Economic and Social Affairs. Population Division, 2001). This is expressed per 100 persons within the working-age population.
Unit [ ]:	%
Methodology:	$Old\ Age\ Dependency\ Ratio = 100\left[\frac{people\ aged\ 65\ and\ over}{people\ ages\ 15\ to\ 64}\right]$
Sources:	Labour market surveys, living standards household surveys and censuses.
Benchmark:	Min: 2.92% Max: 40.53% Calculated from World Bank data (2014).
Standardization: 2.2	$Old\ Age\ Dependency\ Ratio^{(S)} = 100\left[1 - \frac{\ln(Old\ Age\ Dependency\ Ratio) - \ln(Min)}{\ln(Max) - \ln(Min)}\right]$ $Old\ Age\ Dependency\ Ratio^{(S)} = 100\left[1 - \frac{Old\ Age\ Dependency\ Ratio - 1.07}{3.70 - 1.07}\right]$ NOTE: We use the Natural Log (ln) to reduce the scale of data, and this will not affect the statistical distribution of data. Decision: $Old\ Age\ Dependency\ Ratio^{(S)}$ $= \begin{cases} 0, If\ (Old\ Age\ Dependency\ Ratio) \geq 3.70 \\ Old\ Age\ Dependency\ Ratio^{(S)}, If\ 1.07 < (Old\ Age\ Dependency\ Ratio) < 3.70 \\ 100, If\ (Old\ Age\ Dependency\ Ratio) \leq 1.07 \end{cases}$
Limitations:	No recommendation exists about any desired dependency ratio value. Hence, it is not possible to determine exactly what a healthy relationship between the younger and older population should be (United Nations. Dept. of Economic and Social Affairs. Population Division, 2006). Moreover, the dependency ratio ignores some additional facts. First, it ignores the fact that persons 65 years and older are not necessarily dependent; they might be wealthy or still working (especially in developing countries). Second, many young people may be currently unemployed. These facts imply that dependency estimates could be inaccurate (Eurofound, 2012).
References	**Bibliographic References:** Eurofound (2012). Income from work after retirement in the EU. Publications Office of the European Union. Luxemburg. United Nations. Dept. of Economic and Social Affairs. Population Division (2006). World Population Policies 2005. United Nations Publications. United Nations. Dept. of Economic and Social Affairs. Population Division (2001). World Population Ageing: 1950-2001. The World Bank (2014). World Development Indicators 1960 – 2013. [1] **URL references** [1]: http://data.worldbank.org/indicator/SP.POP.DPND.OL, accessed July 2, 2014.

Indicator:	Mean Household Income
Scope	Extended CPI
Rationale:	Household income enables consumption, improves access to education, health care, housing and, broadly achieves higher living standards and resistance to economic shocks (Canberra, 2011). A prosper city seeks to build the appropriate foundations to increase mean household income to increase well-being.
Definition:	The mean household income includes the income earned by the average household in a city. It is calculated by dividing the disposable income of all households (according to household surveys) by the number of households of the city [1].
Unit [ ]	US$ per household (PPP).
Methodology:	To calculate the mean household income, first the disposable household income distribution of a city must be obtained. The disposable household income is defined as the sum of monetary and non-monetary income from labor, monetary income from capital, monetary social security transfers (including work-related insurance transfers, universal transfers, and assistance transfers), and non-monetary social assistance transfers, as well as monetary and non-monetary private transfers, less the amount of income taxes and social contributions paid [2]. Second, all disposable household incomes must be added and divided by the number of households in the city. Finally, this data must be converted to 2011 PPP in order to have a comparable measure of mean household income across countries.
Source:	Household Income: Living standard household surveys, income expenditure household surveys. Exchange rate (PPP): World Bank, 2012 [3].
Benchmark	Min = 6,315 US$ per household (PPP). Max = 44,773 US$ per household (PPP). Own calculations from the Luxembourg Income Study (LIS) Database Key Figures as of 18-Jun-2014 [2] converted to Local Currency Unit and converted to USD PPP$ using PPP exchange rate from World Bank, 2012 [3].
Standardization: 2.1.	$$Mean\ Household\ Income^{(S)} = 100\left[\frac{Mean\ Household\ Income - Min}{Max - Min}\right]$$ $$Mean\ Household\ Income^{(S)} = 100\left[\frac{Mean\ Household\ Income - 6{,}315}{44{,}773 - 6{,}315}\right]$$ Decision: $$Mean\ Household\ Income^{(S)} = \begin{cases} 100, & If\ Mean\ Household\ Income \geq 44{,}773 \\ Mean\ Household\ Income^{(S)}, & If\ 6{,}316 < Mean\ Household\ Income < 44{,}773 \\ 0, & If\ Mean\ Household\ Income \leq 6{,}315 \end{cases}$$
Limitations	The mean household income does not take into account the income distribution of the population. Mean carries with it an assumption that the distribution is symmetrical, but income distributions are usually skewed. This implies that highly unequal cities could have higher mean household income due to high levels of income concentration. Whether this situation indicates a prosperous city is questionable. Moreover, developed countries tend to use equivalence scale measures to calculate disposable total income, while developing countries do not. Therefore, caution should be used when doing cross-country comparisons.
References	**Bibliographic references** Canberra Group (2011). Handbook of Household Income Statistics, 2nd Edition. World Bank Group (2012). World Development Indicators 2012. World Bank Publications. **URL references** [1]: http://www.eastsussexinfigures.org.uk/webview/index/en/ESCCFigures/East-Sussex-in-Figures-4.d.43/Tables-charts-and-maps.d.44/Economy-jobs-and-prosperity.d.54/Earnings-income-and-wealth.d.88/Average-household-income-in-2014-parishes/fCube/200_C1, accessed August 18, 2014. [2]: http://www.lisdatacenter.org/data-access/key-figures/disposable-household-income/, accessed August 18, 2014. [3]: http://data.worldbank.org/indicator/PA.NUS.PPP, accessed August 14, 2014.

2. Economic Agglomeration (EA) Sub-index

Indicator:	**Economic Density**
Scope	Basic CPI
Rationale:	This is an aspect of productivity that looks at the concentrations and distributions of economic activity. Economic Density means, the intensity of labour, human, and physical capital relative to physical space (Ciccone & Hall, 1996). Density is high when there is a large amount of labour, capital and other economic factors per square kilometer. Economic density in the CPI, therefore, looks at the intensity of production that a city generates in monetary terms per specified area i.e. GDP per Square kilometer A high economic density is desirable mainly because of the following reasons: • If there are externalities associated with the physical proximity of production then density will contribute to productivity for this reason as well (Ciccone & Hall, 1996). For example, transportation costs of some goods and services will reduce as a result of closer geographical proximity that arises from higher density • At the same time, economic density enables the specialization of the production of input, final goods and the labour force, which decreases production costs (Ciccone & Hall, 1996; Jenks, Burton and Williams, 2005). A prosperous city will therefore seek to take advantage of these agglomeration effects to increase the well-being of its population.
Definition:	Economic Density is the City Product divided by the city's area (square kilometers).
Unit [ ]	US$ (PPP)/Km^2
Methodology:	$$Economic\ Density = \frac{City\ Product\ (\$PPP)}{City's\ square\ kilometres}$$ In order to have a comparable measure, City Product should be obtained from the economic growth sub dimension.
Source:	City Product: City Product per capita Metadata. Square kilometers: City Map.
Benchmark:	X^* = $857.37 million(PPP)/ Km^2) The reference for the benchmark is the 2010 world GDP per square kilometer estimation from 275 OECD cities. It is the maximum value from the calculations that were done as explained below: • Data was obtained from the OECD database. 275 cities and smaller regions (TL3 regions [1]) were used in the calculation • Components (found in OECD website [2]) used in the calculation were: - City GDP, 2010 - Estimates of GDP of metropolitan areas, expressed in millions of US$, constant prices and constant PPPs, OECD base year (2005). The estimates are derived from the values of TL3 regions - City area, 2006 - The urbanized area is defined as the land area covered by buildings or infrastructure for urban use. It includes, for example, residential and non-residential buildings, major roads, railways, and sport facilities. -
Standardization: 3	$$Economic\ Density^{(S)} = 100\left(1 - \left|\frac{(Economic\ Density) - X^*}{X^*}\right|\right)$$ $$Economic\ Density^{(S)} = 100\left(1 - \left|\frac{(Economic\ Density) - 857.37\ mil}{857.37\ mil}\right|\right)$$ Decision: $$Economic\ Density^{(S)} = \begin{cases} Economic\ Density^{(S)}, & If\ \ 0 \leq\ (Economic\ Density) < 857.37\ mil \\ 100, & If\ \ (Economic\ Density) \geq 857.37\ mil \end{cases}$$

Limitations	The economic density indicator assumes that the economic activity of a city is homogenously spatially distributed, i.e. regional differences within the city area are not taken into account. Moreover, it is possible that a high concentration of the economic activity generates negative externalities (e.g. rising prices, a population's quality of life).
References	**Bibliographic References:** Ciccone, A., & Hall, R. E. (1996). *Productivity and the density of economic activity*. The American Economic Review. Vol 86, N 1. Jenks, Mike, Burton, Elizabeth and Katie, Williams, Eds. (2005). The compact City. A sustainable Urban Form? Taylor & Francis e-Library. United Kingdom. **Url References:** [1]http://www.oecd-ilibrary.org/urban-rural-and-regional-development/data/small-regions-tl3_region-tl3-data-en, accessed 14th August 2015 [2] http://stats.oecd.org/Index.aspx?Datasetcode=CITIES , The estimates are derived from the values of TL3 regions, accessed 13th August 2015

Indicator:	**Economic Specialization**
Scope	Extended CPI
Rationale:	One of the main insights from economic thinking concerning geography and economic development is that firms value agglomeration or "clustering". Economic agglomeration or agglomeration economies are the benefits, savings or (average) cost reductions that come when firms and people locate near one another together in cities and industrial clusters [1]. Firms prefer to concentrate close to other firms in the same or related product lines, and in locations with good access to markets (World Bank, 2009). A critical element of this agglomeration process is specialization. This implies that the economic structure of a city tends to concentrate in certain economic activities to generate and take advantage of increasing returns to scale. The latter are related with: • Decreasing of transaction and information costs • Increasing specialization in labour and input markets and • The promotion of innovation (Romer, 1987; Feldman and Audretsch, 1999). A prosperous city thus seeks increasing economic specialization as a way to improve its competitiveness, economic growth and income.
Definition:	Economic specialization looks at the Industrialization Economies aspect of Economic Agglomeration i.e. the agglomeration effects resulting from the clustering of industrial activities giving rise to an "industrial climate". This indicator will show the level (high or low) at which a city concentrates its economic activities on certain goods and services. It is usually as a way to gain greater degrees of productivity efficiency and take advantage of increasing returns of scale (Romer, 1987; Feldman and Audretsch, 1999).
Unit [ ]	Dimensionless (value between 0 and 1).
Methodology:	A measure of concentration is the Herfindahl-Hirschman index (H). Commonly used to analyze the market structure and concentration of a specific sector, it is used in a more general way to measure industry concentration in a city or region (Dewhurst and McCann, 2002). The H index is given by: $$H = \sum_{i=1}^{N} S_i^2$$ Where: • S_i^2 is the share of employment in industry *i* in the city. Make sure that the share S_i^2 is expressed as a number and not a percentage; for example, 0.15 instead of 15%. • *N* is the total number of industries. H ranges from 1/N to 1. According to the literature, a value of H above 0.25 indicates high concentration (U.S. Department of Justice and the Federal Trade Commission, 2010). The normalized version of the H index, H^*, ranges from 0 to 1, and is computed as follows: $$H^* = \frac{(H - 1/N)}{1 - 1/N}$$ IMPORTANT: To facilitate the treatment of this variable within the CPI, H^* will be used instead of H.
Source:	National or local Industry Surveys, labour market surveys, living standards household surveys, censuses, Chamber of commerce (in cities with low level of informality)
Benchmark	According to the literature, a high level of concentrations occurs when $H^* \geq \frac{(0.25-1/N)}{1-1/N}$; then, the benchmark values, X^*, is defined as follow: $$X^* = \frac{(0.25 - 1/N)}{1 - 1/N}$$ Note that this benchmark varies across cities as the number of industries changes. But this does not affect the comparability of the standardized value.

Standardization: 3	$$H^{*(S)} = 100\left(1 - \left\lvert\frac{H^* - X^*}{X^*}\right\rvert\right)$$ $$H^{*(S)} = 100\left(1 - \left\lvert\frac{H^* - \frac{(0.25 - 1/N)}{1 - 1/N}}{\frac{(0.25 - 1/N)}{1 - 1/N}}\right\rvert\right)$$ Decision: $$H^{*(S)} = \begin{cases} H^{*(S)}, & If\ \ 0 \le H^* < \frac{(0.25 - 1/N)}{1 - 1/N} \\ 100, & If\ H^* \ge \frac{(0.25 - 1/N)}{1 - 1/N} \end{cases}$$
Limitations	A greater H^* index implies higher concentration of economic activity in a group of specific sectors. However, it is possible to find cities specialized in low productivity sectors where it is not possible to exploit economies of scale. Additionally, economic specialization competes with economic diversification, which could be desirable in some cases to avoid high dependence on a limited group of sectors (Duranton and Puga, 2000). Lastly, this measure does not consider the spatial aspects.
References	**Bibliographic references** Dewhurst, J.H and McCann, P (2002*). A Comparison of Measures of Industrial Specialization for Travel-to-Work Areas in Great Britain, 1981-1997*. Regional Studies 36. Duranton, Gilles, and Puga, Diego (2000*). Diversity and Specialization in Cities: Why, Where and When does it matter?* Urban Studies 37. Ellison, Glen and Glaeser, Edward L. (1997*). Geographic Concentration in U.S. Manufacturing Industries. A Dartboard Approach*. Journal of Political Economy 105 (5). Feldman, Maryann and Audretsch, David B. (1999). *Innovation in cities: Science-based Diversity, specialization and located competition*. European Economic Review 43. Romer, Paul M. (1987). *Growth based on Increasing Returns Due to Specialization*. The American Economic Review. Vol 77 (2). The World Bank. (2009). *Systems of Cities: Harnessing urbanization for growth and poverty alleviation.* U.S. Department of Justice and the Federal Trade Commission (2010) *Horizontal Merger Guidelines*. [2]. **URL references:** **[1]:** http://www.nber.org/chapters/c7977.pdf, accessed August 19 2015 [2]: http://www.justice.gov/atr/public/guidelines/hmg-2010.pdf, accessed August 11, 2014.

3. Employment (E) Sub-index

Indicator:	**Unemployment Rate**
Scope	Basic CPI
Rationale:	Work can be defined as a founding value of the human society. This interpretation was not motivated by mere economic reasons, but rather stemmed from the recognition that work is the most appropriate tool for the expression of the human personality in society and that it is an asset and a right that will increase the dignity of every person. Also, it corresponds to a fundamental human desire to fulfill oneself in relationship with other persons and the entire world [1]. Unemployment rate, therefore, is one of the most comprehensive indicators of economic activity and general human well-being. High levels of unemployment are detrimental to the city's economy and reflect structural problems in the labour market. Moreover, people who are willing to work but are unable to do so suffer not only income losses but also a decline in their mental health and social relationships and personal vulnerability effects (Darity and Goldsmith, 1996). In addition, rising levels of unemployment reflect macroeconomic uncertainty that leads to lower consumption, investment and production. A prosperous city will seek to reduce unemployment to lead the economy into a growth path with better opportunities for all its inhabitants.
Definition:	The number of unemployed people as a proportion of the total labour force. • Unemployed Person - according to the International Labour Organization (2013), an unemployed person is one that, during the reference period, is without work but available to work and is actively seeking employment. • Labour force – The labour force comprises all those persons in the working age population (as specified by the country) who either had jobs (the Employed), or those who did not have jobs but were willing, able and looking for work (the Unemployed) [2]. The labour force excluded some groups of people who have voluntarily or involuntarily left the labour market [3]. These include: - People on disability allowance (unable to work) - People on sickness benefits (unable to work) - Women having children on maternity leave - Fathers on paternity leave. - People demotivated by years of unemployment and so no longer seek work. - People who have taken early retirement - Adults in full time education
Unit [ ]	%
Methodology:	$Unemployment\ Rate = 100\left[\frac{Unemployed}{Labour\ Force}\right]$
Source:	Labour Markets surveys, Living standards surveys, censuses, Labour force sample surveys
Benchmark	Min = 1% Max = 28.2% Calculated from The World Bank (2014) [4].
Standardization: 2.2	$Unemployment\ Rate^{(S)} = 100\left[1 - \frac{\sqrt[4]{Unemployment\ Rate} - \sqrt[4]{Min}}{\sqrt[4]{Max} - \sqrt[4]{Min}}\right]$ $Unemployment\ Rate^{(S)} = 100\left[1 - \frac{\sqrt[4]{Unemployment\ Rate} - 1}{2.3 - 1}\right]$ Decision:

	$$Unemployment\ Rate^{(S)} = \begin{cases} 0, & If\ \sqrt[4]{Unemployment\ Rate} \geq 2.3 \\ Unemployment\ Rate^{(S)}, & If\ 1 < \sqrt[4]{Unemployment\ Rate} < 2.3 \\ 100, & If\ \sqrt[4]{Unemployment\ Rate} \leq 1 \end{cases}$$
limitations	The age coverage used to calculate the unemployment rate is 15 years and over. However, some countries have a lower age limit or have imposed an upper age-limit. This means that country comparisons have to be made with caution. Additionally, unemployment rate says nothing about the type of unemployment - whether it is cyclical and short term or structural and long term. Finally, this measure masks information on the composition of the jobless population and therefore misses out on the particularities of the education level, ethnic origin, socioeconomic background, work experience, etc. (ILO, 2013).
References	**Bibliographic References:** Darity, William Jr. and Goldsmith, Arthur H. (1996). *Social Psychology, Unemployment and Macroeconomics*. The Journal of Economic Perspectives. Vol 10 (1). International Labour Organization (ILO). (2013). *Key Indicators of the Labour Markets*. 8th edition. The World Bank (2014). World Development Indicators 1960 – 2013. [4] **URL references:** [1] http://www.ncbi.nlm.nih.gov/pubmed/21298870 - Work as a basic human need and health promoting factor, accessed August 13, 2015 [2]: http://www.sib.org.bz/documentation/labour-force, accessed August 20, 2015 [3]:http://www.economicshelp.org/blog/569/economics/size-of-labour-force-and-working-population/, accessed August 20, 2015 [4]: http://data.worldbank.org/indicator/SL.UEM.TOTL.ZS , accessed August 9, 2014.

Indicator:	**Employment to Population Ratio**
Scope	Basic CPI
Rationale:	The ability of a city to create employment opportunities is a key indicator of growth and social development. Labour market opportunities have a direct effect on the income and wealth of a city, and can help to reduce poverty and improvements in social mobility (United Nations, 2006). Having a high employment to population ratio means that an important proportion of the population in the working age is employed which in general, will have positive effects on the GDP per capita. A prosperous city should hence seek to provide employment opportunities for its inhabitants.
Definition:	The Employment to Population Ratio is the proportion of a country's working age population that is employed (International Labour Organization, 2013). Employed Persons - are ones that: 1. do any work at all as paid employees, work in their own business or profession or on their own farm, or work 15 hours or more as unpaid workers in a family-operated enterprise; and 2. all those who do not work but had jobs or businesses from which they were temporarily absent due to illness, bad weather, vacation, childcare problems, labour dispute, maternity or paternity leave, or other family or personal obligations — whether or not they were paid by their employers for the time off and whether or not they were seeking other jobs. Working Age Population – The total population in a region, within a set range of ages that are considered able and likely to work. The working-age population measure is used to give an estimate of the total number of potential workers within an economy [1]. This is usually the population aged between 15 and 64 years, but this varies from country to country.
Unit [ ]	%
Methodology:	$Employment\ to\ Population\ Ratio\ (EPR) = 100\left[\frac{Total\ Number\ of\ the\ employed}{Working\ Age\ Population}\right]$
Source:	Household surveys of the labour force and censuses.
Benchmark	Min = 30.50% Max = 75.00%
Standardization: 2.1	$$EPR^{(S)} = 100\left[\frac{EPR - Min}{Max - Min}\right]$$ $$EPR = 100\left[\frac{EPR - 30.50}{75.00 - 30.50}\right]$$ Decision: $$EPR^{(S)} = \begin{cases} 100, & If\ EPR \geq 75.00 \\ EPR^{(S)}, & If\ 30.50 < EPR < 75.00 \\ 0, & If\ EPR \leq 30.50 \end{cases}$$
Limitations	The comparability of employment ratios across countries is affected significantly by variations in the definitions used for employment and working age population figures. Firstly, the employment definition does not take into account the type of employment (e.g. formal or informal) and the amount of hours worked. Secondly, the working-age population is normally defined as persons aged 15 years and older. However, the lower limit can vary from country to country due to societal standards for education and work eligibility. Many developed countries impose an upper limit of 65 or 70 years (International Labour Organization, 2013). For these reasons, one needs to be cautious when comparing cities in different countries. The employment ratio is also subject to some manipulation by reporting agencies as well and may be skewed in order to give the perception that an economy, based on this metric, is performing better than it really is. For example, the numerator does not account for individuals who are currently enrolled in an educational institution and not working. These students

	are unemployed by choice but it still results in a lower calculation [2]. The ratio also does not give an indication of working conditions, number of hours worked per person, earnings or the size of the black market. Therefore, the analysis of the labour market must be done in conjunction with other statistics.
References	**Bibliographic references** International Labour Organization. (2013). Key Indicators of the Labour Markets. 8th edition. United Nations. (2006). Full and Productive Employment and Decent Work: Dialogues at the Economic and Social Council. **URL references** [1]: http://www.investopedia.com/terms/w/working-age-population.asp, accessed August 20, 2015 [2]: http://www.investopedia.com/terms/e/employment_to_population_ratio.asp, accessed August 13, 2015.

Indicator:	**Informal Employment**
Scope:	Extended CPI
Rationale:	Economic productivity reflects the capacity of a city to provide adequate employment opportunities for its residents. Informal employment is characterised by lower levels of productivity, unskilled labour demand, lack of protection in the event of non-payment of wages, compulsory overtime or extra shifts, lay-offs without notice or compensation, unsafe working conditions and the absence of social benefits such as pensions, sick pay and health insurance. Higher levels of informality are closely related to lower incomes (including lower wages) and thus, an increased likelihood of living in poverty (ILO, 2013b). A prosperous city reduces informality to improve the productivity, education and working conditions of its labour force.
Definition:	Informal Employment comprises all jobs in unregistered and/or small-scale private unincorporated enterprises (with less than five employees) that produce goods and services for sale. This covers units that employ hired unskilled labour and those operated by individuals working on own account or as self-employed persons, either alone or with the help of unpaid family members (International Labour Organization, 2013a).
Unit [ ]:	%
Methodology:	$Informal\ Employment = 100\left[\frac{Number\ of\ Informal\ Employees}{Total\ Number\ of\ Employed\ Persons}\right]$
Sources:	Labour force surveys, living standard household surveys, and censuses.
Benchmark:	Min = 11 % Max = 75 % According to the ILO (2002, 2013b), up to three-quarters of non-agricultural employment in developing countries is informal. In OECD countries, approximately 11% of total employment is informal (using part-time employment as a proxy for informal employment). Although it is hard to generalize the quality of informal employment, it most often means poor employment conditions and is associated with increasing poverty.
Standardization: 2.2	$Informal\ Employment^{(S)} = 100\left[1 - \frac{Informal\ Employment - Min}{Max - Min}\right]$ $Informal\ Employment^{(S)} = 100\left[1 - \frac{Informal\ Employment - 11}{75 - 11}\right]$ Decision: $Informal\ Employment^{(S)} = \begin{cases} 0, If\ Informal\ Employment \geq 75 \\ Informal\ Employment^{(S)}, If\ 11 < Informal\ Employment < 75 \\ 100, If\ Informal\ Employment \leq 11 \end{cases}$
Limitations:	The specification of the employee size limit of small scale private enterprises depends on national definitions. Therefore, to allow for comparability we use the ILO definition, which establishes that enterprises with fewer than five employees are considered to be informal. In the case of multiple-establishment enterprises, the size limit should apply to the largest establishment (International Labour Organization, 2013a).
References	**Bibliographic references:** International Labour Organization (2002). *Women and Men in the Informal Economy* A statistical picture International Labour Organization (2013b). Women and Men in the Informal Economy A statistical picture. Second Edition. International Labour Organization (2013a). Measuring Informality: A statistical manual of the informal sector and informal employment.

6.2 INFRASTRUCTURE INDEX

Infrastructure is defined as the basic physical systems, organizational structures, facilities, and installations needed for the functioning of a society or economy. The prosperity of a city largely depends on the development of infrastructure. These include transportation, communication, sewage, water, electric systems, etc. Social infrastructure like water supply, sanitation, sewage disposal, and education and health facilities have a direct impact on the quality of life and overall prosperity of the citizens. Physical infrastructures like transportation, power and communication facilities contribute to economic development and industrialization and encourage trade and mobility of labour. Both types of infrastructure connect people to people, goods to markets, workers to jobs, families to services, and the poor in rural areas to urban centres; a connectivity process that is essential to induce economic growth and reduce poverty. Prioritizing infrastructure development, in the long term, fosters economic and social development which is vital for a city to be prosperous. Prosperous cities are those that have vastly improved the range and quality of their infrastructure, and continuously work to invest in their current infrastructure.

