KRISZTINA ANNA FEKETE

Combating Climate Change through Smart Innovations

Examination of smart city concept in light of sustainability

Corvinus University of Budapest

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SUPERVISOR:
DR. ÁGNES ZSÓKA, Professor

Corvinus University of Budapest

International Relations Multidisciplinary

Doctoral School

Institute of World Economy

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Doctoral Dissertation

Fekete Krisztina Anna

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Acronyms and Abbreviations

AI	Artificial Intelligence
AR	Augmented Reality
CCT	Climate Change Talks
CMA	Meeting of the Parties to the Paris Agreement
CMP	Meeting of the Parties to the Kyoto Protocol
CO2e	CO2 equivalent
COP	Conference of the Parties
CPS	Cyber-Physical Systems
CSOs	Civil Society Organizations
ES	Earth Summit
ETS	Emissions Trading System
GARP	Global Atmospheric Research Programme
GCF	Green Climate Fund
GHA	Global Hectares
GHGs	Greenhouse Gases
GIS	Geographic Information System
GTP	Global Temperature change Potentials
GWP	Global Warming Potentials
HDM	Human-Driven Method
ICT	Integrating information and communication technology
IDA	International Development Association
INC	Intergovernmental Negotiating Committee
INDC	Intended Nationally Determined Contributions
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IRF	Integrated Radiative Forcing
IT	Information Technology
ITU	International Telecommunication Union
LUCF	Land-use Change and Forestry
MDGs	Millennium Development Goals
NDC	Nationally Determined Contribution
NFV	Network Function Virtualization
NGO	Nongovernmental Organization
RFID	Radio Frequency Identification
SCC	Summit on Climate Change
SDGs	Sustainable Development Goals
SDN	Software-defined Networking
SSC	Smart Sustainable City
TDM	Technology-Driven Method

U.S. DOT	U.S. Department of Transportation
UHI	Urban Heat Island
UN	United Nations
UN CSD	UN Commission on Sustainable Development
UN-Habitat	United Nations Human Settlements Programme
UNCCC	United Nations Climate Change Conference
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programs
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VR	Virtual Reality
WBG	World Bank Group
WCC	World Climate Conference
WCR	World Cities Report
WEF	World Economic Forum
WR	Warming Resulting

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Abstract

While the Earth's resources and capability are at its limits, while large part of the society is suffering from hardship, the other part is responsible for overconsumption, enormous waste generation. Pollution combined with self-centred human attitude led to the most crucial situation in our century of crises, Climate Change. It is currently one of the most urgent global problems, which are interconnected, complex and it has environmental, economic, social, and technological perspectives. While cities represent most of the population, the biggest greenhouse gas (GHGs) emitter, they use arable land for urban purposes, and they are the centre of services and production. Accordingly, cities were seen as excellent testing-grounds to put smart solutions in a new prospective and examine whether they could be or has been adapted into sustainable climate change combat by increasing the efficiency of mitigation and adaptation processes. For that reason, it will be investigated whether the focus of smart (city) solutions is either primarily environmental (smart-sustainable), or the focus is economic efficiency, but its use is more complex, which enhance sustainability. Based on this aim, the dissertation uses inductive approach, which is applied by using qualitative, explorative methodology such as semi-structured interviews (N=17) with content analysis to define the city level efficiency of the solutions, the driven factors within the decisions, and non-probability sampling methods during the questionnaire (N=550) to specify smart ability to increase climate awareness at the level of individuals. The research findings confirmed that, however the economic efficiency still dominate the development decisions, the environmental aspect is increasingly important mostly in the fields of mobility, energy usage and heating through the more complex, sustainable, resilient applied approaches in the implementation processes. In addition, there is a shrinking knowledge gap between the 'investors' (final users) and the providers of smart solutions, and the relevance of the sensitization and education of the population has become more important. Finally, through the survey, interviews and research, existing smart solutions have been collected within the six sectors of smart city to contribute to the educational purposes.

INTRODUCTION

The milieu of the research is set by the relationship of the Earth and Humanity, which has a highly complex linkage with unpredictable outcome. The Earth's resources and capability are at its limits, while the Earth's population is rapidly growing and exploiting its benefits the most. The inequal distribution of resources (food, water, arable land, capital, labour, etc.) and the different level of exposure to risks divide the globe. Still, it can be stated that poverty, famine, inequality is some of the most significant problems that the world leaders, international organisations have not been able to solve for centuries. These unattended problems spilled over and intensified the risk of weak institutions, non-inclusive educational systems, gender preference (one child policy in China as an example). While some of the society are suffering from hardship, the other part is responsible for overconsumption, enormous waste generation pollution. This division is tangible in the available opportunities in the field of like economy, healthcare, safety, and labour force. By considering these indicators, people can decide to migration where they assume beneficial conditions. According to the driving circumstances this migration can happen within the country (from rural to urban – urbanisation) or to another country.

All elements of the human crisis have its ecological pair. The currently known ecosystem is drastically changing by constantly losing its biodiversity, as a consequence of deforestation (which means a permanent reduction of trees and/or a drastic shift in land use mainly caused by agriculture purposes, anthropogenic forest fires, infrastructure developments (Jayathilake, et al., 2021)) and land degradation (such as aridity, vegetation decline, erosion, salinization, or organic carbon decline of the soil etc. (Pravalie, et al., 2021)). Some species are infested, who have been more adaptable for the changes; some are perished by losing their natural and safe habitat or by the enormous increase of their natural enemies.

Beside the change in the composition of the flora and fauna, the anthropogenic use of the non-renewable and renewable resources became unsustainable. The exploitation of the oil (Petroleum, Orimulsion), natural gas, coal (collectively called fossil fuels) is continuous, which puts the global energy supply, the national and international mobility systems in considerable danger, and pollutes the air and water. The fourth element of the non-renewable resources is the nuclear energy, which has been labelled as ’green energy’ in the EU since July 2022 by the European Parliament (European Parliament, 2022). Although, this form of energy is a low-carbon energy source and cannot be excluded to achieve the countries ambitious climate pledges, there is still significant disinclination because of the safety and environmental risks of the technology and the hazardous waste generation (Vossen, 2020). Using these non-renewable resources irresponsibly by the society and the industry, their indirect consequences creating significant damages within the ecosystem and the renewable resources, such as the intensive water use of industrial production deepens global water stress, or the use of significant gases[1] within products contributes to ozone depletion.

1. Table Distinguish of Ecological and Human crises

Ecological crisis	**Human crisis**
Biodiversity loss	Overpopulation
Land degradation: • aridity, • vegetation decline, • soil erosion, • soil salinization • soil organic carbon decline	Poverty;
	Hunger
	Health and wellbeing crisis
	Inequality
Deforestation	Educational gap
Exploitation of non-renewable resources	Gender inequality
Pollution of renewable natural resources	Economic gap and unemployment
Water (supply) stress	Safety - migration
Ozone layer depletion	Overconsumption;
	High energy demand
	Urbanisation

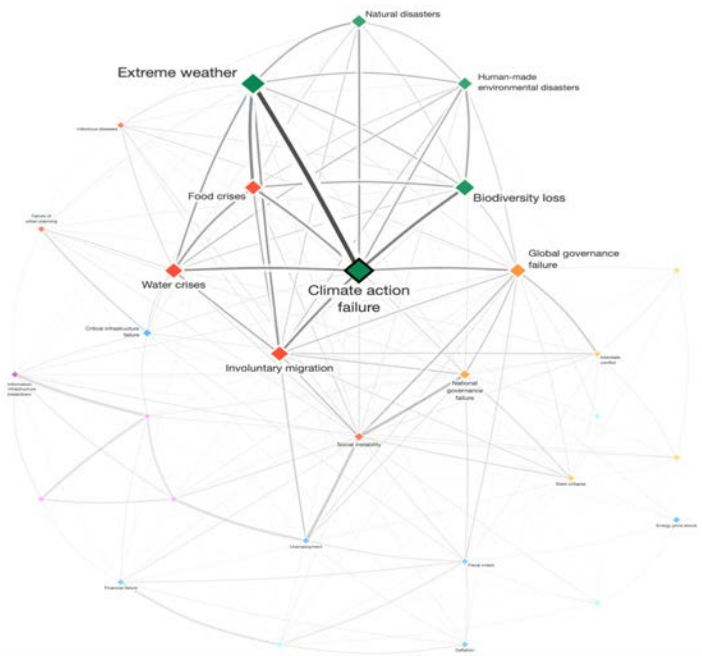
Source: own edition

[1] Chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, carbon tetrachloride, methyl chloroform and methyl bromide.

How did these elements combine with human-centred attitude lead to the most crucial situation, Climate Change, in our century of crises?

It could happen, through the complex interconnectedness of crises. Climate Change became one of the most important global problems and could merit this position through its complexity (interrelationship between ecological and human problems) and the challenge that its unpredictability gives (Table 2.). Climate change appeared in the list of ‘Top 5 Global Risks’ in 2011. Regarding likelihood, climate change was perceived as the fifth most likely global risk, while it was perceived to pursue the second biggest negative impact globally (WEF, 2018, p. 6). For 2020, in terms of likelihood, there were only environmental risks in the ‘Top 5’: extreme weather, climate action failure, natural disasters, biodiversity loss, and finally, human made environmental disasters (WEF, 2020). Although, if we investigate the other risks, which are stated as environmental risks in these reports; we can determine that all have strong connection with climate change, while they are scientifically declared as its direct consequences (European Commission, 2018), namely extreme weather events, such as storms and cyclones; major natural catastrophes –disasters, such as flood, drought; biodiversity loss and ecosystem collapse; water (supply) crises.

1. Figure: The Global Risks Interconnections Map 2020



Source: WEF,2020

2. Table Connection between (Ecological – Human) crises and Climate Change

Ecological crisis	**Human crisis**
Biodiversity loss	Overpopulation
Land degradation: • aridity, • vegetation decline, • soil erosion, • soil salinization, • soil organic carbon decline	Poverty;
	Hunger
	Health and wellbeing crisis
	Inequality
Deforestation	Educational gap
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Pollution of renewable natural resources	Economic gap and unemployment
Water (supply) stress	Safety - migration
Ozone layer depletion	Overconsumption;
	High energy demand
	Urbanisation

Climate Change (Complex, unpredictable; Interconnectedness)

- **Consequences (CQ)**
- **Direct CQ:** extreme weather (storm), natural disasters (drought), ecosystem collapse, water crisis.

Indirect CQ: water stress, food crises, regional conflicts, increasing social instability and large-scale involuntary migration (S), governance failure, interstate conflict, state collapse (GP), unemployment, fiscal crisis, deflation, energy price shock (E), breakdown of critical information infrastructure and networks (T).

Source: own edition

In recent years, the knowledge about anthropogenic climate change has considerably increased (Pachauri, et al., 2015), which can be confirmed by the worldwide increasing number of publications, research programs, mitigation, and adaptations projects[2]. How

[2] In the case of the World Bank Group, in 2014, 224 climate projects with $ 11.9 billion dollars in 77 countries were supported (World Bank, 2018) and more than $ 63 billion dollars were spent on climate related projects between 2011 and 2016 (World Bank, 2017). In 2019, World Bank provided more than

the observation and intensity of climate change impacts have become steadily easier and more notable, the concept of Climate Change and its on-going status became widely accepted (Parry, et al., 2007). Despite the fact, there is still significant uncertainty in the entire procession of the change (Latif, 2011), there are perceptible consequences and the scientific evidence about the effects of climate change is increasing. Due to that, decision makers in the international level, country leaders, politicians, and scientists in the national level, became concerned in the changing climate. The global awareness has increased. That fact put climate change in the position of the most significant topics, and it is progressively more relevant issue on the field of global politics, economics, and environment than ever.

Climate Change is currently one of the most urgent global problems, such as hunger, poverty, overpopulation, loss of biodiversity and resources, and environmental pollution. All these problems are interconnected and have economic, social, environmental, and technological perspectives, and a combination of a top-down and bottom-up approach is needed to tackle them. To do so, in 2015 Paris, 196 countries came together and set targets (Nationally Determined Contribution - NDC) for cutting their greenhouse gas emissions according to the Paris Agreement. These targets put a lot of pressure on the countries and their cities and also their population. If countries committed to their pledges, the biggest contributors by sector (energy), by main centre of emission (cities - through the position of the world's economic activity) (Ovington & Houpis, 2018) and while the world is continuously urbanizing, the people should react simultaneously within the mitigation processes.

Cities represent once the majority of the population, while currently 55,71% (World Bank, 2019) of the world population live in cities and for 2030, the urbanization rate will surpass 60% (UN-Habitat, 2020, p. xvi) and the ratio of urban sprawl will increase likewise. This tendency of expanding urban areas causing problem, namely, they are using arable land for urban purposes by decreasing available land for food production or natural GHGs capture, which increases global and even local vulnerability caused by

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$6.9 billion through its fund, International Development Association (IDA), to more than 254 climate-related projects. By 2020, World Bank Group made a commitment to increase the climate-related share of its lending from 21% to 28%, as an effort to mainstream climate related point of view during all sorts of development projects (World Bank, 2019b).

climate change. Secondly, the greenhouse gas (GHGs) emission is the highest in cities, through the enormous use of transportation, overconsumption of products and groceries, the intensive waste generation, and the high energy consumption etc. Finally, cities are the centre of services and production, which activity requires significant use of energy by further increasing the required energy demand.