Under the CPI, the Infrastructure Development Index is measured using five other sub-dimensions, as listed below:

- Housing Infrastructure
- Social Infrastructure
- Information and Communications Technology, ICT
- Urban Mobility
- Urban form

The indicator variables within the Infrastructure Development Index are classified below:

DIMENSION	SUB-DIMENSION	INDICATORS
INFRASTRUCTURE DEVELOPMENT INDEX (ID)	1. Housing Infrastructure (HI)	1.1. Improved Shelter 1.2. Access to Improved Water 1.3. Access to Improved Sanitation 1.4. Access to Electricity 1.5. Sufficient Living Area 1.6. Population Density
	2. Social Infrastructure (SI)	2.1. Physicians Density 2.2. Number of Public Libraries
	3. Information and Communications Technology (ICT)	3.1. Internet Access 3.2. Home Computer Access 3.3. Average broadband speed
	4. Urban Mobility (UM)	4.1. Use of Public Transport 4.2. Average Daily Travel Time 4.3. Length of Mass Transport Network 4.4. Traffic Fatalities 4.5. Affordability of Transport
	5. Urban Form (UF)	5.1. Street Intersection Density 5.2. Street Density 5.3. Land allocated to streets

To compute the Infrastructure Development Index, at the Basic CPI level, the variables within the sub-dimensions are aggregated as follows:

INFRASTRUCTURE DEVELOPMENT INDEX (ID) = 1/5 [Housing Infrastructure (HI) + Social Infrastructure (SI) + Information and Communications Technology (ICT) + Urban Mobility (UM) + Urban Form (UF)]

Where:
HI = (1/2) [Improved Shelter + Access to Improved Water]
SI = (1/2) [Physicians Density + Number of Public Libraries]
ICT = Internet Access
UM = (1/2) [Use of Public Transport + Average Daily Travel Time]
SC = (1/3) [Street Intersection Density + Street Density + Land allocated to streets]

The Infrastructure Development Index can also be estimated at an Extended CPI level. To do this, aggregate the variables within the sub-dimensions as follows:

INFRASTRUCTURE DEVELOPMENT INDEX (ID) = 1/5 [Housing Infrastructure (HI) + Social Infrastructure (SI) + Information and Communications Technology (ICT) + Urban Mobility (UM) + Urban Form (UF)]

Where:
HI = (1/6) [Improved Shelter + Access to Improved Water + Access to Improved Sanitation + Access to Electricity + Sufficient Living Area + Population density]
SI = (1/2) [Physicians Density + Number of Public Libraries]
ICT = (1/3) [Internet Access + Home Computer Access + Average Broadband Speed]
UM = (1/5) [Use of Public Transport + Average Daily Travel Time + Length of Mass Transport Network + Traffic Fatalities + Affordability of Transport]
SC = (1/3) [Street Intersection Density + Street Density + Land allocated to streets]

1.Housing Infrastructure (HI) Sub-Index

Indicator:	**Improved Shelter**
Scope	Basic CPI
Rationale:	A house is considered improved or durable if it is built on a nonhazardous location, and has a permanent structure adequate enough to protect its inhabitants from extreme climatic conditions such as rain, heat, cold, humidity [1]. Additionally, a housing structure is considered to be durable when certain strong building materials are used for the roof, walls and floor. Although a house may be built with durable materials, the dwellers may not enjoy adequate protection against weather and climate due to the overall state of the dwelling. Some materials may not look durable, in a modern sense, but they are, in a traditional sense for example, vernacular housing constructed using natural materials readily available in villages and maintained by its residents annually (UN-Habitat, 2009).A prosperous city seeks to avoid the presence of non-durable housing to ensure safe and decent living conditions to its population.
Definition:	Proportion of households living in a durable housing unit, i.e. built on a non-hazardous location, and has a permanent structure adequate enough to protect its inhabitants from extreme climatic conditions such as rain, heat, cold, humidity. The Quality of construction (e.g. materials used for wall, floor and roof) should be considered when categorizing housing units (United Nations, 2007). According to UN-Habitat (2009), the following locations should be considered as hazardous: - Housing settled in geologically hazardous zones (landslide/earthquake and flood prone areas); - Housing settled on garbage-mountains; - Housing around high-industrial pollution areas; - Housing around other high-risk zones, e.g. railroads, airports, energy transmission lines. The following durability factors should be considered when categorizing housing units: - Quality of construction (e.g. materials used for wall, floor and roof); - Compliance with local building codes, standards and bye-laws.
Unit [ ]	%
Methodology:	$Improved\ Shelter = 100\left[\frac{number\ of\ city\ households\ livi\square g\ in\ a\ house\ considered\ as\ 'durable'}{Total\ number\ of\ households}\right]$
Source:	Living Standards Households Surveys and censuses.
Benchmark	Min= 84.80% Max = 98.40% Obtained from UN-Habitat (2005).
Standardization: 2.1	$Improved\ Shelter^{(S)} = 100\left[\frac{Improved\ Shelter - Min}{Max - Min}\right]$ $Improved\ Shelter^{(S)} = 100\left[\frac{Improved\ Shelter - 84.80}{98.40 - 84.80}\right]$ Decision:

	$$Improved\ Shelter^{(S)} = \begin{cases} 100, & If\ Improved\ Shelter \geq 98.40 \\ Improved\ Shelter^{(S)}, & If\ 84.80 < Improved\ Shelter < 98.40 \\ 0, & If\ Improved\ Shelter \leq 84.80 \end{cases}$$
Limitations	Durability of building materials is to a very large extent subject to local conditions as well as to local construction and maintenance traditions and skills. The materials considered to be durable under local conditions must be determined by local experts. For example, a common problem in the outskirts of cities in developing countries is that dwellings often follow rural construction patterns, by using materials considered to be non-durable under urban conditions (UN-Habitat, 2009). Also, the Multidimensional Poverty Index or the Unsatisfied Basic Needs Index can provide a framework to support the differences in the assessment of durability of building materials.
References	**Bibliographic references:** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. UN-Habitat (2009). Urban Indicators Guidelines; Better Information, Better Cities. Monitoring the Habitat Agenda and the Millennium Development Goals-Slum Target. UN-Habitat (2005), Urban Indicators Programme Phase III and United Nations, World Urbanization Prospects; The 2003 revision. [2] **URL references:** **[1]:** http://webworld.unesco.org/water/wwap/wwdr/indicators/pdf/C3_Slum_profile_in_human_settlements.pdf, Accessed August 20, 2015 [2]: http://ww2.unhabitat.org/mediacentre/documents/sowcr2006/SOWCR%205.pdf, Accessed July 2, 2014.

Indicator:	**Access to Improved Water**
Scope	Basic CPI
Rationale:	Clean water is necessary for life and health, but nearly 2 billion people lack access to an adequate water supply or can only obtain it at high prices. Households in informal settlements are rarely connected to the network and only rely on water purchased from vendors at up to 200 times the tap price. Improving access to safe water reduces the burden, especially on women, to collect water from the available sources, and also reduces water-related diseases. This will improve the quality of life (UN-Habitat, 2009). A prosperous city must provide access to improved water to all of its entire population so that individuals can spend their time on productive activities rather than fetch household drinking water.
Definition:	The percentage of urban households with access to an improved source of drinking water. According to WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation [1], improved sources of drinking water are: • Piped water into dwelling • Piped water to yard/plot • Public tap or standpipe • Tube wells or borehole • Protected dug well • Protected spring • Rainwater And the following are considered unimproved sources of drinking water: • Unprotected spring • Unprotected dug well • Cart with small tank/drum • Tanker-truck • Surface water • Bottled water
Unit [ ]	%
Methodology:	$Access\ to\ Improved\ Water = 100\left[\frac{number\ of\ households\ with\ sustainable\ access\ to\ piped\ water\ source}{total\ number\ of\ households}\right]$
Source:	Living Standards Households Surveys and censuses, Public utility service companies.
Benchmark	Min= 50% Max = 100% Calculated from The World Bank (2014).
Standardization: 2.1	$Access\ to\ Improved\ Water^{(S)} = 100\left[\frac{Access\ to\ Improved\ Water - Min}{Max - Min}\right]$ $Access\ to\ Improved\ Water^{(S)} = 100\left[\frac{Access\ to\ Improved\ Water - 50}{100 - 50}\right]$ Decision: $Access\ to\ Improved\ Water^{(S)} = \begin{cases} Access\ to\ Improved\ Wate^{(S)}, & If\ 50 < Access\ to\ Improved\ Water \leq 100 \\ 0, & If\ Access\ to\ Improved\ Water \leq 50 \end{cases}$
Limitations	According to United Nations (2007), although the existence of a water outlet near the household is often used as a proxy for availability of safe water, there is no guarantee that water will always be available or safe, or that people will always use such sources.
References	**Bibliographic references:** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. UN-Habitat (2009). Urban Indicators Guidelines; Better Information, Better Cities. Monitoring the Habitat Agenda and the

	Millennium Development Goals-Slum Target. The World Bank (2014). World Development Indicators 1960 – 2013. [2] **URL references:** [1]: http://www.wssinfo.org/definitions-methods/watsan-categories/, Accessed July 2, 2014. [2]: http://data.worldbank.org/indicator/SH.H2O.SAFE.UR.ZS, Accessed July 2, 2014.

Indicator:	Access to Improved Sanitation
Scope	Extended CPI
Rationale:	The lack of sanitation is a major public health problem that causes disease, sickness and even death. Highly infectious, excreta-related diseases such as cholera still affect whole communities in developing countries. Diarrhoea, which is spread easily in an environment of poor hygiene and inadequate sanitation, kills approximately 2.2 million people each year, most of who are children under five years old. Inadequate sanitation, through its impact on health and environment, has considerable implications on economic development, when individuals miss work due to excreta-related sickness and diseases. Moreover, lack of excreta management poses a fundamental threat to global water resources. Adequate sanitation is important for both urban and rural populations, but the risks are greater in slum areas where it is more difficult to avoid contact with waste (UN-Habitat, 2009). A prosperous city seeks to guarantee full coverage of sewer system facilities to improve quality of life and reduce productivity losses due to excreta-related sickness and diseases.
Definition:	Percentage of the population with access to facilities that hygienically separate human excreta from human, animal and insect contact (UN-Habitat, 2009). According to WHO/UNICEF Joint Monitoring Program for Water Supply and Sanitation [1], improved sanitation includes the following facilities: • Flush toilet • Piped sewer system • Septic tank • Flush/pour flush to pit latrine • Ventilated improved pit latrine • Pit latrine with slab • Composting toilet And “unimproved” sanitation includes: • Flush/pour flush to elsewhere • Pit latrine without slab • Bucket • Hanging toilet or hanging latrine • No facilities or bush or field
Unit [ ]	%
Methodology:	$Access\ to\ Improved\ Sanitation = 100\left[\frac{number\ of\ households\ with\ improved\ sanitation}{total\ number\ of\ households}\right]$
Source:	Living Standards Households Surveys and Censuses, Public utility service companies.
Benchmark	Min= 15% Max = 100% Calculated from The World Bank (2014).

Standardization: 2.1	$$Access\ to\ Improved\ Sanitation^{(S)} = 100\left[\frac{Access\ to\ Improved\ Sanitation - Min}{Max - Min}\right]$$ $$Access\ to\ Improved\ Sanitation^{(S)} = 100\left[\frac{Access\ to\ Improved\ Sanitation - 15}{100 - 15}\right]$$ Decision: $$Access\ to\ Improved\ Sanitation^{(S)} = \begin{cases} Access\ to\ Improved\ Sanitation^{(S)}, & If\ 15 < Access\ to\ Improved\ Sanitation \leq 100 \\ 0, & If\ Access\ to\ Improved\ Sanitation \leq 15 \end{cases}$$
Limitations	According to United Nations (2007), this indicator uses a proxy for adequate sanitation facilities, as it is not currently possible to define entirely the proportion of population with sanitary facilities according to the conceptual definitions above.
References	**Bibliographic references:** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. UN-Habitat (2009). Urban Indicators Guidelines; Better Information, Better Cities. Monitoring the Habitat Agenda and the Millennium Development Goals-Slum Target. The World Bank (2014). World Development Indicators 1960 – 2013. [2] **URL references:** [1]: http://www.wssinfo.org/definitions-methods/watsan-categories/, Accessed July 2, 2014. [2]: http://data.worldbank.org/indicator/SH.STA.ACSN.UR, Accessed July 2, 2014.

Indicator:	**Access to Electricity**
Scope	Extended CPI
Rationale:	Access to electricity is important to fulfill basic needs, work and education. Energy services are important for providing adequate food, shelter, water, sanitation, medical care, education and access to communication. Reliable, adequate and affordable energy services are necessary to guarantee sustainable development (United Nations, 2007). A prosperous city must provide access to electricity to its entire population to improve standards of living, foster economic development and productivity.
Definition:	The percentage of households that are connected to the national grid and receive a continuous supply of electricity.
Unit [ ]	%
Methodology:	$Access\ to\ Electricity = 100\left[\frac{number\ of\ households\ with\ connection\ to\ the\ city\ electricity\ grid}{total\ number\ of\ households}\right]$
Source:	Living Standards Households Surveys and censuses, Public utility service companies.
Benchmark	Min= 7% Max = 100% Calculated from The World Bank (2014).
Standardization: 2.1	$Access\ to\ Electricity^{(S)} = 100\left[\frac{Access\ to\ Electricity - Min}{Max - Min}\right]$ $Access\ to\ Electricity^{(S)} = 100\left[\frac{Access\ to\ Electricity - 7}{100 - 7}\right]$ Decision: $Access\ to\ Electricity^{(S)} = \begin{cases} Access\ to\ Electricity^{(S)}, & If\ 7 < Access\ to\ Electricity \leq 100 \\ 0, & If\ Access\ to\ Electricity \leq 7 \end{cases}$
Limitations	This indicator does not cover off-grid access to electricity, i.e., solar, wind or other alternatives access to electricity at the household level.
References	**Bibliographic references:** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. The World Bank (2014). World Development Indicators 1960 – 2013. [1] **URL references:** [1]: http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS, Accessed July 2, 2014.

Indicator:	Sufficient Living Area
Scope	Extended CPI
Rationale:	Reduced space per person is often associated with certain health risks and therefore considered a key criterion to define a slum [1]. This indicator measures the adequacy of shelter, which is a basic human need. Overcrowding is associated with few square meters per person, high occupancy rates - number of persons sharing one room - and a high number of single room units. Slums worldwide include dwelling units that are often overcrowded with five and more persons sharing a one-room unit used for cooking, sleeping, and other household activities. Several local definitions of slums include thresholds for the minimum area, the number of structures in a settlement cluster, number of households or people or the density of dwellings in an area (UN-Habitat, 2009).A prosperous city seeks to avoid overcrowding to improve public health and quality of life.
Definition:	The proportion of households with less than four persons per room. A house is considered to provide sufficient living area for a household if three or fewer people share the same room (UN-Habitat, 2009). A room is defined as a space in a housing unit or other living quarters enclosed by walls reaching the floor to the ceiling or roof covering, or to a height of at least two meters, of an area large enough to hold a bed for an adult, that is at least four square meters. The total number of types of rooms therefore includes bedrooms, dining rooms, living rooms, studies, habitable attics, servants' room, kitchen and other separate spaces intended for dwelling purposes (UN-Habitat, 2009).
Unit [ ]	%
Methodology:	$Sufficient\ living\ area = 100\left[\frac{number\ of\ households\ with\ less\ than\ four\ persons\ per\ room}{total\ number\ of\ household\square s}\right]$
Source:	Censuses or Living Standards Households Surveys.
Benchmark	Min = 2.50% Max = 57.80% UN-HABITAT estimations. [2].
Standardization: 2.1	$Sufficient\ living\ area^{(S)} = 100\left[\frac{\sqrt[4]{Sufficient\ living\ area} - \sqrt[4]{Min}}{\sqrt[4]{Max} - \sqrt[4]{Min}}\right]$ $Sufficient\ living\ area^{(S)} = 100\left[\frac{\sqrt[4]{Sufficient\ living\ area} - 1.26}{2.76 - 1.26}\right]$ Decision: $Sufficient\ living\ area^{(S)}$ $= \begin{cases} 100, & If\ \sqrt[4]{Sufficient\ living\ area} \geq 2.76 \\ Sufficient\ living\ area^{(S)}, & If\ 1.26 < \sqrt[4]{Sufficient\ living\ area} < 2.76 \\ 0, & If\ \sqrt[4]{Sufficient\ living\ area} \leq 1.26 \end{cases}$
Limitations	This measure does not take into account the size of the room. Large rooms with more than three persons may not be considered as overcrowded. Additional indicators of overcrowding can be used such as: average in-house living area per person or the number of households per area; the number of persons per bed or the number of children under five per room may also be viable measures (UN-Habitat, 2009).
References	**Bibliographic references:** UN-Habitat (2009). Urban Indicators Guidelines; Better Information, Better Cities. Monitoring the Habitat Agenda and the Millennium Development Goals-Slum Target. Global Urban Observatory, Database: Urban Info v2.0, Indicator: *Proportion of urban population with sufficient living area*, data by country (1991 – 2007) **URL references:**

	[1]: http://ww2.unhabitat.org/mediacentre/documents/sowcr2006/SOWCR%205.pdf, Accessed June 25, 2014. [2]: http://www.devinfo.info/urbaninfo/, Accessed 13 August 2014.

Indicator:	**Population Density**
Scope	Extended CPI
Rationale:	High population density indicates a high concentration of people and their activities (economic and non-economic). In the context of rapid urbanization, a certain level of density is a smart choice and is at the core of sustainable urban planning. High density has the following economic, social and environmental benefits (UN-Habitat, 2013): • Efficient land use slows urban sprawl because high-density neighborhoods can accommodate more people. • High-density neighborhoods tend to decrease the costs of public services such as police and emergency response, school transport, roads, water and sewage, etc. • Support for better community service. • Reduced car dependency and parking demand, with corresponding increased support for public transport. • Provision of social equity. • Support for better and improved open public spaces. • Increased energy efficiency and decreased pollution. Worries about the perceived connection between density and social problems, such as crime, poverty and depression, are not supported by research. Studies show no such correlation when factors such as income and class are accounted for. A well-designed and organized high-density neighborhood can be safe and comfortable, but high quality design is essential to achieve viable high-density areas (UN-Habitat, 2013). An extreme level of population density at either end is not desirable as it would represent overcrowding or under-utilization.
Definition:	This is defined as the Gross density i.e. the total city population divided by the total urban area in square kilometers.
Unit [ ]	People / km^2
Methodology:	The urban population over the total area of the city in square kilometers (km^2).(Gross Density) $$Population\ Density\ = \frac{City\ population}{Urban\ area}$$
Source:	Population data is usually collected by censuses and surveys. The local authorities must properly delimit the urban areas (or perimeter).
Benchmark	X*=15,000 A density of at least 15,000 people per km^2 (150 people/ha or 61 people/acre) is considered appropriate to promote high-density urban growth, alleviate urban sprawl and maximize land efficiency (UN-Habitat, 2013). However, both excessive and insufficient density can penalize the index.
Standardization: 5	$$Population\ Density^{(S)} = 100\left(1 - \left|\frac{Population\ Density - X^*}{X^*}\right|\right)$$ $$Population\ Density^{(S)} = 100\left(1 - \left|\frac{Population\ Density - 15{,}000}{15{,}000}\right|\right)$$ Decision: $$Populaion\ Densi\square y^{(S)} = \begin{cases} 0, & if\ Population\ Density \leq 0\ or\ Population\ Density \geq 2 * 15{,}000 \\ Population\ Density^{(S)}, & If\ \ 0 < Population\ Density < 2 * 15{,}000 \\ 100, & If\ Population\ Density = 15{,}000 \end{cases}$$
Limitations	Density is often measured as population divided by an administrative boundary, such as, municipal limits, this measure of density is not very useful as municipal limits may include a large amount of vacant land or even bodies of water (Bertraud 2004). In some cities and contexts, it is possible to find functional densities with higher values from the proposed optimal. The higher values of density may vary according to cultural factors and available floor areas per person due to vertical development. Additionally, this indicator does not consider the quality of the urban design, which is essential to achieve viable high-density areas (UN-Habitat, 2013).

References	**Bibliographic references:** UN-Habitat, 2013. Discussion Note 1. Urban Planning. A new strategy of sustainable neighborhood planning: Five principles. [1]. Bertaud, A. 2004. The Spatial Organization of Cities [3] **URL references:** http://unhabitat.org/wp-content/uploads/2014/05/5-Principles_web.pdf, Accessed 28 July, 2014.

Indicator:	**Physicians Density**
Scope	Basic CPI
Rationale:	A health system comprises all activities with the primary goal of improving health. The number of physicians (medical doctors) available in the city relative to the total urban population gives a good idea of the strength of a city's health care system. The number of physicians is positively associated with immunization coverage, outreach of primary care, and infant, child and maternal survival (WHO, World Health Statistics 2006). [1] A prosperous city seeks to provide adequate health care services to the majority of its population to reduce health related productivity losses and improve the quality of life for all.
Definition:	Number of physicians per 1,000 people, relative to the total city population. Physicians are doctors that study, diagnose, treat, and prevent illness, disease, injury, and other physical and mental impairments in humans through the application of modern medicine. [2] Physicians (medical doctors) include generalist and specialist medical practitioners that work in the city.
Unit [ ]	# / 1,000
Methodology:	$Physicians\ Density = \ 1{,}000\left[\frac{number\ of\ physicians\ available\ within\ the\ city}{City\ population}\right]$
Source:	Censuses, labour force statistics and surveys. Local authorities must provide the number of physicians. Cities report the number of physicians based on administrative records such as registered physicians in the city. Medical registration boards usually have a record of all physicians and their accreditation and area of operation.
Benchmark	Min = 0.01 Max = 7.74 Calculated from The World Bank (2014).
Standardization: 2.1	$Physicians\ Density^{(S)} = \ 1{,}000\left[\frac{\sqrt{Physicians\ Density} - \sqrt{Min}}{\sqrt{Max} - \sqrt{Min}}\right]$ $Physicians\ Density^{(S)} = \ 1{,}000\left[\frac{\sqrt{Physicians\ Density} - 0.1}{2.78 - 0.1}\right]$ Decision: $Physicians\ Density^{(S)} = \begin{cases} 100, & If\ \sqrt{Physicians\ Density} \geq 2.78 \\ Physicians\ Density^{(S)}, & If\ \ 0.1 < \sqrt{Physicians\ Density} < 2.78 \\ 0, & If\ \sqrt{Physicians\ Density} \leq 0.1 \end{cases}$
Limitations	Data to measure this indicator at the city level may be difficult to obtain in some countries (e.g., Colombia). Moreover, traditional healers that are important for the primary care health system in some countries are not taken into account in this indicator. This Indicator is strictly defined to only include highly skilled medical professional. The reality is that there are several family members looking after the sick and other unpaid caregivers and volunteers who contribute to the improvement of health, and are part of the health workforce.
References	**Bibliographic references:** The World Bank (2014). World Development Indicators 1960 – 2013. [3] **URL references:** [1]: http://www.cityindicators.org/IndicatorsDescriptions/49851779Hlth-%20physicians.pdf, Accessed June 11, 2014. [2]: https://www.cia.gov/library/publications/the-world-factbook/geos/co.html, Accessed June 27, 2014. [3]: http://data.worldbank.org/indicator/SH.MED.PHYS.ZS/countries/1W?order=wbapi_data_value_2010%20wbapi_data_value&sort=asc&display=default, Accessed July 2, 2014.

Indicator:	**Number of Public Libraries**
Scope	Extended CPI
Rationale:	Public libraries offer no-cost opportunities for the public to educate itself [1]. The number of public libraries per 100,000 people is an indicator of a city's willing and ability to educate the general public. Public libraries can foster education and productivity and complement the education offered in a city. A prosperous city seeks to improve the education offerings, and foster research and reading habits among its residents to fight poverty traps and crime nests.
Definition:	Number of public libraries per 100,000 people.
Unit [ ]	# / 100,000 people
Methodology:	$Number\ of\ public\ libraries\ =\ 100{,}000\left[\frac{number\ of\ public\ libraries\ available\ within\ the\ city}{City\ population}\right]$
Source:	Population data is usually collected by censuses and surveys. Local authorities must provide number of libraries.
Benchmark	Min = 1 Max = 7 Calculated from World Cities Culture Forum, Indicators, Number of public libraries per 100,000 population [2].
Standardization: 2.1	$Number\ of\ public\ libraries^{(S)} = 100{,}000\left[\frac{number\ of\ public\ libraries - Min}{Max - Min}\right]$ $Number\ of\ public\ libraries^{(S)} = 100{,}000\left[\frac{number\ of\ public\ libraries - 1}{7 - 1}\right]$ Decision: $Number\ of\ public\ libraries^{(S)}$ $= \begin{cases} 100, & If\ Number\ of\ public\ libraries \geq 7 \\ Number\ of\ public\ libraries^{(S)}, & If\ 1 < Number\ of\ public\ libraries < 7 \\ 0, & If\ Number\ of\ public\ libraries \leq 1 \end{cases}$
Limitations	This indicator does not consider the size of the library and its actual usage. In some countries, a public library may be composed of several buildings located throughout the city to serve more people while being managed by one institution. The indicator considers this as one library even though each branch could be counted separately to improve the index.
References	**URL references** [1]: http://www.thedailybeast.com/articles/2010/10/24/ranking-americas-smartest-and-dumbest-cities.html, Accessed August 8, 2014. [2]: http://www.worldcitiesculturefforum.com/indicators/number-public-libraries-100000-population, Accessed June 11, 2014.

3. Information and Communications Technology (ICT) Sub-Index

Indicator:	**Internet Access**
Scope	Basic CPI
Rationale:	The Internet is an information distribution system, and its usage brings education and information within the reach of all who have access to it. It can reduce time lags and open up new information resources, new economic opportunities and possibilities for more environmentally-friendly options for the marketplace (United Nations, 2007). The Internet can allow businesses from developing nations to leapfrog into the development mainstream and offer considerable promise in facilitating the delivery of basic services, such as health and education, which are unevenly distributed at present (United Nations, 2007). Access to the Internet is very important to foster creativity and economic productivity. A prosperous city seeks to give access to the Internet to many within its population to ensure connectivity and equal opportunities for all.
Definition:	The Internet is a world-wide public computer network that provides access to a number of communication services including the World Wide Web and carries email, news, entertainment and data files. Internet access may be via a computer, Internet-enabled mobile phones, digital TV, games machines etc. (United Nations, 2007). Internet users are people with access to the worldwide network [1], relative to the total population. It is the ratio of the total number of Internet users in a city to the total city population, expressed per 100 persons.
Unit [ ]	%
Methodology:	$Internet\ access = 100\left[\frac{number\ of\ Internet\ users}{total\ population}\right]$
Source:	Censuses and surveys, or Internet user surveys.
Benchmark	Min= 0% Max = 100%
Standardization: 1.1	Not required.
Limitations	This indicator does not account for the quality of the Internet access. Poor quality access may not be enough to foster creativity, economic productivity and growth.
References	**Bibliographic references:** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. **URL references:** [1]: http://data.worldbank.org/indicator/IT.NET.USER.P2, accessed August 14, 2014.

Indicator:	Home Computer Access
Scope	Extended CPI
Rationale:	Home computer access along with Internet access, are a powerful tool to foster equality as they can allow anyone to increase creativity and economic productivity (United Nations, 2007). A prosperous city seeks to improve the access to home computers which leads to an increase in economic productivity and education opportunities for its population.
Definition:	The percentage of the households in a city that own home computers relative to the total number of households in the city, expressed per 100 households. Going forward, this indicator will also cover tablets and other mobile and fixed gadgets that have computer level capabilities.
Unit [ ]	%
Methodology:	$Home\ computer\ access = 100\left[\frac{number\ of\ households\ that\ own\ home\ computers}{total\ number\ of\ households}\right]$
Source:	Censuses and surveys.
Benchmark	Min= 0% Max = 100%
Standardization: 1.1	Not required.
Limitations	This indicator does not account for the digital divide (i.e. gap between demographics and regions that have access to modern information and communications technology, and those that don't or have restricted access) in some cities. The digital divide is more than just an access problem and cannot be fixed by providing a home computer.
References	**Bibliographic references:** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York.

Indicator:	Average Broadband Speed
Scope	Extended CPI
Rationale:	Access to high speed internet: fosters major economic growth and rapid job creation, increases access to quality health care, enhances access to education (e.g. via distance learning) and increases digital literacy, breaks the barriers of distance and time allowing more rural communities participate in economic and civic activities, and enables more citizen and government interaction for more accountability and better public services. This indicator complements the Internet access indicator by quantifying the average broadband speed in the city. Broadband Internet access is important for city dwellers to participate in socio-economic activities, through ease of sharing information for example real-time content sharing via video applications or peer-to-peer audiovisual applications (OECD, 2009). A prosperous city seeks to increase the average broadband speed to foster economic productivity and ensure equal opportunities for all.
Definition:	Average broadband speed is the average speed of broadband connections for Internet access within the city. The Internet is defined as a worldwide public computer network that provides access to a number of communication services including the World Wide Web and carries email, news, entertainment and data files (United Nations, 2007). Broadband is a high-capacity transmission technique using a wide range of frequencies, which enables a large number of messages to be communicated simultaneously. This service provides Internet access at speeds higher than 256 Kbps (OECD, 2009), but nowadays is usually in the order of several Megabits per second (Mbps, one Mbps equals 1,000 Kbps).
Unit [ ]	Kbps (Kilobytes per second)
Methodology:	Collect the Monthly Average Broadband Speed at city level from Ookla Net Index Explorer [1]. If not available for the city, collect the figure from local Internet Service Providers.
Source:	Internet Service Providers usually measure the average broadband speed, and the Ookla company developed the Net Index [1], a complete picture of global broadband performance that gives month-by-month data since 2012 based on end-users speed tests of current broadband speed. When the city does not have data in the Ookla Net Index Explorer, local Internet Service Providers must be contacted to provide the current broadband speed.
Benchmark	Min = 470 Kbps Max = 87,088 Kbps Source: Average value of the 12 months of 2013 daily broadband speeds at city level obtained from Ookla Net Index, table city_daily_speeds.cvs [2]. This benchmark must be updated yearly meaning that benchmarks for broadband speed average of 2014, 2012, and 2011 will use their year specific averages and not the benchmarks for 2013.
Standardization: 2.1	$Average\ Broadband\ Speed^{(S)} = 100\left[\frac{\sqrt[5]{Average\ Broadband\ Speed} - \sqrt[5]{Min}}{\sqrt[5]{Max} - \sqrt[5]{Min}}\right]$ $Average\ Broadband\ Speed^{(S)} = 100\left[\frac{Average\ Broadband\ Speed - 3.43}{9.73 - 3.43}\right]$ Decision: $Average\ Broadband\ Speed^{(S)} = \begin{cases} 100, If\ Average\ Broadband\ Speed \geq 9.73 \\ Average\ Broadband\ Speed^{(S)}, If\ 3.43 < Average\ Broadband\ Speed < 9.73 \\ 0, If\ Average\ Broadband\ Speed \leq 3.43 \end{cases}$
Limitations	Some cities do not have data in the Ookla Net Index Explorer. The advertised broadband speed of local Internet Service Providers is usually below the current broadband speed measured in the Ookla Index Explorer.
References	**Bibliographic references:** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. OECD (2009) Indicators of Broadband Coverage. Technical report DSTI/ICCP/CISP (2009)3/FINAL, 10-Dec-2009.