According to these factors, cities are the excellent testing-grounds (setting, experimentation, development) (Childers, et al., 2014), (Freeman, 2017) for finding new solutions to increase the efficiency of climate change mitigation and adaptation processes. Smart (city) solutions are going to be analysed in a new point of view, in the light of sustainable solutions for climate change. However, the theory of smart city has already had its own (non-)scientific supporters and opponents, the idea of using this theory and its solutions for principally to climate mitigation and adaptational purposes is original. This modern point of view could be emerged by the improvements of the information and communications technology (ICT), the collection and utilization of city data to inform decision-makers, the monitoring local systems (emission reduction, quality of air, energy use) and provided solutions for remote control over the local or household systems. These symbiosis between ICT and urbanisation in the scope of sustainability (Townsend, 2013) are expected to play a key role in achieving the climate related objectives of nations.

The discussion of the relationship between climate change, suitability, cities, and smart solutions has been initiated a debate over terms, such as: climate smart city, resilient city, low-carbon city, eco city, knowledge city, information city, etc. The two main concepts became the 'sustainable cities' and 'smart cities', although all these terms assume that there is a significant cooperation in economic, social, and environmental fields (de Jong, et al., 2015). Finally, the emerging 'smart sustainable city' concept was formed and adapted in 2014 by the UN, which term suggests that smart solution can be used in favour of solving environmental challenges, meanwhile the dwellers well-being is increasing and remaining efficient.

The dissertation has three main reasons, which give relevance to its topic and represents its different and new approach, which are the following:

1. The complex consequences of the man-made climate change represent that climate change is an urgent problem, that current leaders and societies should moderate or, from an optimistic point of view, solve. We need to use two outlooks during combating climate change. We have to open up for modern technological innovations, smart solutions, that support mitigation and adaptation processes, and we have to implement the climate related point of view in every further development project to moderate our future ecological footprint.

2. The question, whether top-down regulation is necessary, is no longer appropriate. It is needed, but it becomes sufficient with the combination of local bottom – up innovations to combat climate change. The individual responsibility is the source of local best practices, could be adopted in different regions with similar patterns. Through these movements, local bottom-up approaches can lift to national levels, where they can compensate essential failure of states' interventions (Kent, 2011) or complement to state action. The use of ICT / smart solutions in a local level can open new fields for innovation and development, where this technology has not been used at all or a former not suitable solution was adapted. As one of the supporters of this movement, the dissertation provides some applied smart solutions.

3. A multidisciplinary approach is needed to effectively tackle the consequences of climate change. Smart (sustainable) city concept could fulfil this requirement, while it is combining technological, economic, and social factors. However, the theory of smart city has already had its own (non-)scientific supporters and opponents, the idea of using this theory and its solutions for principally to climate mitigation and adaptational purposes is original and evolve environmental factors into the concept.

According to my knowledge and the review of the literature, there has not been done such a work like this dissertation, which tries to examine the potential role of smart solutions in the case of sustainable climate change combat method. For that reason, this work contributes to the literature with the following points:

a) by expanding the literature with the examination of smart city concept adaptability in case of climate change mitigation and adaptation processes as a sustainable solution,
b) by adapting smart solutions, their technological background, and empirical usage of them to the forming smart sustainable city approach,

The dissertation investigates once, to tackle climate change by smart solutions, the environmental approach must be the core, because this perspective affects (in)directly the other three (economic, social, and technological) and moderate their operation and reducing the risk of perspective hazards. Secondly, the smart solutions should provide the technological support for the locally identified problem and not backward. Finally, a well-constructed, complex smart solution, which set up from the social or local government action, can be seen as a bottom-up innovation, that could serve a more efficient and sustainable climate change mitigation and adaptation. The point of these technologically advanced solutions is they could be economically efficient (through reducing expenditures and / or increasing incomes) and have one or both indirect and direct effects on the main greenhouse gases emitter sectors (e.g., energy and agriculture sectors), if they are used in a properly planned and complex grid.

The aim of this dissertation is to put smart solutions in a novel prospective and examine whether they could be adapted into sustainable climate change combat as a suitable approach / methodology / solution. The empirical research aimed to explore the main motivations behind the choice and implementation of smart city solutions and to analyse whether their focus is primarily environmental (smart-sustainable, more human-centric), or the focus is economic efficiency based on the high-tech big data collector, analyser (Techno-centric) point of view, but its use is more complex, which enhance sustainability.

First chapter contains the literature review, trough systematic literature review, which gives the theoretical basis for the dissertation. It gives a panorama about the used literature during the dissertation. This helps to identify and demonstrate once, the problem of the research, Climate Change. This chapter provides information[3] about its principals, fundamental concepts, distribution of GHGs contributions, a snapshot from the current climate trends and conditions and its consequences on cities' vulnerability. This part is needed to 'describe the chaos where we are at the moment, to find a way out in the future through smart sustainable solutions. Secondly, the context (role of cities in climate change) and the focus of the research (smart city concept) is presented. The chapter aim is to present the connection between the role of cities in climate change and the potential smart (sustainable) solutions. It will provide information about sustainability and resilience of cities, the technical background of the smart solutions, its development, and the current trends.

Second chapter present the research design of the dissertation. It summarizes the aim of the research, the research question, and the connected sub-questions before the analysis. It also shows the used methodology and the source of the data (primer (interviews, survey) and seconder source of date). The applied methodology, which trough the research aim can be achieved, are once systematic literature review to observe the development of the term, and the comparison of nine different smart / sustainable benchmark models to examining the environmental aspects headway and set to framework for the further investigation. Finally, the dissertation applies inductive approach through explorative methodology such as semi-structured interviews (with mostly indirect open questions), and non- probability sampling methods during the questionnaire (with direct-indirect, open-closed questions).