	URL references [1]: http://explorer.netindex.com (Net Index Explorer by Ookla), Accessed 30 July 2014. [2]: http://www.akamai.com/dl/akamai/akamai-soti-q413.pdf?WT.mc_id=soti_Q413 (Akamai's State of the Internet, Q4 2013 Report, Vol 6, No 4), Accessed 30 July 2014.

4. Urban Mobility (UM) Sub-Index

Indicator:	**Use of Public Transport**
Scope	Basic CPI
Rationale:	Over dependence on car use can generate several environmental, economic and social problems in urban areas such as congestion, pollution and traffic fatalities and continuous reduction of open public spaces. In order to achieve safer, more affordable, accessible and sustainable mobility in urban areas, a dual approach based on the improvement of public transit systems and the encouragement of non-motorized modes like walking and cycling and public transit system should be encourage. Particularly paying spatial attention the most vulnerable road users. A prosperous city seeks to reduce car use by improving the quality of other transportation systems based on public and non-motorized transport.
Definition:	Percentage of trips made in a Public Transport (PT) mode from the total number of motorized trips.
Unit [ ]	%
Methodology:	**Method A:** $Use\ of\ PT\ ratio = 100\left[\frac{Number\ of\ trips\ in\ PT\ modes}{Number\ of\ total\ motorized\ trips}\right]$
Source:	Local transport authorities.
Benchmark	Min = 5.95% Max = 62.16% Calculated from CERTU world regions (CERTU, 2008)
Standardization: 2.1	$Use\ of\ PT\ Ratio^{(S)} = 100\left[\frac{Use\ of\ PT\ Ratio - Min}{Max - Min}\right]$ $Use\ of\ PT\ Ratio^{(S)} = 100\left[\frac{Use\ of\ PT\ Ratio - 5.95}{62.16 - 5.95}\right]$ Decision: $Use\ of\ PT\ Ratio^{(S)} = \begin{cases} 100, & If\ Use\ of\ PT\ Ratio \geq 62.16 \\ Use\ of\ PT\ Ratio^{(S)}, & If\ 5.95 < Use\ of\ PT\ Ratio < 62.16 \\ 0, & If\ Use\ of\ PT\ Ratio \leq 5.95 \end{cases}$
Limitations:	Although this indicator does not capture non-motorized trips, it is highly recommended that it is included and measured in modal share surveys. Non-formal transport or para-transit is very frequent in some cities, but surveys do not always capture this information.
References	**Bibliographic references** CERTU (2008). Guide pédagogique: Stratégie de Mobilité durable. Lyon (Francia). p.73 Winston, H. Motor vehicles and the environment. Resources for the future RFF Report. Washington. 2003 [1]. **URL references** [1] http://www.rff.org/rff/Documents/RFF-RPT-carsenviron.pdf, Accessed August 14, 2014.

Indicator:	**Average Daily Travel Time**
Scope	Basic CPI
Rationale:	The time spent commuting is an indirect measure of the quality of the mobility systems and the distribution of economic activities in a city. In many cases, the average travel time increases as a consequence of traffic congestion. A prosperous city seeks to reduce travel time by promoting the use of more efficient modes of transport such as mass transit, cycling and walking, and by reducing car use (Rodriguez and Comtois, 2006).
Definition:	The average estimated travel time per trip using any transport means in minutes.
Unit [ ]	Minutes (min.)
Methodology:	The average travel time from all trips using all modes of transport (including motorized and non-motorized modes). Notice that the average time is only for the average trip.
Source:	Local transport authorities and, in some countries, Living Standards Households Surveys.
Benchmark	X^*= 30 min. Calculated from CAF Development Bank of Latin America (2009).
Standardization: 4	$Average\ daily\ travel\ time^{(S)} = 100\left(1 - \left\lvert\frac{Average\ daily\ travel\ time - X^*}{X^*}\right\rvert\right)$ $Average\ daily\ travel\ time^{(S)} = 100\left(1 - \left\lvert\frac{Average\ daily\ travel\ time - 30}{30}\right\rvert\right)$ Decision: $Average\ daily\ travel\ time^{(S)} = \begin{cases} 0, if\ Average\ daily\ travel\ time \geq 2 * 30 \\ Average\ daily\ travel\ time^{(S)}, \quad If\ \ 30 < Average\ daily\ travel\ time < 2 * 30 \\ 100, \quad If\ Average\ daily\ travel\ time \leq 30 \end{cases}$
Limitations:	The average daily travel time can be estimated from different sources, especially surveys. Some of these calculations are made as a function of individual perceptions, which can generate deviations from the true travel times. Calculations made from mobility surveys are more accurate because they are not based on individual perceptions. Mobility surveys often take in consideration only the motorized private vehicle transport, disregarding public and non-motorized mobility.
References	**Bibliographic references** CAF Banco de Desarrollo de América Latina (2009). Observatorio de Movilidad Urbana para América Latina: Información para mejores políticas y mejores ciudades. CAF. [1] Rogriguez, J. Comtois, C. The geography of transports systems. New York. 2006. **URL references:** [1]: http://omu.caf.com/media/30839/desarrollourbano_y_movilidad_americalatina.pdf, Accessed June 11, 2014.

Indicator:	**Length of Mass Transport Network**
Scope	Extended CPI
Rationale:	Transit connects and integrates distant parts of the city. Although various forms of transit support urban transport needs including low and high-capacity vehicles, taxis and motorized rickshaws, bi-articulated buses and trains (ITDP, 2013); high-capacity public transit allows for highly efficient and equitable urban mobility, and supports dense and compact development patterns. A prosperous city seeks to cover most parts of its territory through an adequate public transport network system based on optimal technologies, quality and performance to ensure a more comfortable and efficient system.
Definition:	The total length of all superior modes of public transport; i.e. BRT, trolleybus, tram, light rail and subway, cable cars and ferry relative to the size of the city (number of inhabitants). This indicator applies to cities above 500,000 inhabitants. Intermediate cities with less than 500,000 inhabitants may achieve efficient mobility through lower capacity public transport modes.
Unit [ ]	Km / 1,000,000 people.
Methodology:	$Length\ of\ mass\ transport\ network = 1{,}000{,}000\left[\frac{Total\ length\ of\ mass\ transport\ lanes}{Total\ number\ of\ city\ inhabitants}\right]$
Source:	Local Transportation Authorities
Benchmark	X^*= 80 km per 1,000,000 people. Obtained from CERTU (2008) p.131.
Standardization: 3	$Length\ of\ mass\ transport\ network^{(S)} = 100\left(1 - \left\lvert\frac{Length\ of\ mass\ transport\ network - X^*}{X^*}\right\rvert\right)$ $Length\ of\ mass\ transport\ network^{(S)} = 100\left(1 - \left\lvert\frac{Length\ of\ mass\ transport\ network - 80}{80}\right\rvert\right)$ Decision: $Length\ of\ mass\ transport\ network^{(S)}$ $= \begin{cases} 0, if\ Length\ of\ mass\ transport\ network < 0 \\ Length\ of\ mass\ transport\ network^{(S)}, \quad If\ 0 \leq Length\ of\ mass\ transport\ network < 80 \\ 100, \quad If\ Length\ of\ mass\ transport\ network \geq 80 \end{cases}$
Limitations:	This data must be treated carefully because it doesn't include the conventional bus transport which is the principal form of public transport in the city especially in many cities of the developing countries.
References	**Bibliographic references** Institute for Transportation and Development Policy (2013) TOD Standard v. 2.0. New York. [1] CERTU. (2008). Guide pédagogique: Stratégie de Mobilité durable. Lyon (Francia). **URL references** [1]: http://mexico.itdp.org/wp-content/uploads/TOD_v2_FINAL.pdf, Accessed August 14, 2014.

Indicator:	Traffic Fatalities
Scope	Extended CPI
Rationale:	Traffic fatalities is the eighth leading cause of death globally, and the leading cause of death for young people aged 15–29 years. The World Health Organization predicts that by 2020, traffic fatalities will be the third cause of mortality in the world. This is not only a matter of health care, as many cities have found that by reducing traffic fatalities they reduce related health and productivity losses (World Health Organization, 2004).Over one-third of road traffic fatalities in low and middle-income countries involve pedestrians and cyclists. Less than 35% of low and middle-income countries have policies to protect these road users (World Health Organization, 2013). A prosperous city seeks to reduce traffic fatalities through improvement of physical infrastructure and policy implementation.
Definition:	A traffic fatality is defined as any person killed immediately or dies within 30 days as a result of a road traffic accident. This is calculated as the ratio of the total number of fatalities from traffic accidents per year to the total city population, expressed per 100,000 people.
Unit [ ]	# / 100,000 people
Methodology:	$Traffic\ fatalities\ = 100{,}000\left[\frac{Total\ traffic\ fatalities\ per\ year}{City\ population}\right]$
Source:	Records and reports from traffic or transportation authorities, urban or city police departments and hospitals.
Benchmark	Min = 1 fatalities per 100,000 people per year Max = 31 fatalities per 100,000 people per year Calculated from World Health Organization data [1].
Standardization: 2.2	$Traffic\ fatalities^{(S)}\ = 100\left[1-\frac{Traffic\ fatalities\ -Min}{Max-Min}\right]$ $Traffic\ fatalities^{(S)}\ = 100\left[1-\frac{Traffic\ fatalities\ -1}{31-1}\right]$ Decision: $Traffic\ fatalities^{(S)}\ = \begin{cases} 0, & If\ Traffic\ fatalities\ \geq 31 \\ Traffic\ fatalities^{(S)}, & If\ 1 < Traffic\ fatalities\ < 31 \\ 100, & If\ Traffic\ fatalities\ \leq 1 \end{cases}$
Limitations:	Traffic fatalities are not frequently reported or are partially reported by the authorities. It is necessary that this information is recorded by each city in order to allow for global comparability in a bid to improve road safety.
References	**Bibliographic references** World Health Organization (2004). World report on road traffic injury prevention. Geneva. [2] World Health Organization (2013). Global report on road safety. Luxembourg. [3] **URL references** [1]: http://apps.who.int/gho/data/node.main.A997, Accessed June 11, 2014. [2]: http://www.who.int/violence_injury_prevention/publications/road_traffic/world_report/en/, Accessed June 11, 2014. [3]: http://www.who.int/violence_injury_prevention/road_safety_status/2013/en/, Accessed June 11, 2014.

Indicator:	Affordability of Transport
Scope	Extended CPI
Rationale:	Urban transport can contribute to poverty reduction both indirectly through its impact on the city economy and directly through its impact on the daily needs of poor people (World Bank, 2005).Urban growth often has perverse distributional effects. There are several reasons why people decide to live in the periphery. Sometimes because of cultural reasons, but many times people are forced to live on less expensive land, either in slums or on regular territories of the city located in the periphery. These locations considerably affect the time and cost of transport (World Bank, 2005). A prosperous city seeks to reduce the household budget allocated for transport. Therefore, prosperous cities should seek to make (1) location efficient neighborhoods which are compact with walkable streets, access to transit, and a variety of amenities and (2) public transport services affordable for the poor people. However, urban growth is not the only reason why transport is expensive for poor people in cities. The affordability indicator can be used to determine whether public transport is too expensive in a given city and therefore whether intervention is required. This indicator can therefore be used to compare the affordability of transport before and/or after transport policy interventions are introduced (World Bank, 2009).
Definition:	"Affordability" refers to the extent to which the financial cost of journeys require an individual or household to make sacrifices to travel or the extent to which they can afford to travel when they want to. Therefore, affordability indicates the ability to make necessary journeys to work, school, health and other social services; to visit family members; or to make other urgent journeys without having to curtail other essential activities" (World Bank, 2009). Total amount of budget per month per person, invested in public transport in relation to the per capita income for the lowest income quintile.
Unit [ ]	%
Methodology:	1. Estimate the average cost per trip using public transport in the city 2. Estimate the average per capita income of the bottom quintile in the city 3. Multiply the average cost per trip in public transport by 60 and divide it by the average per capita income of the bottom quintile $Affordability\ of\ transport\ = 100\left[\frac{Number\ of\ trips * average\ cost\ per\ trip}{Per\ capita\ income}\right]$ According to this methodology adopted from the World Bank, the number of trips is equal to 60, and the per capita income is related to the lowest income quintile in the city.
Source:	Various surveys. Living Standards Households Surveys to get the per capita income and sometimes, the average cost per trip. However, the latter may also be obtained from Mobility surveys or from traffic department data.
Benchmark	Min = 4% Max = 26% Estimated from a benchmark provided by the World Bank (2005). p 14.
Standardization: 2.2	$Affordability\ of\ transport^{(S)}\ = 100\left[1 - \frac{Affordability\ of\ transport\ - Min}{Max - Min}\right]$ $Affordability\ of\ transport^{(S)}\ = 100\left[1 - \frac{Affordability\ of\ transport\ - 4}{26 - 4}\right]$ Decision: $Affordability\ of\ transport^{(S)}$ $= \begin{cases} 0, & If\ Affordability\ of\ transport\ \geq 26 \\ Affordability\ of\ transport^{(S)}, & If\ 4 < Affordability\ of\ transport\ < 26 \\ 100, & If\ Affordability\ of\ transport\ \leq 4 \end{cases}$
Limitations:	The average per capita income of the bottom quintile in the city is not available on a systematic basis. However, surveys are available for some cities, and these suggest that the city income distribution is indeed similar to that at the national level (World Bank, 2005). However, individuals do not often declare the total amount of money that they receive and they can exaggerate the costs of daily transportation.
References	**Bibliographic references** World Bank (2005). Affordability of Public Transport in Developing Countries. Washington. [1] World Bank (2007). Affordability and Subsidies in Public Urban Transport. Washington. [2]

	URL references [1]: http://siteresources.worldbank.org/INTTRANSPORT/214578-1099319223335/20460038/TP-3_affordability_final.pdf, Accessed June 11, 2014. [2]: http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-4440, Accessed June 11, 2014.

5. Urban Form (UF) Sub-Index

Indicator:	**Street Intersection Density**
Scope	Basic CPI
Rationale:	Walkability in a city depends on block sizes and intersections that provide places where cars must stop, and pedestrians can cross. The greater the intersection density, the smaller the blocks and the more walkable the neighborhood (Ewing, 1999). However, the size of blocks and connectivity is not sufficient to determine walkability in a city. The use and distribution of the road space in a way that prioritizes pedestrians and other vulnerable road users, as well as traffic regulation and road behavior is very important to facilitate walking. A prosperous city seeks to find a proper block size to promote walkability.
Definition:	Number of street intersections per one square kilometer of urban area
Unit [ ]	# / km^2
Methodology:	1. Obtain the street network map of the urban area 2. Verify the topology: each street segment must be properly connected to other segments. 3. Obtain the start and end point of each segment. 4. Collect events from start and end points: collect the multiple endpoints at an intersection together and count the number of endpoints at each intersection. 5. Exclude points with less than 3 events, i.e. the dead ends or broken segment ends. 6. Count the remaining points and divide by the urban area in km^2.
Source:	Local or City urban planning authorities based on cartography
Benchmark	X^*= 100 intersections per km^2, based on UN-HABITAT Global Urban Observatory estimation (2013).
Standardization: 3	$Street\ intersection\ density^{(S)} = 100\left(1 - \left\lvert\frac{Street\ intersection\ density - X^*}{X^*}\right\rvert\right)$ $Street\ intersection\ density^{(S)} = 100\left(1 - \left\lvert\frac{Street\ intersection\ density - 100}{100}\right\rvert\right)$ Decision: $= \begin{cases} Street\ intersection\ density^{(S)} \\ 0, if\ Street\ intersection\ density < 0 \\ Street\ intersection\ density^{(S)}, \quad If\ \ 0 \le Street\ intersection\ density < 100 \\ 100, \quad If\ Street\ intersection\ density \ge 100 \end{cases}$
Limitations:	This indicator is measured to determine whether a city is permeable enough to guarantee walkability. However, it assumes that all the intersections are secure for pedestrians, which in reality (in some cities) might not be true. With some exceptions, very high intersection densities do not translate in more connected places.
References	**Bibliographic references** Ewing, E.H. (1999) Pedestrian and transit friendly design: A primer for smart growth. Smart growth network. [1] Institute for Transportation and Development Policy (2013) TOD Standard v. 2.0. New York. UN Habitat (2013). The relevance of street patterns and public spaces in urban areas. Working Paper. **URL references** [1]: http://epa.gov/smartgrowth/pdf/ptfd_primer.pdf, accessed August 14, 2014.

Indicator:	**Street Density**
Scope	Basic CPI
Rationale:	The proportion of urban areas dedicated to streets and public spaces is a crucial feature of the spatial plans of cities. The road network is the integrative and dynamic factor between the population and socioeconomic activities. It's a structuring component of geographic space and defines the socio-dynamics of an area being conditioned by the spatial pattern, which restricts the location of roads and human settlements (UN-Habitat, 2013). Short and direct pedestrian and cycling routes require a highly connected network of paths and streets around small, permeable blocks. These features are primarily important for walking and for transit station accessibility, which can be easily discouraged by detours. (ITDP, 2013) Cities that have adequate street and public spaces and greater connectivity are more livable and economically productive (UN-Habitat, 2013). A prosperous city seeks a tight network of paths and streets offering multiple routes to many destinations that also make walking and cycling trips varied and enjoyable. (ITDP, 2013).
Definition:	Number of kilometers of urban streets per square kilometer of land
Unit [ ]	km / km^2
Methodology:	1. Select the streets included in the urban area only 2. Count the number of kilometers of the urban streets 3. Divide the number of kilometers by the total urban surface. $Street\ density = \frac{Total\ lenght\ of\ urban\ streets}{Total\ of\ urban\ surface}$
Source:	Local or City urban planning authorities based on cartography
Benchmark	X^*= 20 kilometers of urban streets per km^2. Based on UN-HABITAT Global Urban Observatory estimations (2013).
Standardization: 5	$Street\ density^{(S)} = 100\left(1 - \left\lvert\frac{Street\ density - X^*}{X^*}\right\rvert\right)$ $Street\ density^{(S)} = 100\left(1 - \left\lvert\frac{Street\ density - 20}{20}\right\rvert\right)$ Decision: $Street\ density^{(S)} = \begin{cases} 0, & if\ Street\ density = 0\ or\ Street\ density = 2 * 20 \\ Street\ density^{(S)}, & If\ \ 0 < Street\ density < 2 * 20 \\ 100, & If\ Street\ density = 20 \end{cases}$
Limitations:	Because this is a measure of "permeability," this indicator includes all kind of streets (i.e. primary and secondary). Walkability is based on the permeability, which is guaranteed by all the streets in a city. Hence, this measure must be combined with the intersection density indicator. This is because many parallel streets without intersections might produce adequate street density but insufficient permeability.
References	**Bibliographic References** Institute for Transportation and Development Policy (2013) TOD Standard v. 2.0. New York. [1] UN Habitat (2013). The relevance of street patterns and public space in urban areas. [2] Universidad Nacional de Luján, Argentina. Programa de Estudios Geográficos (PROEG). Patrón espacial de la cobertura vial como factor integrador y dinamizador de la movilidad urbana en el municipio chacao, estado Miranda. Revista digital del Grupo de Estudios sobre Geografía y Análisis Espacial con Sistemas de Información Geográfica (GESIG). Luján. 2012. [3] **URL references** [1]: http://mexico.itdp.org/wp-content/uploads/TOD_v2_FINAL.pdf, accessed August 14, 2014. [2]: http://mirror.unhabitat.org/downloads/docs/StreetPatterns.pdf, accessed August 14, 2014. [3]: http://www.gesig-proeg.com.ar/documentos/revista-geosig/2012/Investigacion/07-MARTINEZ-GEOSIG4-2012.pdf, accessed June 11, 2014.

Indicator:	**Land Allocated to Streets**
Scope	Basic CPI
Rationale:	Transportation systems consume large amounts of land from spaces allocated for both the circulation and parking of vehicles. Land must be allocated for complementary facilities such as public transport terminals, stations, offices and warehouses related to transportation (CAF, 2010). When cities are shaped for people, personal motor vehicles become largely unnecessary for day-to-day city living. Walking, cycling and the use of high-capacity transit are easy and convenient, and can be supplemented by a variety of intermediary transit modes such as rented vehicles that are much less space-intensive. Valuable urban spaces can be reclaimed from unnecessary roads and parking, and reallocated to more socially and economically productive uses (ITDP, 2013). However, an adequate proportion of land dedicated to streets may guarantee enough space to have a proper mobility system, because it is over those streets where the development of a new public transport system could take place in the future. A prosperous city seeks an optimal allocation of land dedicated to streets to guarantee good performance of the mobility system, share space among modes and to avoid sizeable extensions of spaces dedicated to personal motor vehicles. Cities that have adequate street and public spaces and connectivity are more livable and productive.
Definition:	Total area of urban surface allocated to streets.
Unit [ ]	%
Methodology:	1. Select only the streets included in the urban area 2. Estimate the total urban surface allocated to streets 3. Divide the number of square kilometers of urban streets by the total square kilometers of urban surface. $Land\ allocated\ to\ streets = 100\left[\frac{Total\ surface\ of\ urban\ streets}{Total\ surface\ of\ urban\ area}\right]$
Source:	Local or city urban planning authorities based on cartography
Benchmark	Min = 6% Max = 36% Based on UN-HABITAT Global Urban Observatory estimations (2013), Page. 4.
Standardization: 2.1	$Land\ allocated\ to\ streets^{(S)} = 100\left[\frac{Land\ allocated\ to\ streets\ - Min}{Max - Min}\right]$ $Land\ allocated\ to\ streets^{(S)} = 100\left[\frac{Land\ allocated\ to\ streets\ - 6}{36 - 6}\right]$ Decision: $Land\ allocated\ to\ streets^{(S)}$ $= \begin{cases} 100, & If\ Land\ allocated\ to\ streets\ \geq 36 \\ Land\ allocated\ to\ streets^{(S)}, & If\ 6 < Land\ allocated\ to\ streets\ < 36 \\ 0, & If\ Land\ allocated\ to\ streets\ \leq 6 \end{cases}$
Limitations:	It's challenging to obtain complete information about city streets. It's sometimes necessary to make assumptions about street dimensions, and remote sensing data could be useful in these cases.
References	**Bibliographic references** CAF (2010) Observatorio de Movilidad. Análisis de movilidad urbana, espacio, medio ambiente y equidad. Bogotá. Institute for Transportation and Development Policy (2013) TOD Standard v. 2.0. New York. UN-Habitat (2013) The relevance of street patterns and public spaces in urban areas. Working paper. [1] **URL references** [1]: http://unhabitat.org/the-relevance-of-street-patterns-and-public-space-in-urban-areas/, Accessed June 11, 2014.

6.3 QUALITY OF LIFE INDEX

In the past, prosperity was only defined in terms of economic strength i.e. a person was considered more prosperous as his income or wealth increased. However, attention has shifted to other definitions of prosperity that include more components apart from just economic ability[7]. After extensive study, quality of life was found out to be one of the most significant aspects of prosperity.

The Oxford dictionary describes quality as, "the standard of something as measured against other things of a similar kind". Quality of life can therefore be understood, in general terms, to be how an individual's or society's life or situation is in comparison to another person or society - how good (or bad) someone's life is compared to other individuals of societies. Therefore, this is the measurement of a city's average achievement in ensuring general well-being and satisfaction of its citizens.

Ferrell, who has carried out a large research programme on pain and quality of life, defined quality of life as well-being covering four areas: quality of life is physical, mental, social and spiritual well-being (Ferrell, 1995)[8]. Lindströ and Henriksson, (1996) [9] present a model where quality of life is divided into four life spheres; the global, external, interpersonal and personal sphere where the latter is represented by the physical, mental and spiritual dimension. An individual is therefore satisfied when his external (physical, apart from monetary needs) and internal (mental, social, spiritual and emotional) needs are met. The Quality of life dimensions will measure how well these needs have been catered for by the city. The external aspect of Quality of Life is determined by an individual's health. Without good health, one cannot enjoy life and pursue other dimensions of a good life e.g. work, go to school etc. This section will measure the quality of healthcare provided and how easily these services can be accessed by the city's citizens.

The internal aspect is divided into several categories:

- First will be the quality and level of education that an individual has. This is a basic need that has a strong influence on well-being. Better educated people get higher wages, have a healthier status, participate more in politics and community activities and generally lead more satisfied and happier lives.
- Second is how safe and secure the city is and how safe an individual feels within this city. When people and basic institutions are unsafe and unstable, capital, investment, and people flee. Academic research shows that crime and mistrust stemming from poor social cohesion hinder economic growth. In addition, an environment of fear and uncertainty negatively affects life satisfaction[10].
- Third will be the availability of avenues where social interaction is encouraged and occurs. Man is not an island and interacting with other people is important for a good quality of life. It has been shown that individuals who interact with friends or family regularly have a more satisfied life than those who do not. This interaction breeds trust amongst individuals and a sense of belonging. A prosperous city will therefore seek to provide places where this interaction is encouraged.

Computing the Quality of Life Index
The indicator variables within the Productivity Index are classified below:

DIMENSION	SUB-DIMENSION	INDICATOR
Quality Of Life Index (QoL)	1. Health (H)	1.1. Life Expectancy At Birth 1.2. Under-Five Mortality Rate 1.3. Vaccination Coverage 1.4. Maternal Mortality
	2. Education (E)	2.1. Literacy Rate 2.2. Mean Years Of Schooling 2.3. Early Childhood Education 2.4. Net Enrollment Rate In Higher Education
	3. Safety and Security (SS)	3.1. Homicide Rate 3.2. Theft Rate
	4. Public Space (PS)	4.1. Accessibility To Open Public Area 4.2. Green Area Per Capita

7 SWCR 2012/2013
8 Ferrell, B. (1995). The impact of pain on quality of life. A decade of research. *The Nursing Clinics of North America, 30*(4), 609
9 Lindströ, B., & Henriksson, B. (1996). The essence of existence On the quality of life of children in the Nordic countries. *International Journal of Social Welfare, 5*(2), 117-118.
10 Legatum (2013) *Methodology and Technical Appendix: Safety and Security*, p 22

To compute the Quality Of Life Index, at the Basic CPI level, the variables within the sub-dimensions are aggregated as follows:

QUALITY OF LIFE INDEX (QL) = 1/4 [Health (H) + Education (E) + Safety and Security (SS) + Public Space (PS)]

Where:

H = (1/2) [Life Expectancy at Birth + Under-Five Mortality Rate]
E = (1/2) [Literacy Rate + Mean Years of Schooling]
SS = Homicide rate
PS = Accessibility to Open Public Area

The Quality Of Life Index can also be estimated at an Extended CPI level. To do this, aggregate the variables within the sub-dimensions as follows:

QUALITY OF LIFE INDEX (QL) = 1/4 [Health (H) + Education (E) + Safety and Security (SS) + Public Space (PS)]

Where:

H = (1/4) [Life Expectancy at Birth + Under-Five Mortality Rate + Vaccination Coverage + Maternal Mortality]
E = (1/5) [Literacy Rate + Mean Years of Schooling + Under-Six Participation on First Stage Development Programs + Net enrolment rate in higher education + Number of Top Universities]
SS = (1/2) [Homicide rate + Theft rate]
PS = (1/2) [Accessibility to Open Public Area + Green Area Per Capita]

1. Health Sub-Index

The health sub-index under the Quality of Life dimension of the CPI will measure:

- Quality of health services - the eventual by products of a good health and healthcare system in the city will be measured i.e. long life and low death rates. CPI will measure this using life expectancy at birth, under-5 mortality and maternal mortality.