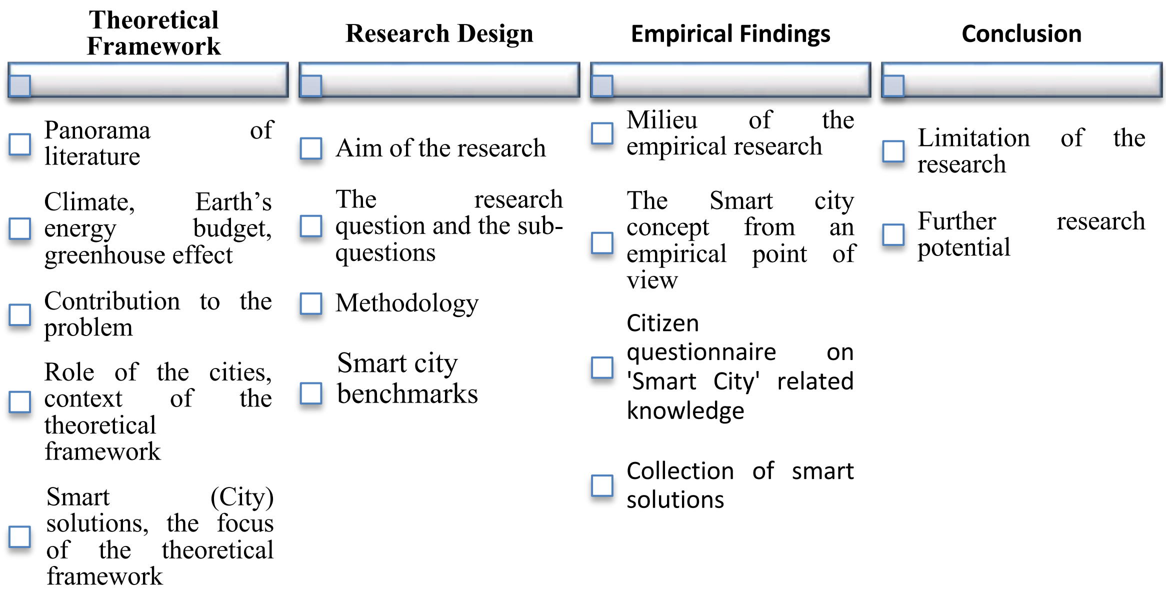
That follows the main examination part in third chapter. This chapter has three subsections. The first one, presents the results of the semi-structured interviews, which were made with experts in the field of IT security, mobility, energetic, smart city, environmentalist; local government such as former city manager, deputy mayors, smart city project leader, and stakeholder of the market (smart solution provider companies) to test the relevance of the environmental approaches in smart solution projects, define the city level efficiency of the solutions through the smart city definitions, examples, implemented areas, and driven factors. The second one, is to evaluate the result of the

[3] More detailed information about climate change is provided in Appendix 1.

questionnaire about the general knowledge of 'smart city' and examine the ability of the smart solutions to increase climate awareness at the level of individuals. Finally, the collected diverse 'smart solutions' are presented from the survey, interviews, research within the six categories of 'smart city' to contribute to the educational purposes.

In the final, fourth chapter the experiences and the results will be conclude. In the conclusion, the main and potentially novel findings are summarized, the reflection to the research question and the sub-questions are made. As a closing of the dissertation the limitations of the research and the further research potential will be collected.

2. Figure: Framework of the research



Source: own edition

1 THEORETICAL FRAMEWORK

1.1 Panorama of literature

The aim of this chapter is to present the literature of climate change, the role of cities in it, smart (sustainable) solutions and show how they depend on and contribute to each other through emission, mitigation and / or adaptation processes. The aim of the dissertation is to analyse the potential of smart solutions as a sustainable tool for climate change combat. For that reason, first it needs to show the theoretical background of the topic, and it must place it in a context. This chapter built up by narrowing down the topic from climate change to its tight relationship with cities and their role in the context. With that knowledge, the dissertation analyses further the special position of the cities by examine the concept of smart (sustainable) city and the smart solutions that this approach can provide. This chapter will demonstrate its findings and potential contradictions in an international atmosphere.

1.2 Climate, Earth's energy budget, greenhouse effect

The Earth has a solar powered climate system, which means that the surfaces, clouds, and atmosphere absorb, around 69%, and radiate back, around 30%, of the solar power on average 342 W/m^2/year (IPCC, 2007), (Shepherd, 2009) over the whole globe, which has been increased 0.53 ± 0.11 W/m^2 (between 2003 and 2018) (Kramer , et al., 2021). The absorbed sunlight is responsible for photosynthesis, ice melt, and warming. Meanwhile the long-wave out-going infrared radiation[4] cools the Earth temperature (Shepherd, 2009). This system is the Earth's energy balance, which controls naturally the Earth' temperature and climate.

The Greenhouse effect has strong connection with the previously introduced energy balance system. It is a natural process, which serves as a 'heater of the Earth' and makes the life comfortable, liveable. This natural indispensable process traps heat in the

[4] They come from the surface radiation and through the atmosphere they are emitted.

atmosphere[5] from the incoming and from the Earth surface re-radiated solar energy by using a certain combination of gases, called greenhouse gases (GHGs[6]). Through this process the average Earth temperature is controlled. Although, a shift in the ratio and / or amount of these certain gases could modify the Earth average temperature and in a long run its climate. All these gases have their own chemical properties, lifetime in the atmosphere, global warming potentials[7] (Table 3.) and leave the atmosphere by different processes. This characteristic has strong connection with the 'thickness' of the Greenhouse layer and through this the temperature on Earth.

3. Table: Main information of the greenhouse gases

GHGs	Formula	GWP (100 y)	Concentration	Atmospheric lifetime (year)
Carbon dioxide	CO_2	1	417.64 ppm	50 - 200
Main human activity source: fossil fuel, land use change				
Methane	CH_4	28	1892.3 ppb	12+/-3
Main human activity source: waste, livestock				
Nitrous oxide	N_2O	265	333.6 ppb	120
Main human activity source: fertilizers				
Hydrofluorocarbons	HFCs	4 - 12 400		1,5 - 264
Main human activity source: refrigerants				
Perfluorocarbons	PFCs	6 630 - 11 100		2 600 – 50 000
Main human activity source: aluminium production				
Sulphur hexafluoride	SF_6	23 500	10.39 ppt	3 200
Main human activity source: electrical insulation				

Source: Own edition based (Myhre, et al., 2013), (Greenhouse Gas Protocol, 2021), (Global Monitoring Laboratory, 2021), (Global Monitoring Laboratory, 2021b), (Global Monitoring Laboratory, 2021c), (Global Monitoring Laboratory, 2021d), (UNFCCC, 2021b), (Center for Sustainable Systems, University of Michigan, 2020)

[5] Layer of the atmosphere: 1) Troposphere: from the Earth surface to 20 km, clouds and weather systems; 2) Stratosphere: between 20 km and 50 km, ozone layer to absorb solar ultraviolet radiation; 3) Mesosphere: between 50 km and 80 km, meteor burning; 4) Thermosphere (+ Ionosphere): between 80 km and 960 km, layer of the satellites and Aurora; 5) Exosphere: above 960 km (NASA, 2017).

[6] Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Fluorinated gases (HFCs, PFCs, SF_6) are defined as Greenhouse gases (UNFCCC, 2021b)

[7] The Global Warming Potential (GWP) was developed to monitories and compare the impacts of different gases. The larger GWP shows that the gas is warmer the Earth's temperature more than a smaller GWP gas in the period of time. It measures "how much energy the emissions of 1 ton of a gas will absorb over a given period of time, relative to the emissions of 1 ton of carbon dioxide" (EPA, 2020).