- Access to the health services - easier access leads to better health. The indicators used will be the proportion of children under 1 year and women who have received their vaccination against infectious diseases. Vaccination programmes that are well implemented reduce significantly the deaths among children leading to longer healthier life and productivity.

Indicator:	**Life Expectancy at Birth**
Scope	Basic CPI
Rationale:	A health system's main objective is to preserve individuals' lives. Life expectancy is the most commonly used measure to describe population health as it reflects the overall mortality levels of a population. It measures on average how long a person is expected to live, based on current age and sex-specific death rates. The life expectancy for a particular person or population group depends on variables such as their lifestyle, access to healthcare, diet, economical status and the relevant mortality and morbidity data [1]. It is, therefore, related to the health conditions of the population, which are key factors in fostering economic growth, sustainable development and increase people's well-being [2]. Life expectancy at birth is expressed as the number of years of life a new born is expected to live if current mortality rates continue to apply[11]. It summarizes the mortality pattern that prevails across all age groups - children and adolescents, adults and the elderly (WHO, 2006). A prosperous city will thus seek to increase the life expectancy of its citizens in order to increase their quality of life.
Definition:	Average number of years that a newborn could expect to live if he or she were subject to the age-specific mortality rates of a given period (United Nations, 2007).
Unit [ ]	Years
Methodology:	The most generalized and widely accepted procedure to estimate this indicator in case it is not available at city level is to construct a life table. The World Health Organization (2014) mentions, "life tables have been developed for all Member States for years 1990-2012 starting with a systematic review of all available evidence from surveys, censuses, sample registration systems, population laboratories and vital registration on levels and trends in under-five and adult mortality rates." According to Fitzpatrick (2001), the information needed to estimate a life table is: a) Population expressed in year age bands (usually in 5 years age bands) and b) Deaths in year age bands (usually in 5 years age bands). Based on that information all other columns of data and the expectation of life can be calculated. The final estimation of life expectancy is made through the following formula: $Life\ expectancy\ at\ birth: e_0 = \frac{T_0}{l_0}$ This equation has been adapted from the following generalized life expectancy estimation formula used to estimate the life table: $e_x = \frac{T_x}{l_x}$ where: • e_x: Life expectancy at age "x", which means the number of years a person aged "x" can be expected to live. • T_x: Total number of years lived at age "x" after the interval. • l_x: Number of people alive at the start of the interval

[11] http://www.who.int/whosis/whostat2006DefinitionsAndMetadata.pdf, pg. 1

	Both "T_x" and "l_x" include previous calculations of the probability of surviving, the average proportion of the year lived by those who die and intervals' corrections and adjustments (For more estimation details, see Fitzpatrick, 2001). It is important to note that as mentioned by World Health Organization (2014) there are alternative ways of estimating life tables and life expectancy; some of them may include adjustments for health and country conditions (e.g., high levels of HIV). Then, the procedure selected depends on the country.
Source:	Usually this indicator is already estimated (and projected) by the Statistics Department of the city/government, Country's Statistics Department: Vital registration systems, censuses or demographic surveys; United Nations Department of Economic and Social Affairs (UN/DESA/Statistics Division; United Nations Children's Fund (UNICEF); and World Health Organization (WHO).
Benchmark	Min = 49 years Max = 83.48 years Calculated from World Bank: World Development Indicators [4].
Standardization: 2.1	$Life\ expectancy\ at\ birth^{(S)} = 100\left[\frac{Life\ expectancy\ at\ birth - Min}{Max - Min}\right]$ $Life\ expectancy\ at\ birth^{(S)} = 100\left[\frac{Life\ expectancy\ at\ birth - 49}{83.48 - 49}\right]$ Decision: $Life\ expectancy\ at\ birth^{(S)}$ $= \begin{cases} 100, & If\ Life\ expectancy\ at\ birth \geq 83.48 \\ Life\ expectancy\ at\ birth^{(S)}, & If\ \ 49 < Life\ expectancy\ at\ birth < 83.48 \\ 0, & If\ Life\ expectancy\ at\ birth \leq 49 \end{cases}$
Limitations	Usually this indicator is estimated every five years. As a result of this, yearly changes may not be available. When high quality data on deaths (from vital registrations) or appropriate age adjustments cannot be found, population censuses can provide adequate information. If high quality data is not available, a method that encompasses indicators of mortality from indirect information on the risks of death obtained from special questions included in censuses or demographic surveys can be used (United Nations, 2007).
References	**Bibliographic references** World Health Organization (WHO). (2006). Metadata: Life Expectancy at Birth. [3] Fitzpatrick, Justine. (2001) Calculating life expectancy and infant mortality rates Technical Supplement. [5] United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. [6] World Health Organization (2014). WHO methods for life expectancy and healthy life expectancy – Department of Health Statistics and Information. Systems (page 5). Geneva, Switzerland [7] **URL references** [1]: http://www.aihw.gov.au/deaths/life-expectancy, accessed August 21, 2015 [2]: http://www.news-medical.net/health/What-is-Life-Expectancy.aspx, accessed August 21, 2015 [3] http://www.who.int/whosis/whostat2006DefinitionsAndMetadata.pdf, accessed June 11, 2014. [4]: http://data.worldbank.org/indicator/SP.DYN.LE00.IN, accessed June 11, 2014. [5]: http://www.lho.org.uk/Download/Public/7656/1/tech_supp_3.pdf, accessed June 11, 2014. [6]:http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/health/life_expectancy.pdf, accessed June 11, 2014. [7]: http://www.who.int/healthinfo/statistics/LT_method.pdf, accessed June 11, 2014.

Indicator:	Under-five Mortality Rate (U5MR)
Scope	Basic CPI
Rationale:	Child health and development is one of the most strongly and universally supported development goals. Because data on the incidences and prevalence of diseases (morbidity data) is frequently unavailable, mortality rates are often used to identify vulnerable populations. The under-five mortality rate captures more than 90 percent of global mortality among children under the age of 5[1].It provides an adequate measure for child health and overall human development and captures the effects of factors such as disease incidence and prevalence on the under-five children, which may not be easy to identify at city level (Millennium Development Goals, 2012; United Nations, 2007). In many cases it reflects social, economic and environmental conditions in which children (and others in society) live, including their health care. This is because under-five mortality levels are influenced by poverty; education (particularly of mothers); availability, accessibility and quality of health services; environmental risks, including access to safe water and sanitation; and by nutrition (United Nations, 2007). A prosperous city will seek to improve quality of life by setting up measures that help reduce the under-five mortality rate.
Definition:	Under-five mortality rate is the probability of a child born in a specific year or period dying before reaching the age of five, subject to age-specific mortality rates of that period [5]. U5MR is not a rate (i.e. the number of deaths divided by the number of population at risk during a certain period of time) but a probability of death derived from a life table and expressed as a rate per 1000 live births.
Unit [ ]	# / 1,000 live births
Methodology:	$Under-five\ mortality\ rate = \frac{Number\ of\ under-five\ deaths}{1{,}000\ live\ births}$ - Under –five deaths have been calculated using life tables and probabilities of death. It is not simply the actual number of observed deaths within that year - Live births: refers to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life - e.g. beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles - whether or not the umbilical cord has been cut or the placenta is attached. Each product of such a birth is considered live born [12]
Source:	Country's Statistics Department: Vital registration systems, censuses or demographic surveys; United Nations Department of Economic and Social Affairs UN/DESA/Statistics Division; United Nations Children's Fund (UNICEF); Child Mortality Estimates [5] and World Health Organization (WHO).
Benchmark	Min = 2.20 children per 1,000 live births Max =181.60 children per 1,000 live births Obtained from World Health Organization [2].
Standardization: 2.2	$Under-five\ mortality\ rate^{(S)} = 100\left[1 - \frac{\ln(U5MR) - \ln(Min)}{\ln(Max) - \ln(Min)}\right]$ $Under-five\ mortality\ rate^{(S)} = 100\left[1 - \frac{\ln(U5MR) - 0.79}{5.20 - 0.79}\right]$ Decision:

[12] http://www.who.int/whosis/whostat2006InfantAndUnder5MortalityRate.pdf?ua=1, accessed August 27, 2015

	$Under-five\ mortality\ rate^{(S)}$ $= \begin{cases} 0, & If\ \ln(U5MR) \geq 5.20 \\ Under-five\ mortality\ rate^{(S)}, & If\ \ 0.79 < \ln(U5MR) < 5.20 \\ 100, & If\ \ln(U5MR) \leq 0.79 \end{cases}$
Limitations	Some countries calculate the under 6 mortality rate i.e. for children aged six and under, instead of 5. Therefore caution is required when computing the indicator and comparing across countries. In addition, some countries may misreport or not report at all their infant and child mortality figures due to inefficient vital registration systems. Adjustments for incomplete registrations can be used using demographic and health surveys (United Nations, 2007).
References	**Bibliography references** Indicators for Monitoring the Millennium Development Goals (2003). The United Nations. New York: The United Nations.[1] Millennium Development Goals (MDG). (2012). Definitions, rationale, concepts and sources: 4.1 Under five mortality rate. [2] United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. [4] **URL references** [1]: http://www.wikiprogress.org/index.php/Under-Five_Mortality_Rate#cite_ref-UNDG_2-1, accessed August 21, 2015 [2]:http://mdgs.un.org/unsd/mi/wiki/4-1-Under-five-mortality-rate.ashx#p3, accessed June 11, 2014. [3]: http://apps.who.int/gho/data/node.main.ChildMort-2?lang=en, accessed June 11, 2014. [4]:http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/health/under_five_mortality.pdf, accessed June 11, 2014. [5]: http://www.childmortality.org/

Indicator:	Vaccination Coverage
Scope	Extended CPI
Rationale:	The goal of immunization is to reduce morbidity and mortality due to communicable diseases. Moreover, lower vaccination coverage may carry long run consequences in terms of absences, lower productivity and higher medical costs (Andre et al., 2008). This indicator, also known as immunization rate, monitors the quality of healthcare system in the city. It shows whether immunization against infectious childhood diseases has been properly complied with at the city level (WHO, 2014). A prosperous city seeks to cover all its population with basic vaccination schemes.
Definition:	The percent of the eligible population that have been immunized according to national immunization policies. Eligible Population: As United Nations (2007) mentions, eligible population usually includes: • For infants: The numerator is the number of infants fully immunized with the specified vaccines during a specified period (year), while the denominator is the number of one year old infants (target age group) in the same period. • For women: The numerator is the number of women immunized with two or more doses of tetanus toxoid during pregnancy, while the denominator is the number of live births. Proper immunization for these eligible persons is when: (i) children immunized against diphtheria, tetanus, pertussis, measles, poliomyelitis, tuberculosis and hepatitis B before their first birthday; and against yellow fever in affected countries of Africa (ii) the proportion of women of child-bearing age immunized against tetanus (United Nations, 2007)
Unit [ ]	%
Methodology:	$Vaccination\ Coverage = 100\ \frac{population\ that\ have\ been\ immunized\ according\ to\ national\ immunization\ policies}{Eligible\ population\ according\ to\ national\ immunization\ policies}$ It is important to note that due to the indicator estimation procedure, some percentages might surpass 100%. Nevertheless, the rank of the indicator will be kept between 0 and 100. If any value surpasses 100% it will be assumed as 100%.
Source:	Country's Statistics Department: Vital registration systems, censuses or demographic surveys, Health Surveys, National Immunization Programs, World Health Organization, Millennium Development Goals
Benchmark	Min = 0% Max = 100%
Standardization: 1.1	Not required
Limitations	Given the composite nature of the indicator it may not be easy to collect the sufficient data for all the different vaccination diseases (United Nations, 2007). While the indicator is appropriate to measure the extent to which vaccination coverage reaches a city, it does not reflect health preventive factors such as education or diet.
References	**Bibliography References** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York [1] World Health Organization (WHO). (2014). Immunization coverage. Factsheet N° 378 [2] Andre, F.; Booy, R.; Bock, H.; Clemens, J.; Datta, S.; John, T.; Lee, B.; Lolekha, S.; Peltola, H.; Ruff, T.; Santosham, M. & Schmitt, H. (2008). Vaccination greatly reduces disease, disability, death and inequity worldwide. Bulletin of the World Health Organization, 86 (2), 81-160. [3] **URL references** [1]:http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/health/immunization.pdf, accessed June 11, 2014. [2]: http://www.who.int/mediacentre/factsheets/fs378/en/, accessed August 7, 2014. [3]: http://www.who.int/bulletin/volumes/86/2/07-040089/en/, accessed August 7, 2014.

Indicator:	Maternal Mortality
Scope	Extended CPI
Rationale:	Problems during pregnancy and childbirth have direct effect on women's survival, especially in developing countries. In 2013, an estimated 289,000 women died of causes related to pregnancy or childbirth. A majority of them died from severe bleeding, sepsis, eclampsia, obstructed labour and the consequences of unsafe abortions – all causes for which there are highly effective interventions. When mothers die, their families are much more vulnerable, and their infants are more likely to die before reaching their second birthday. Working for the survival of mothers is a human rights imperative and a development priority. The best way to achieve this goal is to: ensure all women have access to contraception to avoid unintended pregnancies; provide all pregnant women with skilled care at delivery; and make sure women with complications have timely access to quality emergency obstetric care [1] i.e. improving the healthcare services in the city. A prosperous city therefore seeks to decrease to a minimum its maternal mortality rate. This indicator monitors the access to and quality of primary health care facilities as it reflects the risks associated with each pregnancy related to these aspects of health care services provided by the city (WHO et al., 2012; WHO, 2014).
Definition:	Number of maternal deaths divided by live births for the same geographic area for a specified time period, usually a calendar year. • Maternal deaths - The number of women who die while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes (MMEIG) • Live births - refers to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life - e.g. beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles - whether or not the umbilical cord has been cut or the placenta is attached. Each product of such a birth is considered live born[13]. Where data on the numbers of live births are absent, evaluators can calculate total estimated live births using census data for the total population and crude birth rates in a specified area [7]. Total expected births = population x crude birth rate
Unit [ ]	# / 100,000 live births
Methodology:	$Marternal\ mortality = 100{,}000\left[\frac{Maternal\ Deaths}{Live\ Births}\right]$
Source:	Country's statistics department: Vital registration systems, censuses or demographic surveys, Health Surveys, Department of Health, World Health Organization, Millennium Development Goals, Demographic and Health Surveys.
Benchmark	Min = 1 mother per 100,000 live births Max =1,100 mothers per 100,000 live births Obtained from World Health Organization [2]
Standardization: 2.2	$Maternal\ mortality^{(S)} = 100\left[1 - \frac{\ln(Maternal\ mortality) - \ln(Min)}{\ln(Max) - \ln(Min)}\right]$ $Maternal\ mortality^{(S)} = 100\left[1 - \frac{\ln(Maternal\ mortality)}{7}\right]$ Decision:

[13] http://www.who.int/whosis/whostat2006InfantAndUnder5MortalityRate.pdf?ua=1, accessed August 27, 2015

	$$Maternal\ mortality^{(S)} = \begin{cases} 0, & If\ \ln(Maternal\ mortality) \geq 7 \\ Maternal\ mortality^{(S)}, & If\ \ 0 < \ln\ (Maternal\ mortality) < 7 \\ 100, & If\ \ln(Maternal\ mortality) = 0 \end{cases}$$
Limitations	Maternal deaths are difficult to investigate because of their comparative rarity on a population basis, as well other context-specific factors, such as reluctance to report abortion-related deaths, problems of memory recall, or lack of medical attribution. Thus, no single source or data collection method is adequate for investigating all aspects of maternal mortality in all settings (WHO, 2006) [7].The main drawback of health services data relates to the selectivity of the service-using population. Without detailed knowledge of the catchment population, it is hard to gauge whether the maternal mortality ratio under or over estimates the level for the general population (which also includes non-users of the service). Other problems related to using health services information include inaccuracies in routine registers and omission of deaths occurring outside maternity wards. Maternal mortality data may vary because the data may be augmented by sources other than death certificates including maternal mortality surveillance reports, the findings of maternal mortality review committees within state health departments that routinely review suspected maternal deaths and/or by routinely linking deaths among women of child bearing age to live birth and fetal death files [8]. Finally, including all pregnancies in the denominator gives a true indication of the total population of pregnant and delivering women at risk of maternal death, but researchers and evaluators more commonly use live births since this data is readily available and are easier to collect [7].
References	**Bibliography references** Maternal Mortality Estimation Inter-agency Group (MMEIG). Definitions. [3] World Health Organization. (2006) Reproductive health indicators: Guidelines for their generation, interpretation and analysis for global monitoring. WHO Reproductive Health and Research. [4] WHO, UNICEF, UNFPA & The World Bank estimates. (2012). Trends in maternal mortality: 1990 to 2010. [5] World Health Organization (WHO). 2014. Maternal mortality. Factsheet N° 348. [6] **URL references** [1]: http://www.unfpa.org/maternal-health, accessed August 24, 2015 [2]: http://apps.who.int/gho/data/node.main.15, accessed June 11, 2014. [3]: http://www.maternalmortalitydata.org/Definitions.html , accessed August 7, 2014. [4]: http://whqlibdoc.who.int/publications/2006/924156315X_eng.pdf, accessed August 7, 2014. [5]: http://whqlibdoc.who.int/publications/2012/9789241503631_eng.pdf?ua=1, accessed August 7, 2014. [6]: http://www.who.int/mediacentre/factsheets/fs348/en/, accessed August 7, 2014. [7]. http://www.cpc.unc.edu/measure/prh/rh_indicators/specific/sm/maternal-mortality-ratio-mmr, accessed August 24, 2015 [8] https://naphsis-web.sharepoint.com/about/Documents/MMR_Final_Glenn.pdf, accessed August 24, 2015

2. Education Sub-Index

Here, the CPI will look at:

- The quality of education –This will be measured by the literacy rate of the population above 15 years. A high literacy rate indicates the ability for the population to get better jobs and therefore improve their standard of living.

- Access to education – this will measure how much of the population has access to higher level (tertiary) education. The CPI measures participation in this particular level of education since it comes with better employment, more confidence and in the end a better quality of life. Indicators used are mean years of schooling (the number of years a 25 year old or older has spent in school) and net enrolment rate in higher education.

Indicator:	**Literacy Rate**
Scope	Basic CPI
Rationale:	Literacy is traditionally understood as the ability to read and write [1]. The Literacy rate reflects the most basic educational needs; the capabilities of reading and writing. The United Nations and the Millennium Development Goals (MDGs) states that "literacy is crucial to the acquisition - by every child, youth and adult - of essential life skills that enable them to address the challenges they face in life" (UNESCO, 2014). This is reinforced by a study done by the National Literacy Trust that presents overwhelming evidence that literacy has a significant relationship with a person's happiness and success. It gives a clear indication of the dangers of poor literacy and also the benefits of improving literacy for the individual, the community, the workforce and the nation [2].Therefore, one aspect that every city must guarantee to its citizens is access to quality education, which without reading and writing skills, would be almost impossible to provide. A prosperous city seeks for a high literacy rate to foster productivity, economic growth and quality of life.
Definition:	Adult literacy rate is the percentage of population aged 15 years and older that is literate i.e. can read and write a short simple statement (usually a paragraph) related to his/her everyday life (United Nations, 2007).
Unit [ ]	%
Methodology:	$Literacy\ rate = 100\left[\frac{Number\ of\ literate\ population\ (15\ years\ and\ over)}{Population\ (15\ years\ and\ over)}\right]$
Source:	Living standard household surveys, Ministry of education administrative registers.
Benchmark	Min= 15.0% Max = 99.9% Calculated from The World Bank (2014).
Standardization: **2.1**	$Literacy\ rate^{(S)} = 100\left[\frac{Literacy\ rate - Min}{Max - Min}\right]$ $Literacy\ rate^{(S)} = 100\left[\frac{Literacy\ rate - 15.0}{99.9 - 15.0}\right]$ Decision:

	$$Literacy\ rate^{(S)} = \begin{cases} 100, & If\ Literacy\ rate \geq 99.9 \\ Literacy\ rate^{(S)}, & If\ 15.0 < Literacy\ rate < 99.9 \\ 0, & If\ Literacy\ rate \leq 15.0 \end{cases}$$
Limitations	Most surveys rely on self-declaration but do not perform an actual assessment of reading and writing. This self-reporting might lead to incorrect information or misreporting. In addition, given the simplicity of the definition used, due to restricted availability of information especially in developing countries, it does not consider another dimension of literacy related with number comprehension. A person could be literate in terms of text comprehension but illiterate when it comes to understanding number uses. Finally, different social interactions require different levels of literacy; therefore, the definition should be broad enough.
References	**Bibliographic references** UNESCO (2014). Literacy and Lifelong Learning: Advocacy/UNLD. Bangkok Office. [3] United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. [4] The World Bank (2014). World Development Indicators 1960 – 2013. [5] **URL references** [1]:http://www.merriam-webster.com/dictionary/literate, accessed August 24, 2015 [2]:http://www.literacytrust.org.uk/assets/0000/0402/Literacy_Changes_Lives_Executive_summary.pdf, accessed August 24, 2015. [3]:http://www.unescobkk.org/education/literacy-and-lifelong-learning/literacy/advocacyunld/, accessed August 6, 2014. [4]:http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/education/adult_literacy.pdf, accessed August 6, 2014. [5]: http://data.worldbank.org/indicator/SE.ADT.LITR.ZS, accessed August 6, 2014.

Indicator:	**Mean Years of Schooling**
Scope	Basic CPI
Rationale:	A high quality workforce, or human capital, is considered a critical factor in economic development. The concept of human capital recognizes that not all labor is equal and that the quality of employees can be improved by investing in them. The education, experience and abilities of an employee have an economic value for employers and for the economy as a whole [1]. Cities with higher levels of human capital tend to have higher economic growth levels as well as higher productivity. This productivity is generally reflected in higher wages for the entire population. (Psacharopolous and Arriagada, 1986). Based on raw estimates of returns to education for 98 countries, Psacharopoulos and Patrinos (2004) show empirical evidence that the average rate of return to an additional year of schooling leads to an increase of 10 percent of the wages. This shows that the higher the city's education, the higher the economic returns the citizens perceive. A prosperous city will seeks to provide optimal conditions for its inhabitants to invest in additional years of schooling.
Definition:	Mean years of schooling (MYS) provides the average number of years of education completed by a country's adult population (25 years and older), excluding years spent repeating grades [3].
Unit [ ]	Years
Methodology:	Following UNESCO (2013) the methodology can be defined by two equations: The following formula shows the calculation of $Mean\ years\ of\ schooling$ adjusted by the duration of individual levels: $Mean\ years\ of\ schooling = \sum_a \sum_l HS_{al} * YS_{al}$ Where: • HS_{al}: Proportion of the population in age group *a,* for which the level of education *l* is the highest level attained. • YS_{al}: Official duration of the level of education *l* for age group *a* at the time when this age group was in school. • $Mean\ years\ of\ schooling$ for the population aged 25 years and older is thus the population-weighted average $years\ of\ schooling$ for each age group *a*. If the duration of each level of education remains constant over time, the formula can be simplified as follows: $Mean\ years\ of\ schooling = \sum_l HS_l * YS_l$ Where: • HS_l: Proportion of the population for which the level of education *l* is the highest level attained. • YS_l: Official duration of the level of education *l*.
Source:	Living standards household surveys, labor markets surveys, censuses.
Benchmark	X^*= 14 years The objective is to provide tertiary education to the whole population, which usually includes: 6 years of primary, 3 years of secondary, 3 years upper secondary and minimum 2 years of technical program (Obtained from UNESCO, 2013).
Standardization: **3**	$Mean\ years\ of\ schooling^{(S)} = 100\left(1 - \left\lvert\frac{Mean\ years\ of\ schooling - X^*}{X^*}\right\rvert\right)$ $Mean\ years\ of\ schooling^{(S)} = 100\left(1 - \left\lvert\frac{Mean\ years\ of\ schooling - 14}{14}\right\rvert\right)$ Decision:

	$$Mean\ years\ of\ schooling^{(S)} = \begin{cases} 0, if\ Mean\ years\ of\ schooling\ < 0 \\ Mean\ years\ of\ schooling^{(S)}, \quad If\ 0 \leq Mean\ years\ of\ schooling < 14 \\ 100, \quad If\ Mean\ years\ of\ schooling \geq 14 \end{cases}$$
Limitations	While the optimal value is based on a system with 6 years of primary, 3 years of secondary, 3 years upper secondary and minimum 2 years of technical program, as UNESCO, 2013 propose, systems may vary across countries causing adjustments in some countries. Therefore, caution is required when looking at cross country comparisons. Even though this is an indicator of the stock of human capital, it does not measure the quality of education (or quality of human capital)
References	**Bibliographic references** Psacharopoulous, G. and Patrinos, H. (2004) Returns to Investment in Education: A Further Update. Economics of Education. Vol. 12 No. 2 [2] Psacharopoulos, G., & Arriagada, A. M. (1986). The Educational Attainment of the Labor Force: An International Comparison. Education and training series discussion paper No. EDT 38. Washington, DC: World Bank. [6] UNESCO Institute for Statistics. (2013). UIS Methodology for Estimation of Mean Years of Schooling [4] UNDP (2014). Open Data – Mean Years of Schooling (of adults) years 2005 – 2012. [5] **URL references** [1] http://www.investopedia.com/terms/h/humancapital.asp, accessed August 24, 2015 [2]: http://elibrary.worldbank.org/doi/pdf/10.1596/1813-9450-2881, accessed August 7, 2014. [3]: http://www.uis.unesco.org/Education/Pages/mean-years-of-schooling.aspx, accessed August 24, 2015 [4]:http://www.uis.unesco.org/Library/Documents/mean-years-schooling-indicator-methodology-2013-en.pdf, accessed August 7, 2014. [5]: https://data.undp.org/dataset/Mean-years-of-schooling-of-adults-years-/m67k-vi5c, accessed August 7, 2014. [6]:http://www.wds.worldbank.org/external/default/WDSContentServer/WDSP/IB/2005/09/01/000112742_20050901145133/Rendered/PDF/edt38.pdf, accessed August 7, 2014.

Indicator:	Early Childhood Education
Scope	Extended CPI
Rationale:	The well-being of today's children affects the future vitality of a community. Young children who enjoy positive early experiences are better able to develop the skills that prepare them for higher level schooling and later life. Early childhood education is therefore fundamental to improving future performance at school and also to build a better society (Grantham-McGregor et al., 2007; Kamerman, 2002).School readiness, which is achieved through early childhood education, is a good predictor of long-term achievement. School readiness refers to the development of the cognitive, behavioural, and social skills that help a child to make a smooth transition into formal schooling and enable him to perform at the appropriate level [1]. This eventually leads to a more educated workforce and in turn, higher incomes, more public revenues, and less poverty and crime – in other words, a thriving city that attracts business and jobs. However, only "1% of eligible Sub-Saharan children are enrolled in preschool programs; and few developing countries have achieved preschool coverage of even 25 to 30%. By contrast, 80% of three-year-olds in Belgium, Denmark and France are enrolled in nursery or preschool centers" Bennett (1993) as cited in Young (1996: pg. 3). A prosperous city seeks more participation of children in Early Childhood Education Programs (ECEP) to guarantee a better future to its children and as a society.
Definition:	Children under-six years of age who are enrolled on early childhood education programs. These programs might either be financed by the local government, the central government or provided by private resources.
Unit [ ]	%
Methodology:	$Under-six\ Participation\ on\ Early\ Childhoold\ Education\ Programme = 100\left[\frac{Children\ under\ 6\ in\ ECEP}{Total\ children\ under\ 6}\right]$
Source:	Living standards household surveys, DHS and MICS, Country's Education and Health Ministries.
Benchmark	Min= 0% Max = 100%
Standardization: 1.1	Not required.
Limitations	The indicator does not measure the quality or the type of received education benefits. While some programs may target health issues (mostly nutrition related) others may focus on educational aspects. In addition, it may not cover mothers training in both health and educational aspects of early childhood development. However, it does cover access to early childhood development programs, which is the first step to increase quality of life.
References	**Bibliographic references** Bennett, J. (1993). Early Childhood Care and Education Today – Worldwide Trends. In Lillian Katz, ed. International Encyclopedia of Education, 2nd Edition. Grantham-McGregor, Sally, et al., (2007) 'Developmental Potential in the First 5 Years for Children in Developing Countries', The Lancet, vol. 369, no. 9555, 6–12, pp. 60–70. Kamerman, S. (2002) Early Childhood Care and Education and Other Family Policies and Programs in South-East Asia, United Nations Educational, Scientific and Cultural Organization, Paris. Young, M.E. (1996). Early Child Development: Investing in the Future. Directions in Development, World Bank [2] UNICEF (2014). Early Childhood Development: A Statistical Snapshot - Building Better Brains and Sustainable Outcomes for Children [3] **URL references** [1]: http://www.urbanchildinstitute.org/articles/policy-briefs/pre-k-matters, accessed August 25, 2015 [2]: http://siteresources.worldbank.org/EDUCATION/Resources/278200-1099079877269/547664-1099079922573/ECD_investing_in_the_future.pdf, accessed August 7, 2014.