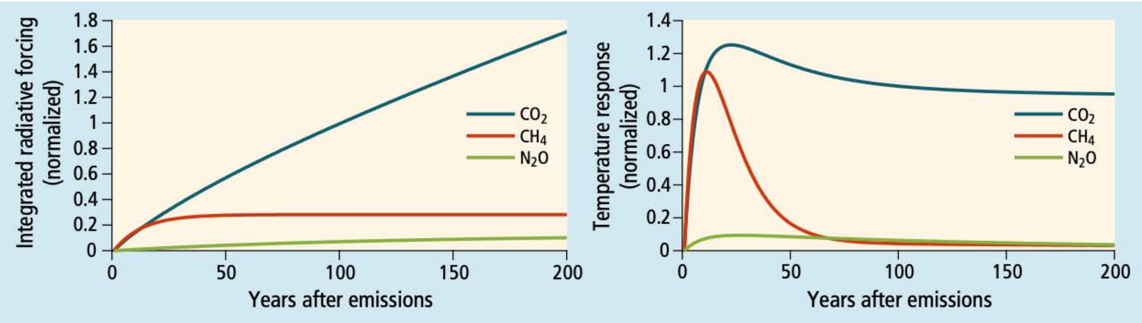
The Earth has its own cyclical climate transformation, when the cooler and warmer periods changing each other. This change is regularly a slow process in order to provide more time to the ecosystem to be acclimatized. During this acclimatization the ecosystem has the prospect to adapt to the new circumstances sufficiently with a mutation or in a less favourable case extinction. In the current change, so-called anthropogenic climate change or 'human-induced' or 'human-caused' changes, human activities such as the intensive use of coal, exploitation of arable soil and natural resources, intensive waste generation through the overconsumption, agricultural production, transportation accelerate the normal climate transformation process by emitting more greenhouse gases (GHGs) (Sinden, 2007) (Gutro, 2005). When GHGs concentration in the atmosphere is increasing or the combination of the GHGs modified and the higher global warming potential (GWP)[8] gases are in the majority, less radiated longwave solar energy could leave the atmosphere and more re-radiated to the Earth's surface and the temperature is increasing.

In the case of CO_2, (Figure 3.) it has a linearly increasing integrated radiative forcing effect (IRF - left side)[9] in a 200-year long timeframe, which has a warming effect in a long run by modifying the incoming and outgoing energy of the Earth atmosphere. While its temperature response in a 200-year long timeframe is increasing and reach the pick in the 30th year and that followed a slow reduction and convergence to value 1. This value (Warming Resulting at a given future point in time (WR - right side)) shows that, just the existence of CO_2 in the atmosphere has at the beginning a strong increasing warming effect which followed by a slower but significant constant temperature increase without any further emission. Compared to CH_4, the integrated radiative forcing effect in a 200-year long timeframe after the first 10 years stays constant at 0,2, while its temperature response is increasing and reaches its peak at 1 within 10-20 years. After 50 years of the emission, the temperature response of methane converges to 0,1.

[8] For example, the GWP index of CO_2 is 1, which means its global warming potential is small, so it needs less energy to absorb the emissions of 1 ton of a carbon dioxide over 100 years.

[9] IRF shows the degree of the radiative force over the incoming and outgoing energy which enters in the Earth atmosphere. If the index is greater than 0 it has a warming, while it is lower than 0 it has a cooling effect. Its base year is preindustrial (1750), and it is calculated in W/m^2 (Mester, 2015, p. 5), (IPCC, 2007, p. 996).

3. Figure: Weighting of current emissions over time



Source: (IPCC, 2014, p. 88)[10]

The current climatic challenge is not just a natural warming period, it is stronger because of the bigger GHGs stock in the atmosphere and for that reason the available adaptation timeframe is shorter, that puts a huge pressure on mankind and the ecosystem and increase vulnerability. We are getting closer to the irreversible point (the Carbon Cycle is into deficit[11]), where there is no turning back. We need to cut our emission otherwise there will be no future for us. Even if immediate action, there will be temperature warming and consequences, that humankind should adapt to, while the 'earlier' emitted GHGs are still in the atmosphere and warming the Earth' temperature.

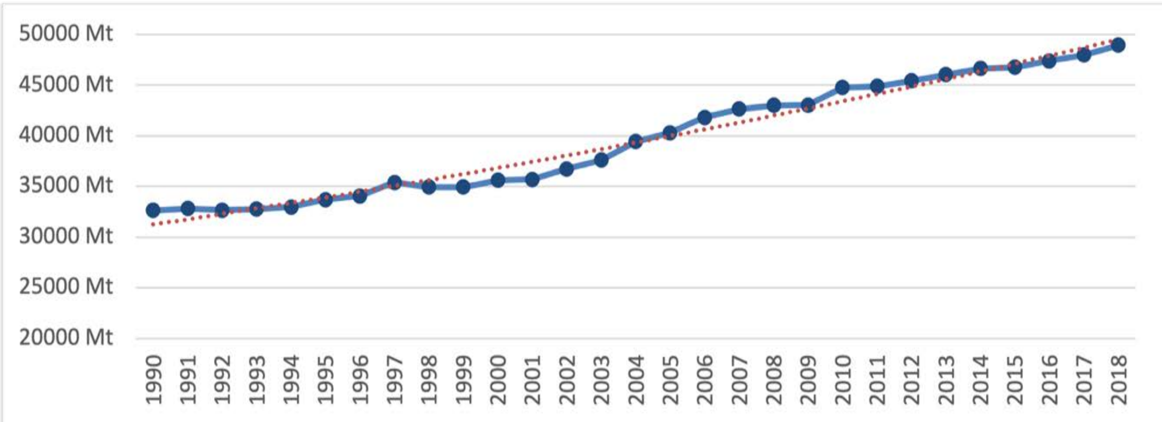
1.3 Contribution to the problem

The GHGs (defined by the Kyoto Protocol[12] (United Nations, 1997, p. Annex A) (Appendix 2.) contribution, analysed by the global historical GHGs emission (Figure 4.), shows a significant steady increase (trend - red line) in the emitted GHGs in CO_2 equivalent (CO_2e)[13] between 1990 and 2018. The growth of the emission has started with the Industrial Revolution[14], where the use of coal has jumped dramatically and boosted

[10] "These two indicators were calculated based on global 2010 emission data from WGIII 5.2 and absolute GWPs and absolute GTPs from WGI 8.7, normalized" (IPCC, 2014, p. 88).
[11] Its formation is in the Appendix 1.
[12] In 1997 the Kyoto Protocol was adopted in Kyoto, Japan and came into force in 2005. This international agreement linked to the United Nations Framework Convention on Climate Change and sets binding targets for 37 industrialized countries and the European community (Annex B) to reduce their greenhouse gas (GHGs) emissions. Later on, in the Brundtland report has appeared the potential outcomes of the 'greenhouse effect' and the importance of the ozone shield protection (United Nations, 1997).
[13] This unit of measurement is used during the dissertation, while it is globally accepted and used to make comparison within the topic of GHGs emission.
[14] It started in Britain in the period 1760 to 1830, that followed the rest of Europe. This was the first Industrial Revolution, followed by three other revolutions, and currently we are in the 4th one, the revolution of digitalization, IoT, AI, ICT.

the economy. In Figure 4. the dots representing the yearly global GHGs emission, which was 48.939,71 MtCO2e in 2018, while the area under the blue line shows the cumulative historical emission. The global average monthly CO_2 concentration of the atmosphere[15] was 413.93 ppm in October 2021, which is a notable increase from the generally 300ppm. In July 2021, the CH_4 concentration was 1886.6 ppb, the N_2O concentration was 334.2 ppb, and the SF6 concentration was 10.64 ppt[16] (Dlugokencky & Tans, 2021). That change generally occurs hundreds or thousands of years, but for mankind it took for decades. This is the proof of the contributions of the main human activities in the global warming process.

4. Figure: Global historical GHGs emission including LUCF in $MtCO_2e$



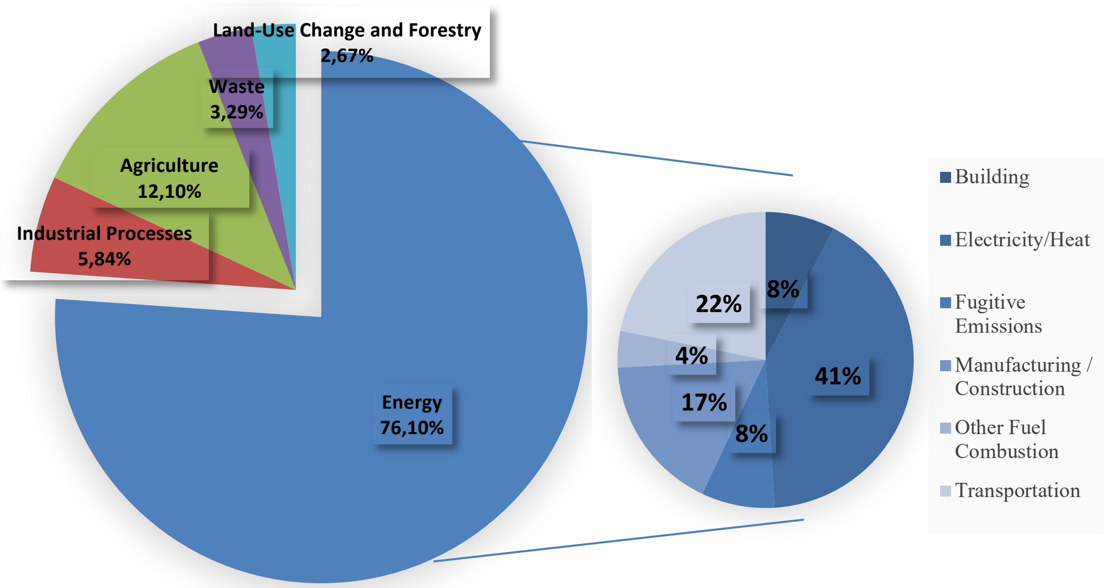
Source: Own edition based Climate Watch Data[17] (Climate Watch Data, 2021)

In the case of sectoral distribution of the GHGs emission (Figure 5.), 5 main sectors could be identified: Energy (Transportation, Electricity and heat, Buildings, and other energy), Industrial processes, Agriculture, Land use change - forestry and Waste. These sectors cover the global GHGs emissions, from them energy generation, plantation, agricultural production emitted mainly carbon-dioxide (74,4% CO_2[18]), which followed by (17,3% CH_4) methane, (6,4 % N_2O) nitrous oxide and the other greenhouse gases (2,1% HFCs,

[15] The yearly concentration from 803,719 BCE to 2018 is available in the Appendix 1.
[16] ppt/ppb/ppm: for parts per trillion/billion/million; 1 ppt/b/m indicates that one out of every trillion/billion/million molecules in an air sample of the relevant GHGs (Dlugokencky & Tans, 2021).
[17] Data is in CAIT, which includes all sectors and gases (Kyoto protocol GHGs), does not count with the countries' official inventories reported to the UNFCCC and the original data sources are the following: Carbon Dioxide Information Analysis Center (CDIAC), International Energy Agency (IEA), U.S. Environmental Protection Agency, U.N. Food and Agriculture Organization, and U.S. Energy Information (Climate Watch Data, 2021d).
[18] The data represents 2016 ratio of the GHGs.

PFCs, SF6) (World Resource Institute, 2020). According to the previously used data set, (Climate Watch Data, 2021c), the most significant contributor to the pollution is the energy sector, which provided approximately 76,10 percent of the total GHGs emission in CO_2 equivalent in 2016. Within this sector the main sub-sectoral contributor was the electricity and heating, with around 41 percent. That followed by the Transportation sub-sector by 22% and the Manufacturing / Construction sub-sector by 17%. The four other sectors represent around 23,90 percent of the emission, which comes from Cement and Chemical industrial activities (~5,84 %), activities in the field of agriculture (12,10 %) such as livestock and manure, agricultural soils, and rice cultivation. The land use change and forestry (2,67%) connect to agricultural activities with burning, framing new cropland or grassland for soy, palm oil, coffee – cacao, timber, beef production, deforestation, and to other industrial activities use of wood as raw material for their production (wood production, building construction etc). Finally, the inappropriately controlled waste management contributes to the GHGs emission with 3, 29% by landfills and wastewater generation (Climate Watch Data, 2021c).