	[3] http://data.unicef.org/ecd/early-childhood-education#sthash.8L3VbSgp.dpuf

Indicator:	Net Enrollment Rate in Higher Education
Scope	Extended CPI
Rationale:	Tertiary education (also called post-secondary education) becomes of primary importance once cities are able to provide access to primary and secondary education. By attending tertiary education, people develop a set of skills that will be relevant when trying to become part of the labor market. Individuals with higher levels of education have higher chances to find a job and usually get more benefits, such as higher wages in the labor market and better health and social outcomes compared to individuals without that level of education (Heckman et al., 2011). This, in turn, will have direct impacts in terms of economic growth and peoples' well-being and quality of life. A prosperous city seeks to improve its inhabitant's quality of life by designing policies and proper conditions to increase the levels of enrolment in tertiary education. The purpose of Net Enrolment Rate is to show the extent of participation in a given level of education (in this case tertiary education) of children, and youths belonging to the official age-group corresponding to the given level of education. This is a very important indicator in measuring rates of access to education [1].
Definition:	Enrolled students divided by corresponding population • Enrolled students - Number of individuals of official tertiary school going age (usually between 18 to 23 years old) who are enrolled in tertiary education • Corresponding population - total individuals of official tertiary school going age
Unit [ ]	%
Methodology:	$Net\ Enrollment\ Rate\ in\ Higher\ Education$ $= 100\left[\frac{Population\ enrolled\ that\ belongs\ in\ tertiary\ education}{People\ that\ belong\ to\ the\ tertiary\ education\ age\ range}\right]$ Due to the calculation procedures, some percentages might surpass 100%. Nevertheless, the range of the indicator will be kept between 0 and 100 to standardize it. Then, if any value surpasses 100% it will be transformed to 100%.
Source:	Living Standards Household Surveys, Country's Ministry of Education,School register, school survey or census for data on enrolment by age; population censuses or estimates for school-age population normally obtained from the central statistical office [1]
Benchmark	Min = 0% Max = 100%
Standardization: 1.1	Not required.
Limitations	The age range and duration for tertiary education vary across countries. Caution is advised when making cross-country comparisons [1].The indicator measures access to tertiary education but it does not measure quality of education. The duration of tertiary programs may vary across countries and programs inside the countries. There will be inconsistencies when the selected age range does not include individuals who are enrolled in the longer programs.
References	**Bibliographic references** UNESCO Institute for Statistics. UIS Indicator Definitions: Education Indicators, Technical Guidelines. UNESCO. UNESCO (page 10) [1] Heckman, J.; Humphries, J.; Urzua, S. and Veramendi, G. (2011). The Effects of Schooling on Labor Market, Health, and Social Outcomes. Working Papers 2011-002, Human Capital and Economic Opportunity Working Group. UNESCO Institute for Statistics. (2014). Glossary of Indicators [2] **URL references** [1]: http://www.uis.unesco.org/Library/Documents/eiguide09-en.pdf, accessed August 26, 2015 [2]: http://glossary.uis.unesco.org/glossary/en/term/2048/en, accessed August 7, 2014.

3. Safety and Security

This sub-dimension under CPI looks at safety and security in the aspect of personal safety. This will consider crimes that are as a result of poor social cohesion and affect the individual's well-being i.e. theft and homicide rates

Indicator:	**Homicide Rate**
Scope	Basic CPI
Rationale:	Crime affects a city negatively, mainly by affecting personal security, the attractiveness of an area for recreation and general amenities. Homicide rate provides an approximation to the degree of criminality in a city. Local governments have to work in order to reduce the levels of crime. Their job is to guarantee the rights of their citizens to be protected from crime, violence and aggression. In a safe city, individuals can prosper and society can develop (United Nations, 2005). A prosperous city seeks to increase its inhabitants' quality of life through a better management of security that leads to a reduction on the number of homicides.
Definition:	Number of intentional and unlawful deaths (Homicide) purposefully inflicted on a person by another person [1]
Unit [ ]	Homicides per 100,000 inhabitants
Methodology:	$$Homicide\ rate = 100{,}000\,\frac{homicides}{city\ population}$$
Source:	Local Police data or data from the criminal observatory (if the city has it).
Benchmark	Min = 1 homicides per 100,000 inhabitants Max = 1,654 homicides per 100,000 inhabitants Obtained from United Nations Office on Drugs and Crime (UNODC) [2]
Standardization: 2.2	$$Homicide\ rate^{(S)} = 100\left[1 - \frac{\ln(Homicide\ rate) - \ln(Min)}{\ln(Max) - \ln(Min)}\right]$$ $$Homicide\ rate^{(S)} = 100\left[1 - \frac{\ln(Homicide\ rate)}{7.41}\right]$$ Decision: $$Homicide\ rate^{(S)} = \begin{cases} 0, & If\ \ln(Homicide\ rate) \geq 7.41 \\ Homicide\ rate^{(S)}, & If\ \ 0 < \ln(Homicide\ rate) < 7.41 \\ 100, & If\ \ln(Homicide\ rate) \leq 0 \end{cases}$$
Limitations	The indicator may differ based on the efficiency of police systems across countries. If city governments are not independent of the central government, they may not be able to affect their corresponding homicide rates. However, it should be understood that the indicator does not aim to identify police efficiency. Deaths caused by injuries, suicides may not be included in this indicator as well as non-reported homicides that are common in conflict countries.
References	**Bibliography references** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. [3] United Nations (2005). In larger freedom: towards development, security and human rights for all: Report of the Secretary-General. [4]

	URL references [1]https://www.unodc.org/documents/data-and-analysis/IHS%20methodology.pdf, accessed August 25, 2015 [2]: https://www.unodc.org/gsh/en/data.html , accessed June 11, 2014. [3]:http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/governance/homicides.pdf, accessed June 11, 2014. [4]: http://www.un.org/en/ga/search/view_doc.asp?symbol=A/59/2005, accessed June 11, 2014.

Indicator:	Theft Rate
Scope	Extended CPI
Rationale:	Theft is defined as the physical removal of an object that is capable of being stolen without the consent of the owner and with the intention of depriving the owner of it permanently. The thief need not intend to keep the property himself; an intention to destroy it, sell it, or abandon it in circumstances where it will not be found is sufficient [1]. This indicator brings relevant information about security and safety in the city. Theft rate is correlated with homicide rate but they represent different degrees of violence. On one hand, homicide rate is given by one type of crime called specialized crime; on the other thefts (burglary, robbery, assault, motor theft) are committed by people who do not need any special arms or previous preparation (Marvell, 1999). A prosperous city seeks to decrease the theft rate to a minimum.
Definition:	Number of reported thefts affecting people, places of residence and commerce; and of vehicles and motorcycles.
Unit [ ]	Thefts per 100,000 inhabitants
Methodology:	$Theft\ rate = 100{,}000 \frac{thefts}{city\ population}$
Source:	Local Police data or criminal observatory (if the city has it).
Benchmark	Min = **25.45** thefts per 100,000 inhabitants Max = 6,159.11 thefts per 100,000 inhabitants Obtained from United Nations Office on Drugs and Crime [2]. (Aggregate information of thefts, assault, robbery, kidnapping, theft of private cars and burglary).
Standardization: 2.2	$Theft\ rate^{(S)} = 100\left[1 - \frac{\sqrt[4]{Theft\ rate} - \sqrt[4]{Min}}{\sqrt[4]{Max} - \sqrt[4]{Min}}\right]$ $Theft\ rate^{(S)} = 100\left[1 - \frac{\sqrt[4]{Theft\ rate} - 2.24}{8.86 - 2.24}\right]$ Decision: $Theft\ rate^{(S)} = \begin{cases} 0, & If\ \sqrt[4]{Theft\ rate} \geq 8.86 \\ Theft\ rate^{(S)}, & If\ 2.24 < \sqrt[4]{Theft\ rate} < 8.86 \\ 100, & If\ \sqrt[4]{Theft\ rate} \leq 2.24 \end{cases}$
Limitations	The indicator does not distinguish on the different types of committed thefts, which may vary across countries. Yet, the indicator aims to capture the extent to which crimes are committed. There is also evidence on misreporting and underreporting of small crimes (Baer & Chambliss, 1997; Pudney et al., 2000), therefore the results may be underestimated in some cities.
References	**Bibliography references** Baer, J. & Chambliss, W. (1997). Generating fear: the politics of crime reporting. Crime, Law and Social Change, 27, 87-107. Marvell, T. (1999) Homicide trends 1947-1996: Short-term versus Long-term Factors. Proceedings of the Homicide Research Working Group Meetings, 1997 and 1998. Department of Justice, Washington D.C., USA. [3] Pudney, S.; Deadman, D. & Pyle, D. (2000). The relationship between crime, punishment and economic conditions: is

	reliable inference possible when crimes are under-recorded. Journal of the Royal Statistical Society: Series A (Statistics in Society), 163(1), 81-97. **URL references** [1]: http://www.britannica.com/topic/theft, accessed August 26, 2015 [2]: https://www.unodc.org/unodc/en/data-and-analysis/statistics/crime.html, accessed June 11, 2014. [3]: http://homicideworkinggroup.cos.ucf.edu/include/documents/hrwg9798-6.pdf, accessed June 11, 2014.

4. Public Space

Indicator:	**Accessibility to Open Public Space**
Scope	Basic CPI
Rationale:	Open Public Space (OPS) alludes to Public Space with "Open" features. This is the non-built up public areas within the city's urban footprint. Also "Open area" concept is related to free access. In most of the countries around the world, the concept of "open public area" is related to "green area" (green areas are defined as public and private areas that have flora such as plants, trees and grass). However, OPS include but is not limited to green area. Nevertheless, the two principal roles an open public area must provide are to provide a healthy social interaction space and to contribute to air quality and a healthy environment (WHO, 2012). People living in towns and cities should have an accessible natural green space or an open public space less than 400 meters from home (Natural England; see also The Wildlife Trust & Natural England, 2009; Harrison et al., 1995; Barker, 1997; Handley et al., 2003; Wray et al., 2005; [1]). This indicator looks at how accessible these open public spaces are to the population. It also takes into the way in which total public area is distributed across the city. A prosperous city has enough open public area for its population, it is properly distributed and people have easy access to it.
Definition:	According to POT Medellin (2013), Sandalack & Alaniz (2010) and Project for Public Spaces [2], the elements which can be considered as open public space are: • Park: open space inside a municipal territory. Its objective is to provide free air recreation and contact with nature. The principal characteristic is the significant proportion of green area in the zone. • Civic parks: open space created as the result of building agglomeration around an open area, which later was transformed to a representative and civic area. It has a considerable proportion of nature, specifically gardens. It is a good place for cultural events and passive recreation. • Square: open space created as a result of building agglomeration around an open area. Its main characteristics are the significant proportion of architectonic elements and the interaction between those buildings and the open area. Squares are usually public spaces that are relevant for the city due to their location, territorial development and/or cultural importance. • Recreational green area: public green areas that contribute to environmental preservation. All recreational green areas have to guarantee accessibility and have to be linked to urban areas. Their main functions are ornament and passive recreation. • Facility public area: open space meeting and recreational facilities that are part of the land for city's facilities (a facility is defined such as places which are elementary in all cities. Places that all cities have to have; e.g.: public libraries, stadium, public sports centres, etc.). This land complies with the following characteristics: public property, free transit and access, and active and passive recreation. (e.g.: public area outside a stadium)
Unit [ ]	%
Methodology:	**Methodology A**: $Accessibility\ to\ open\ public\ area$ $= 100 \frac{population\ less\ than\ 400m\ away\ open\ public\ area}{city\ population}$ "Population" is referring to every person that lives less than 400m away from an open public area, nevertheless it is complicated to get data of every person that complies with that characteristic, and almost no city has that information available.

	If the information is available, the best is to estimate the indicator with that information; otherwise, Methodology "B" must be followed. **Methodology B** Percentage of urban area that is located less than 400 meters away from an open public space. $Accessibility\ to\ open\ public\ area$ $= 100 \frac{urban\ area\ less\ than\ 400m\ away\ open\ public\ area}{total\ urban\ area}$ To calculate the indicator it is necessary to use a map of urban open public areas and to follow these steps: - Delineate a buffer of 400 meters from the open public spaces polygons. - Merge and clip with urban perimeter. - Calculate areas inside the 400 meters buffer. - Calculate the proportion of urban area located inside the buffer. Remote sensing imagery can be used to identify intra-urban open public areas when no other information is available.
Source:	Local urban planning authorities.
Benchmark	Min= 0% Max = 100%
Standardization: 1.1	Not required.
Limitations	Types of Open Public Space vary across cities; however the types listed in this indicator are usually the most accepted ones. Contemporary constraints on mobility and behavior need to be examined before physical distance in order to measure effectively the accessibility to open public space. There are social and cultural constraints on access, anxiety and fears for personal safety are some of them (Harrison et al., 1995)
References	**Bibliography references** Natural England. Natural England website http://www.naturalengland.org.uk/ The Wildlife Trust & Natural England. (2009). Analysis of Accessible Natural Greenspace provision for Essex, including Southend-on-Sea and Thurrock Unitary Authorities. Harrison, C., Burgess, J., Millward, A., Dawe, G., 1995. Accessible natural green space in towns and cities: a review of appropriate size and distance criteria. English Nature research report number 153. English Nature, Peterborough. Barker, G., 1997. A framework for the future: green networks with multiple uses in and around towns and cities. English Nature research report number 256. English Nature, Peterborough. Handley, J., Pauleit, S., Slinn, P., Barber, A., Baker, M., Jones, C., Lindley, S., 2003. Accessible natural green space standards in towns and cities: a review and toolkit. English Nature research report number 526. English Nature, Peterborough. Sandalack, B. & Alaniz, F. (2010). Open space typology as a framework for design of the public realm. In The faces of Urbanized Space, R. Barelkowski (editor). World Health Organization (WHO). (2012). Health Indicator of sustainable cities: in the context of the Rio+20 UN Conference on sustainable development. [3] Wray, S., Hay, J., Walker, H., Staff, R., 2005. Audit of the Towns, Cities and Development Work stream of the England Biodiversity Strategy. English Nature research report number 652. English Nature, Peterborough. POT Medellín (2013). Plan de Ordenamiento Territorial – Medellín. Revisión y ajuste del Plan de Ordenamiento Territorial de Medellín: Evaluación y Seguimiento – Tomo IIIC. Versión 2: Concertación con área metropolitana del Valle de Aburrá. Pago.: 153. UN-Habitat (2014) Guidelines and Metadata on the City Prosperity Initiative, use of selected indicators, Nairobi. UN-Habitat (2013) Streets as Public Spaces and Drivers of Urban Sustainability, Nairobi. UN-Habitat (2013) The relevance of street patterns and public space in urban areas, Nairobi. Institute for Transportation and Development Policy (2013) TOD Standard, v. 2.0, New York. **URL references** [1]: http://ec.europa.eu/environment/europeangreencapital/index_en.htm, accessed June 11, 2014. [2]: http://www.pps.org/, accessed June 11, 2014.

	[3]: http://www.who.int/hia/green_economy/indicators_cities.pdf, accessed August 18, 2014. http://epa.gov/smartgrowth/pdf/ptfd_primer.pdf

Indicator:	**Green Area Per Capita**
Scope	Extended CPI
Rationale:	Green areas are defined as public and private areas that have flora such as plants, trees and grass (e.g. forests, parks, gardens). These areas are also a way to compensate for CO_2 emissions as green spaces generally generate environmental sustainability. This indicator provides information about the amount of geographical space that the city dedicates to green space. A prosperous city seeks to increase the green areas per capita to have a better air quality and improve the quality of life of its population.
Definition:	Total green area within the city (forests, parks, gardens, etc.) per inhabitant.
Unit [ ]	Squared meters (m^2) per inhabitant
Methodology:	$Green\ area\ per\ capita = \frac{Total\ green\ area\ within\ de\ city}{city\ population}$
Source:	Local urban planning authorities. Remote sensing imagery can be used to identify intra-urban green areas when no other information is available.
Benchmark	X^*= 15 m^2/hab Obtained from POT Medellin (2013) based on World Health Organization's suggestion.
Standardization: 3	$Green\ area\ per\ capita^{(S)} = 100\left(1 - \left\lvert\frac{Green\ area\ per\ capita - X^*}{X^*}\right\rvert\right)$ $Green\ area\ per\ capita^{(S)} = 100\left(1 - \left\lvert\frac{Green\ area\ per\ capita - 15}{15}\right\rvert\right)$ Decision: $Green\ area\ per\ capita^{(S)} = \begin{cases} 0, if\ Green\ area\ per\ capita < 0 \\ Green\ area\ per\ capita^{(S)}, \quad If\ \ 0 < Green\ area\ per\ capita < 15 \\ 100, \quad If\ Green\ area\ per\ capita \geq 15 \end{cases}$
Limitations	Cities located in deserted areas have a natural disadvantage; However, it is a duty of the city to guarantee a minimum amount of green space to its population.
References	**Bibliography references** Fuller, R. & Gaston, K. (2009). The scaling of green space coverage in European cities. Biology letters, On-line publication: doi:10.1098/rsbl.2009.0010. [1] Laghai, H. & Bahmanpour, H. (2012). GIS Application in Urban Green space Per Capita Evaluation. Annals of Biological Research, 2012, 3 (5):2439-2446. POT Medellín (2013). Plan de Ordenamiento Territorial – Medellín. Revisión y ajuste del Plan de Ordenamiento Territorial de Medellín: Evaluación y Seguimiento – Tomo IIIC. Versión 2: Concertación con área metropolitana del Valle de Aburrá. Pago.: 156. **URL references** [1]: http://rsbl.royalsocietypublishing.org/content/early/2009/02/22/rsbl.2009.0010.full, accessed June 11, 2014.

6.4 EQUITY AND SOCIAL INCLUSION INDEX

An inclusive society is one that over-rides differences of race, gender, class, generation, and geography, and ensures inclusion, equality of opportunity as well as capability of all members in the society to determine an agreed set of social institutions that govern social interaction[14]. This can be achieved partly by enhancing gender equality, protecting the rights of minority and vulnerable groups, as well as ensuring participation by all in the social, political and cultural spheres. The failure of cities to fully integrate excluded groups into their decision-making process creates and reinforces poverty and other inequities. A Prosperous City should seek to be socially inclusive via available and collective transparent decision-making processes. Prosperity thrives on equity, which involves reduction of barriers on individual/collective potential, expansion of opportunities, and strengthening of human agency and civic engagement. When equity is embedded in urban development strategies, efficiency is enhanced, asset utilization becomes optimal, economic productivity improves, and social cohesion is strengthened. Equity has a significant impact on economic performance, since the greater the degree of equity, the greater the chances of a fuller, more efficient use of available resources, including skills and creative talent. This fosters city prosperity.
Under the CPI, the Equity and Social Inclusion Index is measured using four sub-dimensions as listed below:

- Economic Equity
- Social Inclusion
- Gender Inclusion
- Urban Diversity

The indicator variables within the Equity and Social Inclusion Index are classified below:

DIMENSION	SUB-DIMENSION	INDICATORS
Equity and Social Inclusion Index (ESI)	1. Economic Equity (EE)	1.1. Gini Coefficient 1.2. Poverty Rate
	2. Social Inclusion (SI)	2.1. Slum Households 2.2. Youth Unemployment
	3. Gender Inclusion (GI)	3.1. Equitable Secondary School Enrolment 3.2. Women in Local Government 3.3. Women in the Work Force
	4. Urban Diversity (UD)	4.1. Land Use Mix

To compute the Equity and Social Inclusion Index at the Basic CPI level, the variables within the sub-dimensions are aggregated as follows:

EQUITY AND SOCIAL INCLUSION INDEX (ESI) = 1/3 [Economic Equity (EE) + Social Inclusion (SI) + Gender Inclusion (GI)]

Where:
EE = (1/2) [Gini Coefficient + Poverty Rate]
SI = (1/2) [Slum Households + Youth Unemployment]
GI = Equitable Secondary School

The Equity and Social Inclusion Index can also be estimated at an Extended CPI level. To do this, aggregate the variables within the sub-dimensions as follows:

EQUITY AND SOCIAL INCLUSION INDEX (ESI) = 1/4 [Economic Equity (EE) + Social Inclusion (SI) + Gender Inclusion (GI) + Urban Diversity (UD)]

[14] Expert Group Meeting on Promoting Social Integration, Helsinki, July 2008, http://www.un.org/esa/socdev/egms/docs/2009/Ghana/inclusive-society.pdf, Accessed August 2015, Page 8

Where:

EE = (1/2) [Gini Coefficient + Poverty Rate]
SI = (1/2) [Slum Households + Youth Unemployment]
GI = (1/3) [Equitable Secondary School + Women in Local Government + Women in the Work Force]
UD = Land Use Mix

1. Economic Equity (EE) Sub-Index

Indicator:	**Gini Coefficient**
Scope	Basic CPI
Rationale:	The Gini coefficient is an indicator widely known to measure income inequality across the income (or consumption expenditure) distribution. In this context, it is intended to estimate the income distribution of a city. Cities are the cores of economic development, and a prosperous city cannot develop under conditions of large income inequalities. Moreover, income inequality should be considered as the core of policies that aim to build a more equitable and inclusive city. There is compelling evidence on the relationship between urban development and income inequality. Glaeser et al., (2008) demonstrates that income inequality is related to high crime rates, unhappiness and lower growth rates (of both income and population). A prosperous, equitable and inclusive city seeks to reduce income disparities among its inhabitants.
Definition:	The Gini Index (Gini Ratio or Gini Coefficient) measures the extent to which the distribution of income (or consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution [1]. A Gini coefficient of zero expresses perfect equality, where all values are the same i.e. where everyone has the same income. A Gini coefficient of one (or 100%) expresses maximal inequality among values i.e. a city in which one person has all the income (Mandal, 2014).
Unit [ ]	Dimensionless (value between 0 and 1).
Methodology:	$Gini = \frac{1}{2m}\frac{1}{n^2}\sum_{i=1}^{n}\sum_{j=1}^{n}\lvert y_i - y_j\rvert$ Where: y_i= Minimum level of income y_j= Maximum level of income n= Total population m= Average income If available, consumption expenditure is preferable to income. However, most household surveys do not have this information. The measure of welfare used is household per capita income which includes labour (both monetary and in kind), and non-labour income (both monetary and in kind).
Source:	Cities household surveys; National level surveys with representative city household data; Income and expenditure surveys.
Benchmark	Min = 0.24 Max = 0.63 Calculated from The World Bank (2014).
Standardization: 2.2	$Gini^{(S)} = 100\left[1 - \frac{Gini - Min}{Max - Min}\right]$ $Gini^{(S)} = 100\left[1 - \frac{Gini - 0.24}{0.63 - 0.24}\right]$ Decision: $Gini^{(S)} = \begin{cases} 0, & If\ Gini \geq 0.63 \\ Gini^{(S)}, & If\ 0.24 < Gini < 0.63 \\ 100, & If\ Gini \leq 0.24 \end{cases}$
Limitations	Due to data characteristics, some cities may switch to households rather than individuals. When population households are measured with inconsistent definitions, results are not fully comparable. Given the construction of the Gini coefficient, cities with similar incomes and Gini coefficients may have different income distributions [3]. Given that the Gini coefficient measures relative wealth, it should be noted that an increase of the Gini coefficient does not imply absolute poverty reduction; therefore a complementary measure of poverty is needed.

References	**Bibliographic references** Glaeser, Edward L., Resseger, Matt and Tobio, Kristina, (2009), Inequality in cities, *Journal of Regional Science*, 49, issue 4, p. 617-646. Mandal, R.M. (2014). Economic Inequality among the Rural Tribal People in Arunachal Pradesh: An Empirical Study. *Journal of Global Economy* 10.1: 24-36. The World Bank (2014). World Development Indicators 1960 – 2013. [2] **URL References** [1]: http://data.worldbank.org/indicator/SI.POV.GINI?page=5, Accessed June 11, 2014. [2]: http://datos.bancomundial.org/indicador/SI.POV.GINI?page=2, Accessed June 11, 2014. [3]: http://www3.nccu.edu.tw/~jthuang/Gini.pdf, Accessed June 11, 2014.

Indicator:	**Poverty Rate**
Scope	Basic CPI
Rationale:	This indicator measures the extreme poverty rate. Progress against poverty is now a widely accepted yardstick for assessing the overall performance of developing economies. Therefore, cities as the core of economic development must use poverty as a core indicator to estimate prosperity. Moreover, this indicator is used for monitoring progress towards the achievement of Goal 1 of the Millennium Development Goals - to eradicate extreme poverty and hunger - established in the year 2000 by world leaders at the general assembly of the United Nations in the third plenary session [1]. This agreement established a threshold of one dollar Purchasing Power Parity, PPP per day, which was later revised to one dollar and twenty five cents PPP [2]. The proportion of the population below this measure provides a uniform measure of absolute poverty for the developing world, using data from national representative household surveys (Chen and Ravallion, 2007). A prosperous, equitable and inclusive city seeks to increase the well-being of its population by minimising poverty.
Definition:	This indicator captures the percentage of the extremely poor population with respect to the total population of the city. To do this, it is necessary to compare the household per-capita income (composed of household labour income and household non-labour income) to the poverty line. The international extreme poverty line is set at $1.25 PPP per, measured in international prices [3]. A person is considered poor if his or her income level falls below a minimum level necessary to meet basic needs. When estimating poverty worldwide, a uniform poverty line has to be used and expressed in a common unit. For the purposes of global aggregation and comparison, international organizations use a poverty line of $1.25 [4]. The indicator goes from 0 (no one below poverty line) to 100 (the entire population below the poverty line). To ensure a positive effect of this index in the economic equity sub dimension, we invert the indicator by taking the maximum value and subtract the actual poverty rate value.
Unit [ ]	%
Methodology:	$Poverty\ rate = 100\left[\frac{Population\ below\ \$1.25\ PPP\ a\ day}{Total\ population}\right]$ If available, it is preferable to use consumption expenditure rather than income. However, most household surveys do not have this information. The measure of welfare to be used is household per capita income, which includes labour (both monetary and in kind), and non-labour income (both monetary and in kind).
Source:	Data computed from cities household Surveys and National Household Surveys with Cities representation.
Benchmark	Min = 0.02% Max = 81.29% Calculated from The World Bank (2014).
Standardization: 2.2	$Poverty\ rate^{(S)} = 100\left[1 - \frac{\sqrt[4]{Poverty\ rate} - \sqrt[4]{Min}}{\sqrt[4]{Max} - \sqrt[4]{Min}}\right]$ $Poverty\ rate^{(S)} = 100\left[1 - \frac{\sqrt[4]{Poverty\ rate} - 0.38}{3.00 - 0.38}\right]$ Decision: $Poverty\ rate^{(S)} = \begin{cases} 0, & If\ \sqrt[4]{Poverty\ rate} \geq 3.00 \\ Poverty\ rate^{(S)}, & If\ 0.38 < \sqrt[4]{Poverty\ rate} < 3.00 \\ 100, & If\ \sqrt[4]{Poverty\ rate} \leq 0.38 \end{cases}$
Limitations	The national poverty rate as a "headcount" measure fails to reflect the fact that among the poor people there may be wide differences in income (consumption expenditure) levels. In addition, this indicator measures income (consumption expenditure) based on poverty and does not consider other dimensions of poverty such as inequality, vulnerability, housing quality etc. [3] and therefore, it must be complemented with other measures that capture these factors.
References	**Bibliographic references** Chen, S., and Martin R. (2007). Absolute poverty measures for the developing world, 1981–2004. *Proceedings of the*

	National Academy of Sciences 104.43: 16757-16762. The World Bank (2014). World Development Indicators 1960 – 2013. [3] **URL References** [1]: http://www.un.org/ga/55/pvlista55.htm, Accessed June 11, 2014. [2]: http://econ.worldbank.org/external/default/main?pagePK=64165259&piPK=64165421&theSitePK=469372&menuPK=64216926&entityID=000158349_20080902095754, Accessed August 13, 2014. [3]: http://data.worldbank.org/indicator/SI.POV.DDAY , Accessed August 12, 2014.