5. Figure: Greenhouse gases emission by economic sectors in 2016 (%)



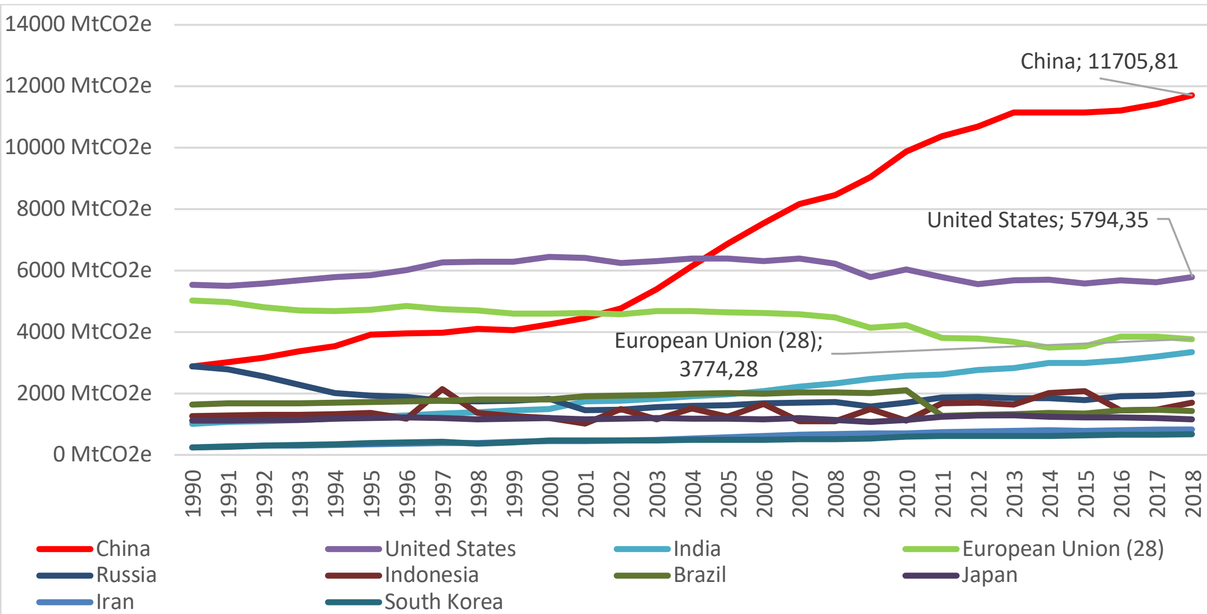
Source: own edition based, (Climate Watch Data, 2021c), (Our World in Data, 2020)

By calculating the global historical emission, the question of responsibility has emerged. There are several different models and estimations to define the responsibility of developed and developing countries in the cumulative historical GHGs emission.

According to the Community Earth System Model (CESM), the developing countries' CO_2, CH_4, N_2O contribution between 1850 and 2005 was just around approximately 39% - 47% (Wei, et al., 2015). By using data from World Resources Institute and U.S. Energy Information Administration, it is showed that between 1850 and 2004, G8[19] countries were responsible for 61% of the cumulative GHG emissions, meanwhile the BICS[20] countries plus Mexico were responsible for 13% (Wei, et al., 2015, p. 693). According to Den Elzen (den Elzen, et al., 2013), the developed countries' contribution decreased to 51.9%, while the developing countries contribution increased up to 48.1% in the case of the global GHGs emission from 1850 to 2010 (Ward & Mahowald, 2014, p. 5).

Currently the available data shows (in the 1990-2021 timeframe) (Figure 6.), 64% of GHGs emission comes from just 10 countries, the TOP 10 biggest emitter, China, USA, EU28[21] (from February 2020 it is EU27) (Appendix 3.), India, Russia, Japan, Brazil, Indonesia, Iran, South Korea, while the 100 least-emitting contributed less than 3% (Climate Watch Data, 2021).

6. Figure: Top 10 GHGs emitter, 1990-2018 (MtCO2e)



Source: own edition based (Climate Watch Data, 2021b)

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[19] France, Germany, Italy, the United Kingdom, Japan, the United States, Canada, and Russia

[20] Brazil, India, China, South-Africa

[21] The data usually represents the emissions of the 2014, 2016, 2018 years. In these years the EU28 is the relevant reference while the United Kingdom was an EU member country until January 31, 2020. Since then, the EU 27 is the correct form.

The final index, that is revised in case of global emission review is ‘Ecological footprint’. The term first was used by Rees in 1992 (Rees, 1992), when he raised the awareness to the unsustainability that cities and urbanisation contains. He argues that the remaining natural capacities will be the most relevant explanatory factors in case of environment-development related tension, and projects that human bio-ecology aspect will dominate the understanding of political and socio-economic relevance of urban development. This concept was further detailed by Wackernagel (Wackernagel, et al., 1999) early work, in which six components were identified such as fossil energy land, arable land, pasture, forest, built-up area, sea space. In this model the source of the category defined the attribute of the land, while in his 2002 article (Wackernagel, et al., 2002) the separation was made by the human activities and their significant biologically productive space demand[22]:

1. Cultivation (growing crops for food) - *Cropland*;
2. Livestock breeding (animals for meat, wool, milk) – *Grazing Land*;
3. Logging (harvesting timber for wood, fuel) – *Forest Products*;
4. Fishing – *Fishing Grounds*;
5. Infrastructure (housing, transportation, industrial production, power generation) – *Built-up land*;
6. Burning fossil fuel - *Carbon*.

By aggregating these components and multiplying with the ‘equivalence’ factors, the result compares the human demand of natural resources to nature’s biological productivity and ability to regenerate, by other words it shows, how much biologically productive area (land and sea) is required to provide for all the competing demands of people/companies/cities in a given year:

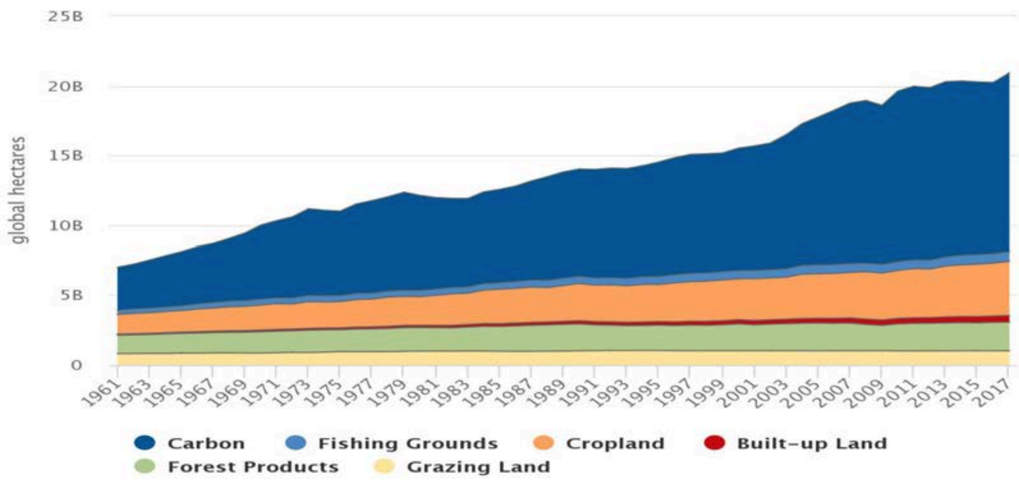
$$\frac{(ecological\ resource, natural\ capita) + waste\ production}{regenerative\ capacity\ of\ the\ Earth}$$

Since then, the relation between the human demand and the nature’s supply is calculated. If the needs overpass the supply, it is called ‘overshoot’. In 1961 this point was not

[22] All in all, the six same category was created.

reached, in 1999 20% more Earth would be needed to fulfil the humanity needs and still be able to regenerate. In 2022, humanity "consumed" 100% of the Earth resources by 28th of July and with that reached the 'overshoot day'.