2. Social Inclusion (SI) Sub-Index

Indicator:	**Slum Households**
Scope	Basic CPI
Rationale:	Spatial inequalities are generally expressed as segregation of certain population groups, which may indicate poverty as well as inadequate life conditions (United Nations, 2007). Moreover, rapid urbanization, if not well managed, increase informal settlements and poverty (Duque et al., 2012). Therefore, to develop appropriate policies it is necessary to identify and quantify the slums of a city. A prosperous and inclusive city seeks to reduce spatial inequalities.
Definition:	The proportion of people living in households lacking at least one of the following five housing conditions: access to improved water; access to improved sanitation facilities; sufficient living area (i.e. not overcrowded); and durable housing (United Nations, 2007).
Unit [ ]	%
Methodology:	The proportion of households that lack one or more of the following: Durable housing, sufficient living space, easy access to safe water and access to adequate sanitation; are described to be living in slum households. The United Nations (2007) proposed the following definitions. **Access to improved water**: A household is considered to have access to improved drinking water if it has sufficient amount of water for family use which is at least 20 litres per person per day. The following criteria are used to determine the access to improved water: • Piped connection to house or plot • Public stand pipe serving no more than 5 households • Protected spring • Rain water collection • Bottle water (new) • Bore hole • Protected dug well **Access to improved sanitation:** A household is considered to have access to improved sanitation according to the following criteria: • Direct connection to public sewer • Proper flush latrine • Pit latrine with slab, (this condition has a weight of 50% on total of the criterion) • Ventilated improved pit latrine • Direct connection to septic tank **Sufficient living area:** A dwelling unit provides sufficient living area for a household if there are fewer than four people per habitable room. Additional indicators of overcrowding have been proposed: area-level indicators such as average in-house living area per person or the number of households per area. Additionally housing-unit level indicators such as the number of persons per bed or the number of children under five per room may also be viable. **Structural quality/durability of dwellings:** A house is considered durable if it is built on a non-hazardous location and has a permanent and adequate structure able to protect its inhabitants from the extremes of climatic conditions. The following criteria are used to determine the structural quality/durability of dwellings: • Permanency of Structure • Compliance with building codes • The dwelling is not in need of major repair • The dwelling is not located on or near toxic waste • The dwelling is not located in a flood plain • The dwelling is not located in a dangerous right of way (rail, highway, airport, power lines). • Permanent building material for the walls, roof and floor • The dwelling is not in a dilapidated state • The dwelling is not located on a steep slope • Location of house (hazardous)

	From the methodology, slum households can therefore be estimated as: $Slum\ Households = 100\left[\frac{Number\ of\ people\ living\ in\ slum}{City\ population}\right]$
Source:	UN-HABITAT, Global Urban Indicators Database 2012 and data are computed from Household Surveys and Censuses
Benchmark	Min = 0% Max = 80% Obtained from Millennium Development Goals: "Goal 7. Ensure environmental sustainability" [2]
Standardization: 2.2	$Slum\ Households^{(S)} = 100\left[1 - \frac{Slum\ Households - Min}{Max - Min}\right]$ $Slum\ Households^{(S)} = 100\left[1 - \frac{Slum\ Households}{80}\right]$ Decision: $Slum\ Households^{(S)} = \begin{cases} 0, & If\ Slum\ Households \geq 80 \\ Slum\ Households^{(S)}, & If\ \ 0 < Slum\ Households < 80 \\ 100, & If\ Slum\ Households \leq 0 \end{cases}$
Limitations	The indicator does not cover the spatial dimension of slums. Because the indicator cannot consider how many and the extent to which the five conditions of deprived housing are fulfilled, it cannot provide information on the severity of slum conditions (United Nations, 2007).
References	**Bibliographic references** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. [1] Duque, J. C., Royuela, V. and Noreña, M. (2012) A stepwise tool for spatial delineation of marginal areas. Medellin (Colombia) as a case study. In Fernández-Vazquez, E. and Rubiera-Morollón, F., editor, Defining the Spatial Scale in Modern Regional Analysis. New Challenges from Data at Local Level. Springer, Berlin Heidelberg, pp 237-254. ISBN: 978-3-642-31994-5. **URL References** [1]: http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets.pdf, Accessed June 12, 2014. [2]: http://mdgs.un.org/unsd/mdg/Metadata.aspx?IndicatorId=0&SeriesId=710, Accessed June 12, 2014.

Indicator:	**Youth Unemployment**
Scope	Basic CPI
Rationale:	In general, youth unemployment rates are higher than adult unemployment rates both in developed and developing countries (Byambadori, 2007; O'Higgins, 1997). Existing research indicate that youth unemployment rates vary more in response to economic conditions than adult rates do, increasing more during recessions and recovering more quickly during booms (O'Higgins,1997). This critical fact affects the potential labour markets of the city as well as its sustainability. Considering current economic circumstances, addressing youth unemployment has become a priority for developed and developing countries through local level programs that aim to increase labour market possibilities and skill development programs [1]. A prosperous and inclusive city should be able to provide employment opportunities for young residents.
Definition:	Youth unemployment comprise all persons between the age of 15 and 24 who, during the reference period, were: (a) without work; i.e., for even one hour in any economic activity (paid employment, self-employment, or unpaid work for a family business or farm); (b) currently available for work; and (c) actively seeking work; i.e., had taken active steps to seek work during a specified recent period (usually the past four weeks). Youth labour force comprises all persons between the age of 15 and 24 who were either employed or unemployed over a specified reference period [1].
Unit [ ]	%
Methodology:	$Youth\ Unemployment = 100\left[\frac{number\ of\ unemployed\ young\ persons}{Youth\ labor\ force}\right]$ **Labor Force:** The economically active population of a country between ages 15 and 65, including all persons employed, unemployed and members of the armed forces, but excluding students and people who provide unpaid care to others such as housewives [2].
Source:	Living Standards Households Surveys and Censuses, and Reports from Labour Agencies.
Benchmark	Min = 2.7% Max = 62.8% Obtained from Millennium Development Goals: "Goal 1. Eradicate extreme poverty and hunger" [3]
Standardization: 2.2	$Youth\ Unemployment^{(S)} = 100\left[1 - \frac{\sqrt[4]{Youth\ Unemployment} - \sqrt[4]{Min}}{\sqrt[4]{Max} - \sqrt[4]{Min}}\right]$ $Youth\ Unemployment^{(S)} = 100\left[1 - \frac{\sqrt[4]{Youth\ Unemployment} - 1.28}{2.82 - 2.24}\right]$ Decision: $Youth\ Unemployment^{(S)} = \begin{cases} 0, & If\ \sqrt[4]{Youth\ Unemployment} \geq 2.82 \\ Youth\ Unemployment^{(S)}, & If\ 1.28 < \sqrt[4]{Youth\ Unemployment} < 2.82 \\ 100, & If\ \sqrt[4]{Youth\ Unemployment} \leq 1.28 \end{cases}$
Limitations	Some factors that are attributable to unemployment statistics may affect comparability across countries. The definition of labour force and the labour force age may differ across countries [1].
References	**Bibliographic references** Byambadori, Purvee (2007). The youth unemployment situation in Sweden. University of Goteborg, Department of Social Work [4] O'Higgins, Neil (1997). The challenge of youth unemployment. Employment and Training Department of ILO. **URL References** [1]: http://www.ilo.org/public/english/employment/yen/whatwedo/projects/indicators/2.htm, Accessed June 11, 2014. [2]: http://www.worldbank.org/depweb/beyond/beyondsp/glossary.html , Accessed August 8, 2014. [3]: http://mdgs.un.org/unsd/mdg/Metadata.aspx?IndicatorId=0&SeriesId=630, Accessed June 11, 2014. [4]: https://gupea.ub.gu.se/handle/2077/4603, Accessed June 11, 2014.

3. Gender Inclusion (GI) Sub-Index

Indicator:	**Equitable Secondary School Enrolment**
Scope	Basic CPI
Rationale:	In many cities, gender inequality persists and women continue facing discrimination in access to education, employment and economic assets, as well as participation in government. Ensuring equitable enrolment in secondary education will directly affect the well-being of the society due to its long lasting effects, as education is critical to facilitate long term development. Female education creates powerful poverty-reducing synergies and yields enormous intergenerational gains. It is positively correlated with increased economic productivity, more robust labour markets, higher earnings, and improved societal health and well-being. This indicator, aligned with the Millennium Development Goal 3 -promote gender equality and empower women-, monitors whether boys and girls complete secondary schooling (Tembon and Ford, 2008). A prosperous city should reduce gender inequality and provide equal opportunities for males and females.
Definition:	The ratio of net secondary education enrolment between boys and girls, in both private and public schools. It is also the ratio between male to female enrolment in secondary school. An ideal scenario would be 1, and any deviation from 1 is undesirable as it reflects inequalities between males and females.
Unit [ ]	Dimensionless (Value between 0 and ∞).
Methodology:	$$Equitable\ Secondary\ School\ Enrolment = \frac{\frac{female\ enrolment\ in\ secondary\ school}{female\ that\ belong\ to\ the\ secondary\ education\ age\ range}}{\frac{male\ enrolment\ in\ secondary\ school}{male\ that\ belong\ to\ the\ secondary\ education\ age\ range}}$$
Source:	Household Surveys, Administrative registries of Ministry of Education and Statistical Offices.
Benchmark	X^* = 1
Standardization: 5	$$Equitable\ Secondary\ School\ Enrolment^{(S)} = 100\left(1 - \left|\frac{Equitable\ Secondary\ School\ Enrolment - X^*}{X^*}\right|\right)$$ $$Equitable\ Secondary\ School\ Enrolment^{(S)} = 100\left(1 - \left|\frac{Equitable\ Secondary\ School\ Enrolment - 1}{1}\right|\right)$$ Decision: $$Equitable\ Secondary\ S.E.^{(S)} = \begin{cases} 0, & if\ Equitable\ Secondary\ S.E. = 0\ or\ Equitable\ Secondary\ S.E. = 2 * 1 \\ Equitable\ Secondary\ S.E.^{(S)}, & If\ \ 0 < Equitable\ Secondary\ S.E. < 2 * 1 \\ 100, & If\ Equitable\ Secondary\ S.E. = 1 \end{cases}$$
Limitations	Both the number of years of secondary education and secondary education age range vary across the world and therefore, this indicator may not be fully comparable between global cities. In some special cases the net enrolment may exceed 100% due to discrepancies between enrolment and population data. A threshold of one hundred percent could be used.
References	**Bibliographic references** Tembon, M., & Fort, L. (2008). *Girls' education in the 21st century: gender equality, empowerment, and economic growth*. Washington, DC: World Bank.

Indicator:	**Women in the Local Government**
Scope	Extended CPI
Rationale:	In most cities of the world, female participation in decision-making positions is disproportionately limited. This fact accentuates the problems of gender inequality and exclusion. Promoting gender equality and the empowerment of women to eliminate all forms of gender-based discrimination in decision making positions is essential to defeat poverty and foster sustainable development. Policies aimed at eradicating the gender gap are crucial to allow women to develop the skills and competencies they need to better participate in decision making positions and increase their contribution to the local and global economies [1]. Female participation is limited, and from this perspective, women are excluded from the opportunity to make decisions and fight for laws that benefit them. When this occurs, the skills and opportunities for training and development of women is violated and slimed, and social and economic growth of the cities is hampered [2]. A prosperous city must seek to be inclusive in political representation.
Definition:	Female representation rate in decision making positions i.e. within the city mayor and council offices is a measure of gender equality and equity established by the UN to observe the inclusion of women in the socio-political life of a nation and its cities. Moreover, it aims to capture the influence of female population on local policies. The index does not differentiate among nations with minimum quota for female participation in government and representation reached freely.
Unit [ ]	%
Methodology:	$Women\ in\ the\ local\ government = 100\left[\frac{number\ of\ women\ in\ government\ jobs}{Total\ of\ government\ jobs}\right]$
Source:	Administrative registries [3], Local Governments and Electoral Offices.
Benchmark	X^*= 50% Obtained from Mossuz-Lavau (2005) [4].
Standardization: 5	$Women\ in\ the\ local\ government^{(S)} = 100\left(1 - \left\lvert\frac{Women\ in\ the\ local\ government - X^*}{X^*}\right\rvert\right)$ $Women\ in\ the\ local\ government^{(S)} = 100\left(1 - \left\lvert\frac{Women\ in\ the\ local\ government - 50}{50}\right\rvert\right)$ Decision: $Women\ in\ the\ local\ government^{(S)}$ $= \begin{cases} 0, & if\ Women\ in\ the\ local\ government = 0\ or\ Women\ in\ the\ local\ government = 2*50 \\ Women\ in\ the\ local\ government^{(S)}, & If\ 0 < Women\ in\ the\ local\ government < 2*50 \\ 100, & If\ Women\ in\ the\ local\ government = 50 \end{cases}$
Limitations	Some countries may have female participation quotas established by law. In these particular cases, it would not be possible to identify whether the participation of women in government is by imposition or free will. In addition, some cities may not elect their mayors or councillors. However, given that the indicator aims to capture women influence on policies, these limitations could be justified.
References	**Bibliographic references** Circle of Rights, (2004). Economic, social and cultural rights of women. Module 4. Universidad de Minnesota en Estados Unidos. [2] Mossuz-Lavau, J. (2005). La paridad hombres/mujeres en política. Embajada de Francia en Bogotá. [4] **URL References** [1] http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/econ_development/women_wage_employment.pdf , Accessed June 11, 2014.

	[2] http://www1.umn.edu/humanrts/edumat/IHRIP/circle/modules/module4.htm , Accessed July 12, 2014. [3] http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=557, Accessed June 11, 2014. [4] http://www.ambafrance-co.org/La-paridad-hombres-mujeres-en, Accessed June 11, 2014.

Indicator:	**Women in the Workforce**
Scope	Extended CPI
Rationale:	In most cities around the world, women are disproportionately represented in labour markets. Promoting gender equality and the empowerment of women to eliminate all forms of gender-based discrimination in labour markets is essential to defeat poverty and foster sustainable development and inclusive societies (United Nations, 2007). Policies aimed at eradicating the gender gap in education are crucial to allow women to develop the skills and competencies they need to better participate in the labour market and make their contribution to the global economy. Their increased role in turn will boost women's economic security, which ultimately helps families out of poverty and hunger, and improves the health and education of their children. These changes are fundamental for sustainable development [1]. A prosperous city seeks to increase female participation in the work force as a way of achieving equal opportunities for men and women and to improve health and education.
Definition:	The share of women in the labour force is the share of female workers in the non-agricultural sector expressed as a percentage of total employment of the city. The non-agricultural sector includes industry and services. 'Industry' includes mining and quarrying (including oil production), manufacturing, construction, electricity, gas, and water, corresponding to divisions 2-5 in the International Standard Industrial Classification of All Economic Activities (ISIC-Rev.2) [2] and tabulation categories C-F (ISIC-Rev. 3) [2] (United Nations, 2007). Services include wholesale and retail trade, restaurants and hotels; transport, storage, and communications; financing, insurance, real estate, and business services; and community, social, and personal services, corresponding to divisions 6-9 (ISIC-Rev. 2) and tabulation categories G-Q (ISIC-Rev. 3). This indicator is consistent with Millennium Development Goals 3: "Promote gender equality and empower women." This index is obtained by dividing the number of women in non-agricultural paid employment by the total number of people in paid employment in the non-agricultural sector, and multiplying it by 100 (United Nations, 2007).
Unit [ ]	%
Methodology:	$Women\ in\ the\ workforce = 100\left[\frac{number\ of\ women\ in\ non-agricultural\ paid\ employment}{total\ number\ of\ people\ in\ paid\ employment\ in\ the\ non-agricultural\ sector}\right]$
Source:	Living Standards Households Surveys, Censuses.
Benchmark	X^*= 50% Obtained from Millennium Development Goals **3**: "Promote gender equality and empower women" [3]
Standardization: 5	$Women\ in\ the\ workforce^{(S)} = 100\left(1 - \left\lvert\frac{Women\ in\ the\ workforce - X^*}{X^*}\right\rvert\right)$ $Women\ in\ the\ workforce^{(S)} = 100\left(1 - \left\lvert\frac{Women\ in\ the\ workforce - 50}{50}\right\rvert\right)$ Decision: $Women\ in\ the\ workforce^{(S)} = \begin{cases} 0, & if\ Women\ in\ the\ workforce = 0\ or\ Women\ in\ the\ workforce = 2*50 \\ Women\ in\ the\ workforce^{(S)}, & If\ \ 0 < Women\ in\ the\ workforce < 2*50 \\ 100, & If\ Women\ in\ the\ workforce = 50 \end{cases}$
Limitations	In many countries (especially developing countries), wage employment represents only a small portion of total employment. As a result, the contribution of women to the national economy may be underestimated and therefore misrepresented. In addition, this indicator fails to reveal the differences in the quality of employment regarding earnings, conditions of work, or any legal and social protection the job offers. [1]

References	**Bibliographic References** United Nations (2007). Indicators of Sustainable Development: Guidelines and Methodologies. Third Edition, United Nations, New York. [1] **URL References** [1] http://www.un.org/esa/sustdev/natlinfo/indicators/methodology_sheets/econ_development/women_wage_employment.pdf, Accessed June 11, 2014. [2]: http://laborsta.ilo.org/ , Accessed June 11, 2014. [3] http://mdgs.un.org/unsd/mdg/SeriesDetail.aspx?srid=722, Accessed June 11, 2014.

4. Urban Diversity (UD) Sub-Index

Indicator:	**Land use mix**
Scope	Extended CPI
Rationale:	When land use is balanced through complementary uses and activities within a local area (a mix of residences, workplaces and local commerce), daily trips are short and walkable. Diverse uses' peaking at different times ensures animated and safe local streets that encourage walking and cycling, and fosters a vibrant human environment where people want to live (Kajtazi, 2007). The location of activities within a city is very important due to its influence on the spatial interactions. If we consider distance as a function of the location, the importance of a suitable location has a significant influence on economic activities and land uses; i.e., in the specialization of urban space, and therefore the presence of various sectors in the city [1]. Land use characterizes the cityscape, while its spatial distribution determines the structure and organization of the city (Institute for Transportation and Development Policy, 2013). A prosperous city seeks to distribute the major urban activities to balance its systems and functions.
Definition:	The diversity of land use per square kilometer, within a city or urban area.
Unit [ ]	Dimensionless (value between 0 and 1.61).
Methodology:	1. Obtain urban land use map classified as follows: residential, commercial + services, industrial, public facilities, and public spaces. Public facilities are all the institutional structures defined for purposes such as: education, culture, sports and administration. Public spaces include all the open spaces that could be used for recreation such as: parks, public spaces related to the equipment and green zones that are accessible to people. 2. Overlay a regular grid of 500 m x 500 m cell size. 3. Calculate the area allocated to each land use class within each cell. 4. The land allocated to the streets must not be included, which means that this value must be extracted from the total of surface. 5. Calculate de Shannon-Wiener diversity index for each cell *j* as follows: $Shannon - Wienner\ diversity\ index_j = [-\sum_i p_i * ln(p_i)]$, Where p_i is the share of each land use class within the cell calculated as the area of each class divided by the total cell unit area (250,000m²). 6. Calculate the average as follows: $Land\ use\ mix = \frac{\sum_j Shannon - Wienner\ diversity\ index_j}{Total\ number\ of\ cells}$
Source:	Local urban and city planning authorities.
Benchmark	Min = 0 Max = 1.61, which is the maximum value of the Shannon-Wienner diversity index for five categories; i.e., Max($hannon - Wienner\ diversity\ index$) = $\ln(5) = 1.61$.
Standardization: 2.1	$La\square d\ use\ mix^{(S)} = 100\left[\frac{Land\ use\ mix - Min}{Max - Min}\right]$ $Land\ use\ mix^{(S)} = 100\left[\frac{Land\ use\ mix}{1.61}\right]$ Decision:

	$$Land\ use\ mix^{(S)} = \begin{cases} 100, & If\ Land\ use\ mix \geq 1.61 \\ Land\ use\ mix^{(S)}, & If\ \ 0 < Land\ use\ mix < 1.61 \\ 0, & If\ Land\ use\ mix \leq 0 \end{cases}$$
Limitations:	Because this information comes from the regulatory plans, they do not always reflect the reality on the ground. Sometimes urban development is inconsistent with regulatory plans especially in developing countries.
References	**Bibliographic references** Kajtazi, B. (2007) Measuring multi-functionality of urban area. International Institute for Geo-Information Science and Earth Observation, Enschede, the Netherlands. [1] Institute for Transportation and Development Policy (2013) TOD Standard v. 2.0. New York. **URL references** [1]: http://www.itc.nl/library/papers_2007/msc/upla/kajtazi.pdf , Accessed June 11, 2014.

6. 5 ENVIROMENTAL SUSTAINABILITY INDEX

Sustainability is the ability to maintain or strengthen something. Environmental sustainability is therefore the ability to maintain and strengthen things or qualities that are valued in the physical environment (which includes the natural and biological environments[15]) or the maintenance of the factors and practices that contribute to the quality of the environment on a long-term basis[16]. For example, most people want to sustain (maintain):

- human life
- the capabilities that the natural environment has to maintain the living conditions for people and other species (e.g. clean water and air, a suitable climate)
- the aspects of the environment that produce renewable resources such as water, timber, fish, solar energy
- the functioning of society, despite non-renewable resource depletion
- the quality of life for all people, the livability and beauty of the environment

Degradation of the environment can be caused by a number of factors.
The first major one is pollution. This is the introduction of contaminants into the natural environment that cause adverse changes, thus making the environment dirty and unsafe to use. Pollution can have adverse effect to humans living in polluted areas. In some of the world's worst polluted places, babies are born with birth defects, children have lost 30 to 40 IQ points, and life expectancy may be as low as 45 years because of cancers and other diseases.
The major aspects of pollution are[17]:

- Air Pollution: The air we breathe has a very exact chemical composition; 99 percent of it is made up of nitrogen, oxygen, water vapor and inert gases. Air pollution occurs when things that aren't normally there are added to the air. This is possible in cases of releasing of particles (PM10, PM2.5) into the air, emission of dangerous gasses that could cause chemical reaction in the atmosphere e.g. creating acid rain (SO_2, CO, NO_2) or production of greenhouse gases that cause global warming (CO_2, SO_2) as a result of burning fossil fuels.
- Land Pollution: Land can become polluted by improper disposal of waste - household garbage and by industrial waste
- Water Pollution: Water pollution happens when chemicals or dangerous foreign substances are introduced to water, including chemicals, sewage, pesticides and fertilizers from agricultural runoff, or metals like lead or mercury.

The second major cause of environmental degradation is depletion of the earth's non-renewable resources, usually fossil fuels. These are limited and they produce pollutants into the air during combustion. Further depletion of these should be halted by use of renewable energy sources. This will lead to better environmental sustainability.

Issues of Sustainability arise wherever there is a risk of difficult or irreversible loss of the things or qualities of the environment that people value. And whenever there are such risks there is a degree of urgency to take action.

Environmental Sustainability and the City
Urbanization has enormous environmental consequences, both global and local. Already city dwellers are thought to be responsible for up to 70% of the world's greenhouse gas emissions. Sprawling urban development consumes arable land and vital green spaces. Growing numbers of city residents put pressure on energy and water resources, waste management, sewer systems, and transport networks. Therefore, in order to tackle climate change, avoid lasting damage to vital ecosystems and improve the health and wellbeing of billions of people, solutions to these problems must be sought at the city level.[18]

Economic growth and urbanization are inevitable; and if matched with appropriate and effective policies and governance, the environmental consequences are manageable. Cities must build the financial and other institutions required to achieve environmental sustainability (without which economic growth will fall short of ensuring shared prosperity).

Environmentally sustainable cities are more compact, energy-efficient, clean, less polluted, more accessible, and offer better transport choices. Investments in renewable energies could generate more employment and income for urban households. Waste management and recycling can be a huge source of employment in developing countries. Achieving a prosperous city requires careful balancing of these objectives. As a result, environmental sustainability must go hand-in-hand with other important goals such as promoting economic development, reducing poverty and improving quality of life. Indeed, the green agenda is a necessary part of holistic, city-led strategies for economic, social and environmental sustainability.

[15] http://www.green-innovations.asn.au/A-Perspective-on-Environmental-Sustainability.pdf
[16] http://www.businessdictionary.com/definition/environmental-sustainability.html
[17] http://www.livescience.com/22728-pollution-facts.html
[18] http://www.siemens.com/entry/cc/features/greencityindex_international/all/en/pdf/gci_report_summary.pdf

Computing the Environmental Sustainability Index
The indicator variables within the Environmental Sustainability Index are classified as follows:

DIMENSION	SUB-DIMENSION	INDICATOR
Environmental Sustainability Index (ES)	1. Air Quality (AQ)	1.1. Number of Monitoring Stations 1.2. PM2.5 Concentration 1.3. CO2 Emissions
	2. Waste Management (WM)	2.1. Solid Waste Collection 2.2. Waste Water Treatment 2.3. Solid Waste Recycling Share
	3. Sustainable Energy (SE)	3.1. Share of Renewable Energy Consumption

To compute the Environmental Sustainability Index, at the Basic CPI level, the variables within the sub-dimensions are aggregated as follows:

ENVIRONMENTAL SUSTAINABILITY INDEX (ES) = 1/3 [Air Quality (AQ) + Waste Management (WM) + Sustainable Energy (SE)]

Where:

AQ = (1/2) [Number of Monitoring Stations + PM10 Concentration]
WM = (1/2) [Solid Waste Collection + Waste Water Treatment + Solid Waste Recycling Share]
SE = Share of Renewable Energy Consumption

The Environmental Sustainability Index can also be estimated at an Extended CPI level. To do this, aggregate the variables within the sub-dimensions as follows:

ENVIRONMENTAL SUSTAINABILITY INDEX (ES) = 1/3 [Air Quality (AQ) + Waste Management (WM) + Sustainable Energy (SE)]

Where:

AQ = (1/3) [Number of Monitoring Stations + PM10 Concentration + CO2 Emissions]
WM = (1/3) [Solid Waste Collection + Waste Water Treatment + Solid Waste Recycling Share]
SE = Share of Renewable Energy Consumption

1. Air Quality

The term "air quality" refers to the state of the air around us. Good air quality refers to clean, clear and unpolluted air. Clean air is essential to maintaining the delicate balance of life on this planet — not just for humans, but wildlife, vegetation, water and soil. Poor air quality is a result of a number of factors, including emissions from various sources, both natural and "human-caused." This occurs when pollutants reach high concentrations to endanger human health and/or the environment. Our everyday choices, such as driving cars and burning wood, can have a significant impact on air quality[19].

This sub index will look at air quality in the following perspectives:

- The availability of facilities that measure and track the quality of the air in the city
- The concentration of air pollutants, particularly particulate matter and greenhouse gasses

<table>
<tr><th>Indicator:</th><th>Number of Monitoring Stations</th></tr>
<tr><td>Scope</td><td>Basic CPI</td></tr>
<tr><td>Rationale:</td><td>Air quality monitoring is carried out to assess the extent of pollution, ensure compliance with national legislation, evaluate control options, and provide data for air quality modeling [1]. However, winds, topography, land use, source locations, among others, can cause a significant level of spatial heterogeneity in the concentration levels of air pollutants such as PM10, SO_2 and NO_2. Thus, the quality of the measure of these concentrations depends on the number of monitoring stations located throughout the urban areas (U.S. Government, 2014).

A prosperous city seeks to have a proper measurement of air quality by using several monitoring stations, relative to its population size.</td></tr>
<tr><td>Definition:</td><td>Number of operative Fixed Automatic Monitoring Stations located within the urban area.</td></tr>
<tr><td>Unit [ ]</td><td>#</td></tr>
<tr><td>Methodology:</td><td>Number of operative Fixed Automatic Monitoring Stations located within the urban area.</td></tr>
<tr><td>Source:</td><td>Local environmental authorities</td></tr>
<tr><td>Benchmark</td><td>Min = 0
Max = Set the maximum value according to the following table:
<table>
<tr><th></th><th colspan="3">PM10 Levels</th></tr>
<tr><th>Population category</th><th>>= 48 µg/m3</th><th>>= 32 µg/m3 and < 48 µg/m3</th><th>< 32 µg/m3</th></tr>
<tr><td>>1,000,000</td><td>One station per 125,000 inhabitants</td><td>One station per 250,000 inhabitants</td><td>One station per 500,000 inhabitants</td></tr>
<tr><td>500,000 - 1,000,000</td><td>8</td><td>4</td><td>2</td></tr>
<tr><td>250,000 - 500,000</td><td>4</td><td>2</td><td>1</td></tr>
<tr><td>100,000 - 250,000</td><td>2</td><td>1</td><td>-</td></tr>
</table></td></tr>
<tr><td></td><td>The table is adapted from the Electronic Code of Federal Regulations (U.S. Government, 2014: Table D-4 of Appendix D to Part 58—PM10 Minimum Monitoring Requirements -Approximate Number of Stations Per MSA-)</td></tr>
<tr><td>Standardization: 2.1</td><td>$Number\ of\ monitoring\ stations^{(S)} = \ 100\left[\frac{number\ of\ monitoring\ stations - Min}{Max - Min}\right]$</td></tr>
</table>

[19] http://www.bcairquality.ca/101/what-is-air-quality.html

	$Number\ of\ monitoring\ stations^{(S)} = \ 100\left[\frac{number\ of\ monitoring\ stations\ (NMS)}{Max}\right]$ Decision: $Number\ of\ monitoring\ stations^{(S)}$ $= \begin{cases} 100, & If\ Number\ of\ monitoring\ stations \geq Max. \\ Number\ of\ monitoring\ stations^{(S)}, & If\ \ 0 < Number\ of\ monitoring\ stations < Max. \\ 0, & If\ Number\ of\ monitoring\ stations = 0 \end{cases}$
Limitations	As can be seen in the table above, the suggested number of Fixed Automatic Monitoring Stations located within the urban area depends on the population and PM10 concentration levels; and at the same time, the accuracy in the measurement of PM10 concentration levels depends on the number of Fixed Automatic Monitoring Stations. Thus, it is important to make sure that the determination of the number of Stations is based on the most accurate measure of PM10 concentration level available. If the city has a small number of Fixed Stations it would be important to use additional Mobile Stations to assess how many fixed stations may be lacking.
References	**Bibliographic references** U.S. Government (2014). Electronic Code of Federal Regulations. U.S. Government Printing Office. [2] **URL references:** [1]: http://www.epa.gov/airquality/aqmportal/management/monitoring.htm, accessed August 31, 2015 [2]:http://www.ecfr.gov/cgi-bin/retrieveECFR?gp=&SID=0f3bfa16342b3e5b858743bbbbdcfa4f&r=PART&n=40y6.0.1.1.6#40:6.0.1.1.6.2, accessed June 11, 2014.

Indicator:	**Particulate Matter (PM 2.5) Concentration**
Scope	Basic CPI
Rationale:	Particulate Matter (PM) is the sum of all solid and liquid particles suspended in air, many of which are hazardous. PM are particles of size~ 10 micrometers as well as size~2.5 micrometers. This complex mixture includes both organic and inorganic particles, such as dust, pollen, soot, smoke, and liquid droplets. These particles vary greatly in size, composition, and origin. Particles in air are either directly emitted, for instance when fuel is burnt and when dust is carried by wind, or indirectly formed, when gaseous pollutants previously emitted to air turn into particulate matter.[1] At present, most routine air quality monitoring systems generate data based on the measurement of PM10 and include both the coarse (particle size between 2.5 and 10 µg) and fine particles. They are emitted from households, industry power stations, transportation, among others, can penetrate the lungs and cause health problems (World Health Organization, 2011). A prosperous city seeks to improve air quality and urban sustainability by reducing the emissions that contribute to the concentration level of these particulates in the air.
Definition:	Annual mean concentration of particulate matter of less than 2.5 microns (PM2.5) in cities. PM 2.5 is used because of its greater health impacts. The estimates represent the average annual exposure level of the average urban resident to outdoor particulate matter. High-quality measurements of PM 2.5 concentration from all the monitors in the urban area can be averaged to develop a single estimate.
Unit [ ]	Micrograms per cubic meter (µg/m^3)
Methodology:	The concentration of PM 2.5 is regularly measured from fixed-site, population-oriented monitors located within the urban areas. PM 2.5 concentration can be estimated from PM 10 using national conversion factors (PM 2.5/PM 10 ratios) estimated as population-weighted averages of city specific conversion factors for the country. This is applicable to cities where PM 10 is the only reported PM parameter. In the absence of national conversion factors, an average of the surrounding country-specific conversion factors working as the regional conversion factors can be used. Care should be taken that the monitors used are not unduly influenced by a single source of pollution (i.e. a power plant, factory or highway). Instead, the monitors should reflect exposures over a wide area (World Health Organization, 2011).
Source:	Records from fixed or mobile Dust/PM monitoring stations available in local governments, World Bank (2014).
Benchmark	X^*= 10 µg/m^3. Obtained from WHO Ambient Air Pollution Database, May 2014.
Standardization: 4	$PM\ 2.5\ con\text{entration}^{(S)} = \quad 100\left(1 - \left\lvert\frac{PM\ 2.5\ concentration - X^*}{X^*}\right\rvert\right)$ $PM\ 2.5\ concentration^{(S)} = \quad 100\left(1 - \left\lvert\frac{PM\ 2.5\ concentration - 10}{10}\right\rvert\right)$ Decision: $PM\ 2.5\ concentration^{(S)} = \begin{cases} 0, & \text{f } PM\ 2.5\ concentration \geq 2 * 10 \\ PM\ 2.5\ concentration^{(S)}, & If\ \ 20 < PM\ 2.5\ concentration < 2 * 10 \\ 100, & If\ PM\ 2.5\ concentration \leq 10 \end{cases}$

Limitations	To have an accurate measure of the PM concentration in the city it is important to measure this variable in different sites within the city. For this measurement the appropriate number of Fixed Automatic Monitoring Stations is determined using the same table as used under the Number of monitoring station indicator described above. As it is warned by the World Bank (2014), there are non-anthropogenic sources of outdoor particulate matter pollution (e.g. dust storms). These sources deteriorate the air quality but are linked to causes that are beyond the control of local authorities.
References	**Bibliographic references** Ambient Air Pollution Database, WHO, May 2014 World Health Organization (2011). Indicator and Measurement Registry version 1.7.0. [2] The World Bank (2014). World Development Indicators 1960 – 2013. [3] European Commission (2013). The Clean Air Policy Package. [4] **URL references** [1]:http://www.greenfacts.org/en/particulate-matter-pm/level-3/01-presentation.htm#0p0 accessed August 31, 2015 [2]: http://apps.who.int/gho/indicatorregistry/App_Main/view_indicator.aspx?iid=1349, accessed June 11, 2014. [3]: http://data.worldbank.org/indicator/EN.ATM.PM10.MC.M3, accessed June 11, 2014. [4]: http://ec.europa.eu/environment/air/quality/standards.htm, accessed June 11, 2014.

Indicator:	**CO_2 emissions**
Scope	Extended CPI
Rationale:	Global warming is a term used to describe a gradual increase in the average temperature of the Earth's atmosphere and its oceans. It is believed to be permanently changing the earth's climate, which has negative adverse effects on the planet and its inhabitants. For example [1]: • Rising ocean temperatures leading to melting glaciers that leads to rising sea levels. These in turn will cause increasing coastal erosion, flooding, and property damage during coastal storms on top of the potential for major loss of life from storms in low-lying coastal countries • Warmer sea surface temperatures will result in more and stronger tropical storms (hurricanes and typhoons). Coastlines already ravaged by these storms will expect to see more strong storms than before, increasing the loss of life and damage to infrastructure. • Unpredictable weather patterns will arise meaning new risks and changing conditions for agriculture • Higher CO_2 levels allow for faster growth of plants. Unfortunately these include weeds, whose rapid growth will nullify the improved crop growth • Natural ecosystems will be hard pressed to keep up with the changing climate because the rate of change will be faster than typical long-term natural climate change. This leads to the extinction of many species, especially plant species • Severe summer heat in areas not used to it can lead to deaths. Higher heat and expansion of tropical areas may lead to increased incidence of malaria. Carbon dioxide (CO_2) is the most representative greenhouse gas (GHG). Since the industrial revolution the concentration of this gas in the atmosphere has increased dramatically (The World Bank, 2014). Increased volumes of CO_2 and other greenhouse gases released by the burning of fossil fuels, land clearing, agriculture, and other human activities, are believed to be the primary sources of the global warming that has occurred over the past 50 years. [2] A prosperous city seeks to reduce the levels of CO_2 emissions to improve environmental sustainability and air quality.
Definition:	Total amount of CO_2 emissions in a year. Carbon dioxide emissions are those stemming from the burning of fossil fuels. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring (The World Bank, 2014).
Unit [ ]	Metric tonnes of CO_2 per capita
Methodology:	There exists a wide range of models for measuring greenhouse gas emissions from different sources. One of the most utilized systems is the Long range Energy Alternatives Planning System (LEAP) developed at the Stockholm Environment Institute (Heaps, 2008). The city's local environmental authorities should measure and report the greenhouse gas emissions, which includes CO_2 emissions.
Source:	Local environmental authorities.
Benchmark	Min = 0.01 metric tonnes Max = 40.31 metric tonnes Calculated from The World Bank (2014).
Standardization: 2.2	$CO_2\ emissions^{(S)} = 100\left[1 - \frac{\sqrt[5]{CO_2\ emissions} - \sqrt[5]{Min}}{\sqrt[5]{Max} - \sqrt[5]{Min}}\right]$ $CO_2\ emissions^{(S)} = 100\left[1 - \frac{\sqrt[5]{CO_2\ emissions} - 0.39}{2.09 - 0.39}\right]$ Decision:

	$$CO_2\ emissions^{(S)} = \begin{cases} 0, & If\ \sqrt[5]{CO_2\ emissions} \geq 2.09 \\ CO_2\ emissions^{(S)}, & If\ \ 0.39 < \sqrt[5]{CO_2\ emissions} < 2.09 \\ 100, & If\ \sqrt[5]{CO_2\ emissions} \leq 0.39 \end{cases}$$
Limitations	These calculations usually do not include fuels burning from aircrafts and ships.
References	**Bibliographic references** The World Bank (2014). World Development Indicators 1960 – 2013. [3] Heaps, C. (2008) Long Range Energy Alternatives Planning System: An introduction. Stockholm Environment Institute. [4] **URL references** [1]: http://www.columbia.edu/~vjd1/greenhouse.htm, accessed August 31, 2015 [2]: http://www.livescience.com/topics/global-warming/, accessed August 31, 2015 [3]: http://data.worldbank.org/indicator/EN.ATM.CO2E.PC, accessed June 11, 2014. [4]: http://www.energycommunity.org/documents/LEAPIntro.pdf, accessed June 11, 2014.

2. Waste Management

This is the collection, transportation and disposal of garbage and other waste products. Waste management therefore encompasses management of all processes and resources for proper handling of waste materials, from maintenance of waste transport trucks and dumping facilities to compliance with health codes and environmental regulations[20]. Waste management is intended to reduce adverse effects of waste on health, the environment and aesthetics.

Waste management in the context of the city, is done by municipal services or similar institutions, or by public or private corporations, specialized enterprises or general government (United Nations, 1997). This sub dimension will look at the ability of a city to properly collect and dispose off the waste generated by its inhabitants – either on its own or with the help of private partnerships.

The CPI will consider waste that is produced as a result of day to day human activities. It measures how well the city is equipped to deal with this waste management and disposal i.e.

- Solid waste – will refer to household waste
- Waste water – will refer to sewage

Indicator:	**Solid Waste Collection**
Scope	Basic CPI
Rationale:	Solid waste (in this case domestic/ household waste or residential waste) is waste comprising of garbage and rubbish (such as bottles, cans, clothing, compost, disposable, food packaging, food scraps, newspapers and magazines and yard trimmings) that originate from private homes or apartments. It may also contain household hazardous waste [1]. A prosperous city seeks to collect the most part of solid waste to improve standards of living by decreasing the probability and incidence of waste related vector diseases.
Definition:	Share of waste collected by the city and adequately disposed either in sanitary landfills, incineration sites or in regulated recycling facilities. Expressed in terms of the total volume of waste generated by the city (The Economic Intelligence Unit, 2010: pg.30)
Unit [ ]	%
Methodology:	$Solid\ waste\ collection = 100\left[\frac{Volume\ of\ waste\ collected}{Total\ volume\ of\ waste\ generated\ by\ the\ city}\right]$
Source:	Local solid waste management plans, local authorities.
Benchmark	Min = 0% Max = 100%
Standardization: 1.1	Not required
Limitations	To avoid unfair comparisons this variable does not differentiate between the levels of sophistication of the waste collection systems.
References	**Bibliographic references:** The Economic Intelligence Unit (2010). Latin American Green City Index: Assessing the environmental performance of Latin America's major cities. [2] United Nations (1997). Glossary of Environment Statistics, Studies in Methods, Series F, No. 67, New York. **URL references:** [1]: http://www.businessdictionary.com/definition/household-waste.html, accessed August 31, 2015

[20] http://www.businessdictionary.com/definition/waste-management.html

	[2]: http://www.siemens.com/press/pool/de/events/corporate/2010-11-lam/Study-Latin-American-Green-City-Index.pdf, accessed June 11, 2014.

Indicator:	Wastewater Treatment
Scope	Basic CPI
Rationale:	Water is fundamental to support life and human activities. According to the United Nations, 783 million people do not have access to clean water and around 2.5 billion do not have access to adequate sanitation[21]. Adequate sanitation helps to keep sewage and other contaminants from entering the water supply. If water is not properly cleaned after use, wastewater can have a huge negative impact on the environment and can become lead to vector-borne diseases (US Environmental Protection Agency, 2008; USGS, 2014). Urban wastewater treatment is a key action to mitigate the impact of urban life in the environment by reducing water pollution. This treatment is a process to convert wastewater - which is water no longer needed or suitable for its most recent use - into an effluent that can be either returned to the water cycle with minimal environmental issues or reused. A prosperous city seeks to increase as much as possible the percentage of treated wastewater to ensure environmental sustainability and a less polluted environment.
Definition:	Percentage of sewage treated from sewage produced within the urban agglomeration. Sewage is waste material that is carried away from homes and other buildings in a system of pipes [1]. It consists mostly of greywater (from sinks, tubs, showers, dishwashers and clothes washers), blackwater (the water used to flush toilets, combined with the human waste that it flushes away); soaps and detergents; and toilet paper (less so in regions where bidets are widely used instead of paper). Whether it also contains surface runoff depends on the design of sewer system.
Unit [ ]	%
Methodology:	$Wastewater\ treatment = 100\left[\frac{sewage\ treated\ in\ m^3/year}{sewage\ produced\ in\ m^3/year}\right]$
Source:	Wastewater treatment plans, local authorities.
Benchmark	Min= 0% Max = 100%
Standardization: 1.1	Not required
Limitations	The accuracy of the measurement of sewage effluent produced may vary across countries because the direct measurement of this variable has many technical challenges. For this reason several countries estimate the sewage effluent as a function of the water consumption, which includes both the water supply system and alternative water sources. In this case, the regulatory agencies establish a conversion factor between consumption and discharge of the form: $sewage = water\ consumption \times factor$ where, $factor \leq 1.$ As a result, this factor will be different for different cities.
References	**Bibliographic references:** USGS (2014). The USGS Water Science School: Wastewater Treatment. [2] US Environmental Protection Agency (2008). Tribal Compliance Assistance Center: Wastewater Topics. [3] **URL references:** [1]: http://www.merriam-webster.com/dictionary/sewage, accessed August 31, 2015 [2]: http://water.usgs.gov/edu/wuww.html, accessed June 11, 2014. [3]: http://www.epa.gov/tribalcompliance/wwater/wwwastedrill.html, accessed June 11, 2014.

[21] http://www.unwater.org/water-cooperation-2013/water-cooperation/facts-and-figures/en/

Indicator:	Solid Waste Recycling Share
Scope	Extended CPI
Rationale:	Recycling and reusing solid waste is a way to reduce the amount of waste to be disposed in landfills (US Environmental Protection Agency, 2014). A prosperous city seeks to recycle most part of its solid waste to increase the lifespan of its landfills and to profit from solid waste as much as possible.
Definition:	The recycling rate is the tonnage recycled from municipal waste divided by the total municipal waste arising. Recycling includes material recycling, composting and anaerobic digestion. Municipal waste consists largely of waste generated by households, but may also include similar wastes generated by small businesses and public institutions and collected by the municipality; this latter part of municipal waste may vary from municipality to municipality and from country to country, depending on the local waste management system (Eurostat, 2013).
Unit [ ]	%
Methodology:	$Solid\ waste\ recycling\ share = 100\left[\frac{volume\ of\ waste\ recycled}{total\ volume\ of\ waste\ collected}\right]$
Source:	Local solid waste management plans and local authorities.
Benchmark	X^*= 50% Obtained from European Parliament, Council of the European Union (2008).
Standardization: 3	$Solid\ waste\ recycling\ share^{(S)} = \quad 100\left(1 - \left\lvert\frac{Solid\ waste\ recycling\ share - X^*}{X^*}\right\rvert\right)$ $Solid\ wast\ recycling\ share^{(S)} = \quad 100\left(1 - \left\lvert\frac{Solid\ waste\ recycling\ share - 50}{50}\right\rvert\right)$ Decision: $Solid\ waste\ recycling\ share^{(S)}$ $= \begin{cases} Solid\ waste\ recycling\ share^{(S)}, & If\ \ 0 \leq Solid\ waste\ recycling\ share < 50 \\ 100, & If\ Solid\ waste\ recycling\ share \geq 50 \end{cases}$
Limitations	The data quality varies widely among different countries. Accurate recycling statistics are available in cities with Solid Waste Management Plan, while rough estimates usually come from cities with a predominant informal recycling system.
References	**Bibliographic references:** Eurostat (2013). Recycling rate of municipal waste (t2020_rt120). [1] Eurostat (2014). Recycling rate of municipal waste (t2020_rt120). [2] European Parliament, Council of the European Union (2008). Directive 2008/98/EC on waste and repealing certain Directives. Official Journal of the European Union. [3] US Environmental Protection Agency (2014). Municipal Solid Waste. [4] **URL references:** [1]:http://epp.eurostat.ec.europa.eu/cache/ITY_SDDS/EN/t2020_rt120_esmsip.htm#relatedmd1401955141433, accessed June 11, 2014. [2]:http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&plugin=1&language=en&pcode=t2020_rt120, accessed June 11, 2014. [3]:http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0098, accessed June 11, 2014. [4]: http://www.epa.gov/epawaste/nonhaz/municipal/, accessed June 11, 2014.

3. Sustainable Energy

This sub-dimension looks at the depletion of the earth's own non-renewable resources and how to minimize further damage to the environment by using alternative sources of energy.

Indicator:	**Share of Renewable Energy**
Scope	Basic CPI
Rationale:	Fossil fuels such as coal, oil, and natural gas, contribute greatly to global climate change by releasing carbon dioxide into the air when they are burned. Also, when we use them all up we can never get more. They are non-renewable sources of energy. It is therefore important to look to alternative sources of energy that are sustainable and clean, for the sake of our environment A renewable source of energy is the answer to the above problem. It is "any naturally occurring, theoretically inexhaustible source of energy that is not derived from fossil or nuclear fuel" [1]. They are usually much more environmentally friendly than fossil fuels. Overall, they release very few chemicals, like carbon dioxide, that can harm the environment. The incentive to use renewable energy, for electricity, transport, or even total primary energy supply has been motivated by global warming and other ecological as well as economic concerns. The Intergovernmental Panel on Climate Change said that there are few fundamental technological limits to integrating a portfolio of renewable energy technologies to meet most of total global energy demand/needs (Intergovernmental Panel on Climate Change, 2011). Hydropower is not considered in this indicator as large dams and reservoirs have an impact on ecosystems. Among these impacts, they are a barrier to migrating fish and they disrupt the delivery of sediments to agricultural areas down streams and to deltas. In some locations, biomass decomposing in reservoirs releases methane and CO2 in amounts roughly equivalent to the carbon emissions avoided through not burning fossil fuels. (UNEP Yearbook, 2010) A prosperous city seeks to improve energy consumption sustainability and to reduce emissions from energy generation by using clean and renewable energy sources.
Definition:	Electricity production from renewable sources (% of total electricity produced) i.e. Electricity produced by the following renewable sources of energy; geothermal, solar photovoltaic, solar thermal, tide, wind, industrial waste, municipal waste, primary solid biofuels, biogases, bio-gasoline, biodiesels, other liquid biofuels, non-specified primary biofuels and waste, and charcoal. **Hydropower is excluded** (The World Bank, 2014). Divided by total electricity production which is the total number of GWh generated by power plants separated into electricity plants and CHP plants.
Unit [ ]	%
Methodology:	Share of renewable energy sources from total energy sources, expressed as percentage.
Source:	Electricity companies that feed the city grid, The International Energy Agency (IEA), The World Bank.
Benchmark	Min = 0 % Max = 20 %
Standardization: 2.1	$Share\ of\ renewable\ energy^{(S)} = 100\left[\frac{Share\ of\ renewable\ energy\ - Min}{Max - Min}\right]$ $Share\ of\ renewable\ energy^{(S)} = 100\left[\frac{Share\ of\ renewable\ energy\ (SRE)}{20}\right]$ Decision: $Share\ of\ renewable\ energy^{(S)}$

	$$= \begin{cases} 100, & If\ SRE \geq 20 \\ Share\ of\ renewable\ energy^{(S)}, & If\ 0 < SRE < 20 \\ 0, & If\ SRE = 0 \end{cases}$$
Limitations	When the cities within a country get their energy from a national interconnected system, there will not be differences in the values on the share of renewable energy consumption. Moreover, off-grid energy source may not be taking into account. Hydropower is excluded from this indicator. Hydroelectric power plants supply nearly 20 per cent of all electricity consumed worldwide. Some countries have a very high proportion of electricity production using hydropower.
References	**Bibliographic references** Intergovernmental Panel on Climate Change (2011). "Special Report on Renewable Energy Sources and Climate Change Mitigation". Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. p. 17. The World Bank (2014). World Development Indicators 1960 – 2013. [2] United Nations Environment Programme (2010) UNEP Year Book 2010: New Science and Developments in Our Changing Environment. UNEP/Earthprint European Commission The World Bank (2014). **URL references:** [1]: http://dictionary.reference.com/browse/renewable+energy, accessed August 31, 2015 [2]: http://wdi.worldbank.org/table/3.7, accessed June 11, 2014.

6. 6 URBAN GOVERNANCE AND LEGISLATION INDEX

Governance is the exercise of managing and country's political, economic and administrative affairs at all levels, whilst legislation refers to a body of laws, rules, rulings, regulations, acts, bills, statutes, enactments, ordinances etc. that would facilitate governance. Governance and legislation comprises the complex mechanisms, processes, and institutions through which citizens and groups articulate their interests, mediate their differences, and exercise their legal rights and obligations, to ensure administrative authorities are accountable in the use and distribution of public resources. Good governance and legislation is among other things participatory, transparent, accountable, effective and equitable, and promotes the rule of law. Good governance and legislation assures that political, social and economic priorities are based on broad consensus in society and that the voices of the poorest and the most vulnerable are heard in decision-making over the allocation of economic resources. Governance and Legislation includes the state, but transcends it by taking in the private sector and civil society. The state creates a conducive political and legal environment, while the private sector generates jobs and income, and the civil society facilitates political and social interactions by mobilizing groups to participate in economic, social and political activities[22].

The Urban Governance and Legislation dimension has been developed, following the increasing realization that it needs to acquire a more prominent and measurable condition within urban prosperity. Therefore, Legislation and Governance constitutes the sixth "spoke" of the "Wheel of Prosperity". The Legislation and Governance dimension has the purpose of demonstrating the role of good urban governance in catalysing local action towards prosperity, including the capacity to regulate and manage responsibly the urbanization process. As a measurable spoke, it will assist local governments in taking informed decisions based on evidence, and perform as a monitoring mechanism of urban power functions.

Therefore, a prosperous city seeks to ensure that the local legislation and urban governance effectively controls the functioning of the other prosperity dimensions; to achieve societal norms and practices that empower and encourage people to take increasingly greater control over their own development in a manner that does not impinge upon the rights of other city dwellers.

Under the CPI, the Urban Governance and Legislation Index is measured using four sub-dimensions as listed below:

- Participation and Accountability
- Municipal Finance and Institutional Capacity
- Governance of Urbanisation.

The structure of the Urban Governance and Legislation Index is as follows:

DIMENSION	SUB-DIMENSION	INDICATOR
Urban Governance and Legislation Index (UGL)	1. Participation (P)	1.1. Voter Turnout 1.2. Access to Public Information 1.3. Civic Participation
	2. Municipal Financing and Institutional Capacity (MFIC)	2.1. Own Revenue Collection 2.2. Days to Start A Business 2.3. Subnational Debt 2.4. Local Expenditure Efficiency
	3. Governance of Urbanization (GU)	3.1. Land Use Efficiency

To compute the Urban Governance and Legislation Index at the Basic CPI level, the variables within the sub-dimensions are aggregated as follows:

URBAN GOVERNANCE AND LEGISLATION INDEX (UGL) = 1/3 [Participation (P) + Municipal Financing and Institutional Capacity (MF) + Governance of Urbanisation (GU)]

Where:
P = Voter Turnout
MF = (1/2) [Own revenue Collection + Days of Starting Business]
GU = Land Use Efficiency

[22] UNDP Internet Conference Forum on "Public Private Interface in Urban Environmental Management" http://www.gdrc.org/u-gov/governance-define.html, Accessed 01 September 2015

The Urban Governance and Legislation Index can also be estimated at an Extended CPI level. To do this, aggregate the variables within the sub-dimensions as follows:

URBAN GOVERNANCE AND LEGISLATION INDEX (UGL) = 1/4 [Participation (P) + Accountability and Transparency (AT) + Institutional Capacity (IC) + Regulatory Quality (RQ)]

Where:

P = (1/3) [Voter Turnout + Access to Public Information +Civic Participation]
MF = (1/4) [Own Revenue Collection + Days to Start a Business + Subnational Debt + Local Expenditure Efficiency]
GU = Land Use Efficiency

1. Participation (P) Sub-Index

Indicator:	**Voter Turnout**
Scope	Basic CPI
Rationale:	Voter turnout indicates the degree of civic engagement within a society and a measure of individual participation in elections. Political participation is the foundation of democratic institutions; it ensures accountability of governments and public institutions and increases the likelihood that decisions and policy makers reflect the will of a large number of individuals. People vote to affect the actions of government in ways that are meaningful to them (OECD, 2011, p. 189). Although voter turnout is the best means of measuring civic and political engagement, this measure is far from ideal because of institutional differences in electoral systems, the population's education level since more educated people are more likely to vote, and voter's age because older people are more likely to vote than younger people [2]. A prosperous city seeks to motivate the eligible voters to participate in all elections and hence promote democratic practices, and increase the chance that the political systems reflect the will of the majority and for the city government to have a high degree of legitimacy [2].
Definition:	Voter turnout is the number of eligible voters who cast a ballot in an election. The voter's turnout varies between countries based on factors such as type of electoral system, place of residence, level of education, type of election (national or local), among others.
Unit [ ]	%
Methodology:	$Voter\ turnout = 100\left[\frac{Voters\ who\ cast\ a\ ballot\ in\ a\ local\ election}{Number\ of\ eligible\ voters}\right]$ The number of eligible voters changes between countries and it is not necessarily the total adult population. Since local elections do not occur every year, the city should use the voter turnout of the most recent elections.
Source:	National Electoral Authorities, International Institute for Democracy and Electoral Assistance (IDEA).
Benchmark	Min = 0% Max = 100%
Standardization: 1.1	Not required
Limitations	Cities within non-democratic countries cannot assess this indicator.
References	**Bibliographic references** OECD (2011) "Civic engagement and governance", in *How's life? Measuring well-being.* OECD Publishing. [1] **URL references** [1]: http://dx.doi.org/10.1787/9789264121164-11-en, Accessed August 6, 2014. [2]: http://www.oecdbetterlifeindex.org/topics/civic-engagement/, Accessed August 6, 2014.

Indicator:	Access to Public Information
Scope	Extended CPI
Rationale:	Improving government accountability improves service delivery, particularly for the poor, and accountability mechanisms safeguard against misuse and abuse of power and governance (World Bank, 2003). Accountability is a measure of responsibility that lies between the local authorities and city residents, which is based on answerability, transparency, good governance and enforcement. Answerability refers to the obligation of the authorities to inform residents about their conduct and the people's power to interrogate the authorities and to question the adequacy of the information or the legitimacy of the conduct, while enforcement refers to the people's power to pass judgment on the conduct of the authorities (Yilmaz et al., 2008). Easy access to information on the local government operations is critical to improving government accountability by minimizing opportunities for corruption within the local government and helping to examine the local realities and specific conditions that perpetuate corruption (UN-Habitat and Transparency International, 2004). Many local authorities worldwide run websites for their cities and use the Internet to conduct many of their transactions with its citizens. Every literate person with Internet access can review information made public on the web. The provision of both general and specific information on the local government website strengthens the link and trust between the people and local authorities, which in turn builds a more informed citizenry and a more transparent community (UN-Habitat and Transparency International, 2004). Although many local authorities already publish considerable amounts of data, the challenge is that much of this information varies from less sensitive to very sensitive data [1]. The emphasis on this indicator is to ensure that basic accountability information is made available openly, so that residents can check the efficiency, correctness and transparency of their city government and be able to hold it accountable for any inconsistencies. Transparency and accountability to local people using the Internet requires a commitment by the local government or the organization that maintains the web page to provide an updated site; and it requires human and financial resources as well as electronic capability on the part of the local government (UN-Habitat and Transparency International, 2004). A prosperous city seeks to increase transparency and accountability to avoid corruption and increase trust in the local government.
Definition:	To evaluate the degree of access to information about local authorities through the Internet, the local government website must be assessed according to the existence of a number of required elements listed below (see Methodology).
Unit [ ]	%
Methodology:	The following elements must be reviewed to calculate this indicator. The value of the indicator is the sum of the positive answers. $Access\ to\ Local\ Public\ Information = 100\left[\frac{number\ of\ elements\ present\ in\ the\ local\ web\ page}{10}\right]$ Does the E-government website possess the following element? 1- Budgets and spending 2- Senior salaries 3- Organizational chart 4- Copies of contracts and tenders 5- Access to statistics 6- Posting public notices on meetings, resolution, etc. 7- Local reporting complaints, concerns, and emergencies. 8- Results of local elections 9- Tax information 10- Open tendering procedures
Source:	Local authorities' website.
Benchmark	Min = 0% (low transparency) Max = 100% (high transparency)
Standardization: 1.1	Not required
Limitations	According to UN-Habitat and Transparency International (2004), widespread computer literacy and access to the Internet is required for local residents to make published information valuable.

References	**Bibliographic references** UN-Habitat (United Nations Human Settlements Programme) and Transparency International (2004). Urban Governance Toolkit Series. HS/702/04E. Nairobi. (ISBN: 92-1-131694-4). [2] World Bank (2003). World Development Report 2004: Making Services Work for Poor People. World Bank. © World Bank. https://openknowledge.worldbank.org/handle/10986/5986 License: CC BY 3.0 IGO.[3] Yilmaz, S.; Beris, Y.; and Serrano-Berthet, R. (2008). Local Government discretion and accountability: A diagnostic framework for local governance. Social Development Papers, Local Governance & Accountability Series, Paper No. 113. World Bank, Social Development Department. **URL references** [1]: http://localtransparency.readandcomment.com, Accessed August 6, 2014. [2]: http://ww2.unhabitat.org/cdrom/transparency/html/2b_5.html, Accessed August 6, 2014. [3]: https://openknowledge.worldbank.org/handle/10986/5986, Accessed August 6, 2014.

Indicator:	Civic Participation
Scope	Extended CPI
Rationale:	Voter turnout provides only partial information about political participation, and there is need to consider other forms of political engagements related to city governance and management (OECD, 2011, p.190). Civic engagement can be defined as the individual and collective actions designed to identify and address issues of public concern [2]. People with high levels of civic engagement are positive about the communities in which they live and actively work to improve them [3]. Engagement in civic associations is important because they can counteract public policies, monitor authorities and government institutions, and improve the quality of a democracy and city governance. A prosperous city seeks to increase civic participations to foster democracy, and align policy and government actions with the needs and the will of all its residents.
Definition:	The percentage of adults engaged in civic associations including religious organizations, where a civic association is a type of organization whose official goal is to improve neighborhoods through volunteer work by its members
Unit [ ]	%
Methodology:	$Civic\ participation = 100\left[\frac{people\ engaged\ in\ civic\ associations}{adult\ people\ in\ the\ city}\right]$
Source:	Household's surveys and censuses.
Benchmark	Min = 0% Max = 100%
Standardization: 1.1	Not required
Limitations	This indicator may not be reliable in cities within non-democratic countries. The definitions of civic associations may also vary across countries. Also some countries have restrictive laws and regulations that limit the right of associations.
References	**Bibliographic references** OECD (2011) "Civic engagement and governance", in *How's life? Measuring well-being.* OECD Publishing. [1] **URL references** [1]: http://dx.doi.org/10.1787/9789264121164-11-en, Accessed August 6, 2014. [2]: http://www.apa.org/education/undergrad/civic-engagement.aspx, Accessed August 6, 2014. [3]: http://www.gallup.com/poll/145589/civic-engagement-highest-developed-countries.aspx, Accessed August 6, 2014.

2. Municipal Finance and Institutional Capacity (MFIC)

Indicator:	**Own Revenue Collection**
Scope	**Basic CPI**
Rationale:	Decentralization increases the responsibilities of subnational governments in city development. As part of this process, subnational governments, such as cities, must mobilize resources to finance the expenditure needs of their regions (Canavire-Bacarreza et al., 2012). These resources generally comprise: own revenue collection, shared revenue and government transfers. Revenue sources must be balanced and controlled, but a large proportion of government transfers generates dependence on these resources and causes most shortages of city's own source revenue. (Bird & Smart, 2002; Bird, 2011). A prosperous city seeks to generate its own revenue and reduce dependence on government transfers. Greater fiscal autonomy guarantees more expenditure efficiency and can be used as local fiscal performance indicator.
Definition:	Own source revenue as percentage of the total city revenue.
Unit [ ]	%
Methodology:	The information required can be extracted from local fiscal accounts. It is important to obtain information about the sources of the local revenue. With this information the following proportion has to be calculated: $Own\ Revenue\ Collection = 100\left[\frac{Own\ source\ revenue}{Total\ local\ revenue}\right]$
Source:	Where; Total Local Revenue includes all revenue collected locally and that which is provided to the local authorities from external sources e.g. central government or external loans or grants (from private sector or international funds) etc. Local Fiscal Accounts.
Benchmark	Min: 17% Max: 80% Data is obtained from Fiscal Decentralization Indicators of the IMF's Government Finance Statistics (GFS) and The World Bank [2].
Standardization: 2.1	$Own\ Revenue\ Collection^{(S)} = \ 100\left[\frac{Own\ Revenue\ Collection - Min}{Max - Min}\right]$ $Own\ Revenue\ Collection^{(S)} = \ 100\left[\frac{Own\ Revenue\ Collection - 17}{80 - 17}\right]$ Decision: $Own\ Revenue\ Collection^{(S)}$ $= \begin{cases} 100, & If\ Own\ Revenue\ Collection \geq 80 \\ Own\ Revenue\ Collection^{(S)}, & If\ \ 17 < Own\ Revenue\ Collection < 80 \\ 0, & If\ Own\ Revenue\ Collection \leq 17 \end{cases}$
Limitations	In some countries, the definition of "own revenue" could be difficult to specify. Nevertheless, this indicator allows for deeper analysis of the meaning of own revenue. It provides information about the capacity of local government to manage and collect its resources (the main own revenue sources at city level are property and vehicle taxes as well as charges and fees – Tax Policy Center).
References	**Bibliography references** Bird, R. & Smart, M. (2002). Intergovernmental fiscal transfers: Lessons from international experience. World Development, 30(6), 899–912 Bird, R. (2011). Subnational taxation in developing countries: A review of the literature. Journal of International Commerce, Economics and Policy, 2(1), 139-161. Canavire-Bacarreza, G.; Martínez-Vázquez, J. & Sepúlveda, C. (2012). Sub-national revenue mobilization in Peru. IDB Bank Working Papers Series, 299. Tax Policy Center. The tax policy briefing book. [1] **URL references**

	[1]: http://www.taxpolicycenter.org/briefing-book/state-local/revenues/local_revenue.cfm, Accessed August 19, 2014. [2]: http://www1.worldbank.org/publicsector/decentralization/fiscalindicators.htm, Accessed August 20, 2014

Indicator:	**Days to Start a Business**
Scope	**Basic CPI**
Rationale:	A government should provide a conducive environment in the market it regulates as competition improves quality of goods and services, lowers cost for both producers and consumers, and creates facilities for those who want to enter any market. Excessive business regulation affects economic performance and development as it increases the costs of engaging in the formal economy (Doing Business, 2014). A prosperous city should develop regulatory framework that permits an easy entry of any firms in the market.
Definition:	One way to identify the ease of starting a business is the number of days it takes a firm to register. Registration must ideally include obtaining all necessary licenses and permits and completing any required notifications, verifications or inscriptions for the company and its employees with the relevant authorities. [1]
Unit [ ]	Days
Methodology:	Days to start a business recorded in calendar days. The measure captures the median duration that incorporation lawyers indicate as necessary to complete all required registration procedures.
Source:	Doing Business Indicator and Entrepreneur Surveys
Benchmark:	Min= 2 days Max= 208 days Obtained from the Doing Business ranking. [2]
Standardization: 2.2	$Days\ to\ start\ a\ business^{(S)} = 100\left[1 - \frac{\ln(Days\ to\ start\ a\ business) - \ln(Min)}{\ln(Max) - \ln(Min)}\right]$ $Days\ to\ start\ a\ business^{(S)} = 100\left[1 - \frac{\ln(Days\ to\ start\ a\ business) - 0.69}{5.34 - 0.69}\right]$ Decision: $Days\ to\ start\ a\ business^{(S)}$ $= \begin{cases} 0, & If\ \ln(Days\ to\ start\ a\ business) \geq 5.34 \\ Days\ to\ start\ a\ business^{(S)}, & If\ \ 0.69 < \ln(Days\ to\ start\ a\ business) < 5.34 \\ 100, & If\ \ln(Days\ to\ start\ a\ business) \leq 0.69 \end{cases}$
Limitations	Data is obtained through enterprise surveys made mostly by the World Bank, which makes the data not available for all cities.
References	**Bibliographic References:** Doing Business (2014). Understanding Regulations for Small and Medium-Size Enterprises. 11th Edition. **URL references** [1]: http://www.doingbusiness.org/Methodology/starting-a-business#time, Accessed August 6, 2014. [2]: http://www.doingbusiness.org/data/exploretopics/starting-a-business, Accessed August 6, 2014.

Indicator:	**Subnational Debt**
Scope	**Extended CPI**
Rationale:	Some cities (local governments) have the option to borrow money from the private sector or international funds. This debt is usually used to finance expensive projects that would be nearly impossible to finance with local or central government revenues alone. Nevertheless, cities must guarantee they will repay their loans (Vulovic, 2011). However, it is possible that a city may be operating way above its debt limits due to its inability to generate enough revenues in a given fiscal period to cover it expenditures and thus may accumulate huge amounts of debts that may be unsustainable in just a single fiscal period. It is accepted to apply limits to the level of debt (usually under a regulatory scheme). The objective of maintaining city debt within the established limits is to guarantee local and national budget future sustainability because in many cases when the local government is unable to pay for its own debt, the central government will have to assume it (Sutherland et al., 2006; Garcia, 2012; Marcel, 2013). A prosperous city seeks to sustainably borrow and manage its debt financing, and effectively utilize loans to facilitate projects that have great impact on the city and its residents.
Definition:	Percentage of subnational debt from local government' total revenue. This is computed as the ratio of the debt aggregates at a given time divided by the local government's revenue.
Unit [ ]	%
Methodology:	The information required can be extracted from local fiscal accounts. The formula to estimate debt sustainability is the following: $Subnational\ Debt = 100\left[\frac{Total\ existing\ Amount\ of\ debt}{Total\ current\ local\ revenue}\right]$
Source:	Local Fiscal Accounts.
Benchmark	X^*= 60% Drawn from the IMF (2011) based on information about debt ceilings in some European Union countries and The World Economic Outlook Database, which suggest a threshold of debt equal to 60% of the country GDP. "When public debt exceeds or is projected to exceed 60 percent of GDP for a substantial part of the projection horizon […] a detailed discussion of potential risks to sustainability arising from high debt levels would normally be expected"
Standardization: 4	$Subnational\ Debt^{(S)} = 100\left(1 - \left\lvert\frac{Subnational\ Debt - X^*}{X^*}\right\rvert\right)$ $Subnational\ Debt^{(S)} = 100\left(1 - \left\lvert\frac{Subnational\ Debt - 60}{60}\right\rvert\right)$ Decision: $Subnational\ Debt^{(S)} = \begin{cases} 0, & if\ Subnational\ Debt \geq 2 * 60 \\ Subnational\ Debt^{(S)}, & If\ \ 60 < Subnational\ Debt < 2 * 60 \\ 100, & If\ Subnational\ Debt \leq 60 \end{cases}$
Limitations	Some countries may not allow borrowing at subnational or the local level, therefore caution should be taken in cross-country comparisons.
References	**Bibliography references** Sutherland, D.; Price, R. & Joumard, I. (2006). Fiscal rules for subnational governments: Design and impact. OECD Network on Fiscal Relations Across Levels of Government. García, G. (2012). Reglas fiscales para la estabilidad y sostenibilidad. En: Las Instituciones Fiscales del Mañana. Banco Interamericano de Desarrollo (editor). Jaime, Q. (2009). Public Financing Sustainability in Sub National Governments. Publication No. 12, Debt Relief International Ltd. United Kingdom. Marcel, M. (2013). Structural fiscal balances: methodological, conceptual and practical alternatives. Inter-American Development Bank: Fiscal and Municipal Management Division.

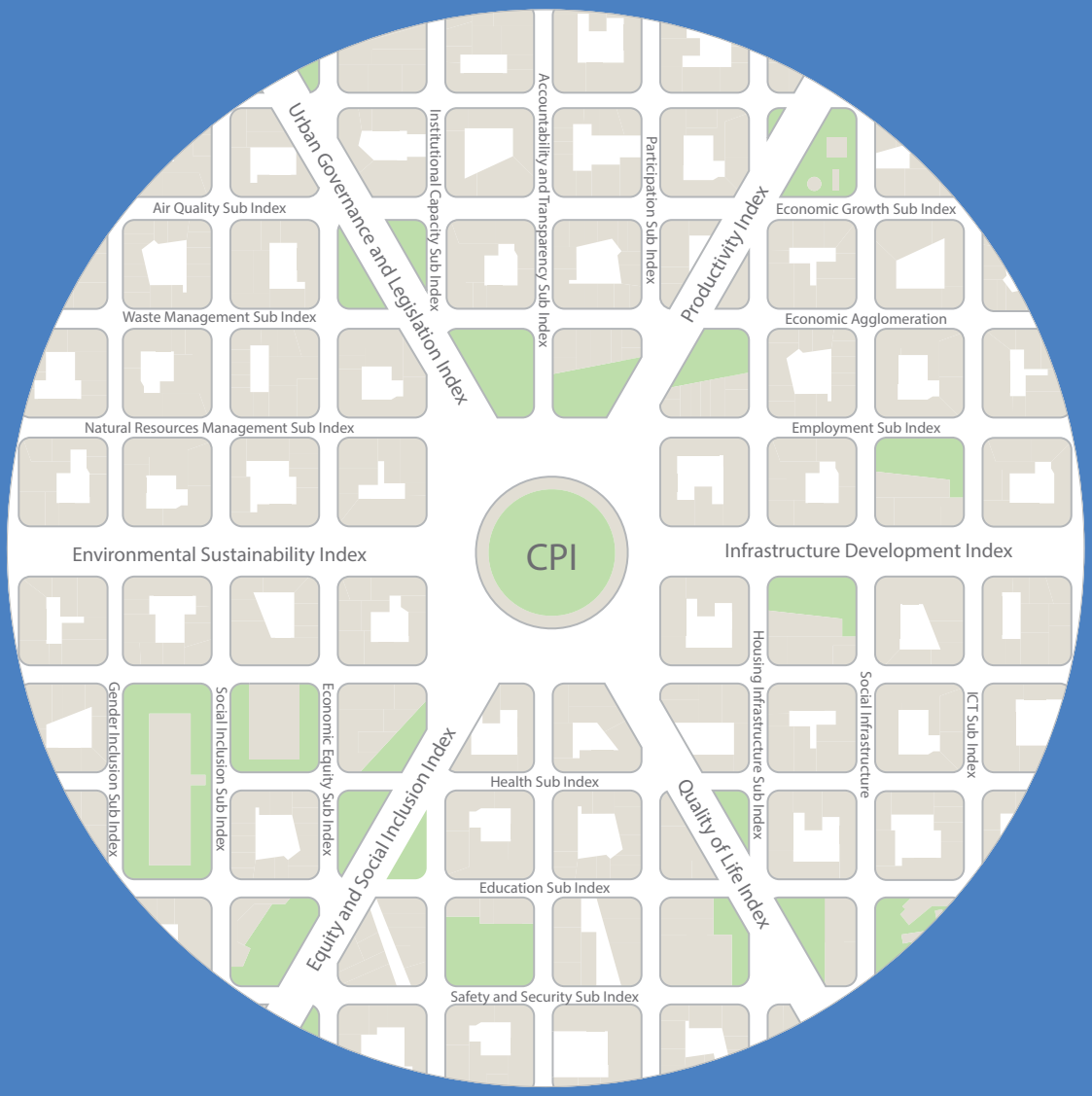
	International Monetary Fund - IMF (2011). Modernizing the framework for fiscal policy and public debt sustainability analysis. Vulovic, V. (2011). Sub-national borrowing, is it really a danger?. Economics Dissertations, Georgia State University, 77.

Indicator:	Local Expenditure Efficiency
Scope	Basic CPI
Rationale:	Local expenditure provides information about the amount of money the local government spends to provide public goods and to support administrative functions. Although this information is valuable, it does not consider whether this money reflects the capacity and efficiency of the local government. The proportion of real expenditure with respect to estimated budget can indicate the capacity of local governments to anticipate their future expenditure and improve the use of their resources (McLure and Martinez-Vazquez, 2004) The objective is not to reach a higher level of local expenditure but instead to look for an appropriate level aligned with the fiscal capacity of the city. A prosperous city seeks to balance its Expenditure Budget. To achieve this, local governments must predict their budget according to their needs and revenue, which implies that the real local expenditure is similar to the estimated expenditures (Sutherland et al., 2006; Garcia, 2012; Marcel, 2013).
Definition:	Real local expenditure divided by estimated local expenditure.
Unit [ ]	%
Methodology:	The information required can be extracted from local fiscal accounts. To calculate this indicator the city's local expenditure and estimated expenditure for the previous year are required. $Local\ Expenditure = 100\left[\frac{Real\ local\ expenditure}{Estimated\ expenditure}\right]$
Source:	Local Fiscal Accounts. Government Finance Statistics (IMF)
Benchmark	X^*= 100%, this means that the local government has the capacity to predict its budget accurately. This means that its fiscal system considers all possible shocks and local expenditure is efficient.
Standardization: 5	$Local\ Expenditure^{(S)} = 100\left(1 - \left\lvert\frac{Local\ Expenditure - X^*}{X^*}\right\rvert\right)$ $Local\ Expenditure^{(S)} = 100\left(1 - \left\lvert\frac{Local\ Expenditure - 100}{100}\right\rvert\right)$ Decision: $Local\ Expenditure^{(S)}$ $= \begin{cases} 0, & if\ Local\ Expenditure = 0\ or\ Local\ Expenditure = 2 * 100 \\ Local\ Expenditure^{(S)}, & If\ \ 0 < Local\ Expenditure < 2 * 100 \\ 100, & If\ Local\ Expenditure = 100 \end{cases}$
Limitations	It might be difficult to obtain information about the predicted local government expenditure. Nevertheless, the law requires some cities must publish this information.
References	**Bibliography references** Sutherland, D.; Price, R. & Joumard, I. (2006). Fiscal rules for subnational governments: Design and impact. OECD Network on Fiscal Relations Across Levels of Government. García, G. (2012). Reglas fiscales para la estabilidad y sostenibilidad. En: Las Instituciones Fiscales del Mañana. Banco Interamericano de Desarrollo (editor). Marcel, M. (2013). Structural fiscal balances: methodological, conceptual and practical alternatives. Inter-American Development Bank: Fiscal and Municipal Management Division. McLure, C.E., and Martinez-Vazquez, J. (2004) The Assignment of Revenues and Expenditures in Intergovernmental Fiscal Relations. The World Bank. [1] **URL references** [1]: http://www1.worldbank.org/publicsector/decentralization/March2004Course/AssignmentRevenues.pdf, Accessed August 6, 2014.

3. Governance of Urbanisation

Indicator:	**Land Use Efficiency**
Scope	**Basic CPI**
Rationale:	Cities require an orderly urban expansion that makes the land use more efficient. They need to prepare for future population growth of their own population and the one resulting from migrations. They also need to accommodate for new and thriving urban functions as they grow. However, frequently the physical growth of urban areas is disproportionate in relation to population growth, and this result in land use that is wasteful in different forms. This type of growth turns out to violate every premise of sustainability that an urban area could be judged by (2). It has been accused of encroaching on environmentally sensitive areas and is blamed for consuming land and resources. (2) It has also been attributed negative social and economic consequences, increasing spatial inequalities and affecting the functionality of the urban form with the decline of central areas and the reduction of economies of agglomeration. When cities grow in endless peripheries with discontinuous forms, high degree of fragmentation and vast interstitial open spaces, residential densities tend to dramatically reduce (1). This reduction diminishes the capacity of the city to generate economies of scale and agglomeration and prevent the realization of the potential that urbanization offers. Inefficient land use patterns present a major challenge for "making cities inclusive, safe, resilient and sustainable". More often than not, they contribute to the proliferation of cars, the increase in distance travelled and in the length of paved roads, as well in the levels of energy consumption. Inefficient land use result in the leap-frogging of vast areas that leave agricultural enclaves inside the city, placing unnecessary strains on urban service and infrastructure provision (2). It also alters ecological structures and accelerates the conversion of rural land into urban uses – all of which are environmentally unsustainable. A prosperous city should be able to track and manage its urban growth in comparison to its population needs.
Definition:	Ratio of land consumption rate to population growth rate. The indicator of land-use efficiency measures, benchmarks and monitors the relationship between land consumption and population growth to enable decision-makers to track and manage urban growth at multiple scales to promote orderly urban expansion.
Unit [ ]	Dimensionless [0-∞]
Methodology:	The information required can be extracted from local City or Urban Authorities. The formula to estimate the Land use efficiency is as follows: $Land\ Use\ Efficiency = \left(\left\lvert \frac{Urban\ Expansion\ annual\ Growth\ rate}{Population\ annual\ Growth\ rate} \right\rvert\right)$ $Land\ Use\ Efficiency = \left(\frac{\left[\left(\frac{Urb_{t+n} - Urb_t}{Urb_t}\right)^{1/y}\right]}{\left[\left(\frac{Pop_{t+n} - Pop_t}{Pop_t}\right)^{1/y}\right]} \right)$ Where : t *The initial year under consideration* $t+n$ *The final year under consideration* y *number of years of consideration between the initial and final year* Urb_t *The built up area in square kilometres in the initial year* Urb_{t+n} *The built up area in square kilometres in the final year* Pop_t *Total population within the built up area in the initial year* Pop_{t+n} *Total population within the built up area in the final year*
Source:	UN DESA population Data and urban growth rates. Satellite imagery from open sources.
Benchmark	Min : 0 Max : 3 There is no specific maximum threshold for this indicator and thus the desirable range is envisioned to range from 0 to a maximum of 3. Cities are advised to have urban growth rates that are lower than their population growth rates (i.e. a ratio lower than 1). However, in infrequent cases of very high population densities (above 30,000 inhabitants per km2) cities may be in need to expand in an orderly way above the rate of the population growth.
Standardization: 2.2	$Land\ Use\ Efficiency^{(S)} = 100\left[1 - \frac{Land\ Use\ Efficiency - Min}{Max - Min}\right]$

	$Land\ Use\ Efficiency^{(S)} = \ 100\left[1 - \frac{Land\ Use\ Efficiency}{3}\right]$ Decision: $Land\ Use\ Efficiency^{(S)} = \begin{cases} 0, & If\ Land\ Use\ Efficiency \geq 3 \\ Land\ Use\ Efficiency^{(S)}, & If\ \ 0 < Land\ Use\ Efficiency < 3 \\ 100, & If\ Land\ Use\ Efficiency = 0 \end{cases}$
Limitations	There are times when it is difficult to measure the urban expansion by conurbations of two or more urban areas that are in close proximity, to whom to attribute the urban growth and how to include it as one metric usually becomes a challenge. At the same time data would not always coincide to administrative levels, boundaries and built-up areas.
References	**Bibliography references:** Lincoln institute (2011) Making Room for a Planet of Cities [3] Lincoln Insittute (n.d) Atlas of Urban Expansion.[4] Sedesol (2012) La expansion de las ciudades 1980-2010 [5] OECD (2013), "Urbanisation and urban forms", in OECD Regions at a Glance 2013, OECD Publishing. [6] **URL references** [3] http://www.lincolninst.edu/pubs/1880_Making-Room-for-a-Planet-of-Cities-urban-expansion [4] http://www.lincolninst.edu/subcenters/atlas-urban-expansion/ [5]http://ciczac.org/sistema/docpdf/capacitacion/foro%20sedatu/02.-%20LA%20EXPANSION%20DE%20LAS%20CIUDADES%201980-2010.pdf [6] http://dx.doi.org/10.1787/reg_glance-2013-7-en



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