7. Figure: World ecological footprint by land type (global hectares)



Source: Global Footprint Network-National Footprint and Biocapacity Account (Global Footprint Network, 2021)

If we compare the ratios between the different sectors in case of the CO_2 equivalent and the ecological footprint gha (Figure 7.), the dominance of Energy is significant, that follows the agricultural sector and the Land-use change. The differences between the two methodologies are once that the waste generation is included in the ecological footprint calculation within each segment, while in case of the CO_2 equivalent sectoral share shows it as an individual one. Secondly, the categories of Carbon and Built-up land are combined in case of the CO_2 equivalent sectoral share.

In the 2010s the examination of the original conflict between the environmental and the economic aspects in case of the Earth resources was expanded by testing the environment Kuznets curve hypothesis (Charfeddine, 2017) and the environmental influence on the real GDP (Uddin, et al., 2017). However, the term itself and use of the method is developing, there has been critique about the concept in terms of underlying research objectives, similarity with other approaches, methodology etc (Galli, et al., 2016, p. 224)[23].

Therefore, we can conclude a tendency in the last two decades, which we can summarise as the following: the share of developing countries' GHGs emission is permanently growing, however the accurate share is diverse from research to research. In the meantime, the developed countries' GHGs contribution is stagnated or slowly decreased, but in the share of the emission still the developed countries dominate. The global CO_2 equivalent emission is still steadily increasing, and this tendency could occur because of mainly three factors:

1. China, the biggest emitter, is still considered as a developing (or economy in transition) country;
2. Increasing the number of developing countries, which are entered the higher-level economic sectors, which provokes more intensive GHGs emission;
3. Developed countries started to mitigate (emission growth is slowing) and / or in the meantime they are outsourcing their emission to the developing countries.

1.4 Role of the cities, context of the theoretical framework

Cities[24] represent more than 55% of the world population (~ 60% for 2030) with their inhabitants' opportunities, challenges, needs and requirements. For that reason, one of the cities' obligations that they should provide social services such as housing facilities, health care, safety net, mobility, and electricity. Cities are the centre of services, development, decision-making, industrial activities, and enterprises. According to that, they could control political power, resources, and financial and human capital. They are the platform of the flow of people, capital, information, commerce, and energy and through this an overlapping network of trade, production and communication is built. For all these reasons and with a strong simplification, cities could be seen as a miniature of countries' and could be a good mapping for potential risks, climate related as well, to

[23] Galli in his work collects and compares the 10 most relevant pro and contra arguments related to this term. These authors contributions to the methodology are not presented, while they are out of the main scope of the research.
[24] In developed and in developing worlds, megacities and small cities, rich and poor, with high or low population density.

conclude nationally and globally relevant deductions for climate actions. The following Table 4. concludes the main challenges and climate change related problems of cities, their contribution to them and how big the exposure of cities is to these elements according to the literature which were presented.

4. Table: Urban challenges

Challenges/Problems	Contributions to	Exposure of
Urbanisation	Increasing population in hope of better job opportunities and services	Increasing population density, Increasing housing pressure, Increasing expenditures
Land consumption	Uncontrolled physical expansion of cities (taking arable land)	Dependency on the rural areas, the 'owner' of the primer natural resources
Dependence on Hinterland (Agriculture, forestry, mining)	Taking arable land for housing and infrastructure (land use change)	Dependence on food production, water resource, energy generation from outside, No tool or impact to influence them (a little through the purchasing habits)
Pollution (Air, water, waste, noise, thermal)	Traffic jams, industrial activities, waste mismanagement, high density, lack of green spaces	Decreasing well-being and health status
Heat islands	Reducing the available green space (trees, bushes, shadow), Using built environment (concrete)	Increasing temperature within the city, Slower cooling process, Health effect of heat waves
Energy use	Dwellers' electricity needs are high, Higher life standard requires more energy, From distant land, which aggregate impacts	Energy generation outside of the cities' territory, which requires infrastructure and increase dependence
Inclusive, affordable housing	Already reached the limit of the available lands for cities	Unsafe and unhealthy living conditions - slums, Inner decay, Neighbourhood collapse (loss of young, educated people)
Improvement and maintenance of the infrastructure	More and more people use them, Need of bigger coverage	Declining living standards
Waste management	Municipal and illegal waste generation, Lack or wrong waste treatment, GHGs emission (mainly Methane)	Air pollution, Consequences of climate change
Ecological Footprint of Commuting	Population density, urban structure, location of classes, emission of transport system	Consequences of climate change

Energy related GHGs emission (electricity, transportation, heating, buildings)	High energy demand, Use of unsustainable energy sources, heating infrastructures, old transports	Consequences of climate change
Urban- industrial GHG and other dangers gas emission	Industrial activities	Air pollution, Consequences of climate change
Migration (inner – international)	Expectations for better quality of life, Higher income, more job opportunity Impacts of Climate Change	migration: rural to urban, regulated, irregulated, refugees

Source: own edition based on (Meadows, et al., 1972), (United Nations, 1987), (United Nations, 2012) , (OECD, 2010), (UN-Habitat, 2011), (Revi, et al., 2014), (UN-Habitat, 2020), (Kocsis, et al., 2016), (Kovács, et al., 2017).

One of the many factors that push people to the cities, is the promise of a better life. It can mean more and diversified job opportunities, higher salary, inclusive heath care and safety, increasing well-being and happiness. If the cities' charm is stronger than its ability to provide equal conditions for people, they will face with increasing housing pressure, population density, social expenditure, disparity, which can create inner conflicts. Until cities try to solve their housing problems and promote their further growth, they "consuming" more and more neighbouring land and put the border of the city farther. However, this movement solve or handle their problem for a while, but endanger the available arable land and natural resources, which without they cannot maintain or increase the urban lifestyle, well-being. All in all, cities' wealth generations and the urban well-being is depending on the ecological resources, which is available somewhere else (Hinterland). According to Rees (Rees, 1992, p. 128), this attribute makes cities the" node of pure consumption of existing parasitically on an extensive external resource base".

On the other hand, while cities are the centres of the industrial production, services, they never sleep. This constant moving, generates pollution, such as air pollution and noise trough mobility or constructions, water pollution through not controlled industrial processes, waste pollution through landfill or illegal dumps, thermal pollution through lack of green spaces. The latter, simply using concrete instead of trees and bushes, is one of the main factors that the temperature within cities is higher, more unbearable and dangerous. It is dangerous for not just people with weaker health system, but for the environment as well. Since these generated heat waves, called "heat islands", which caused by the atmospheric waste heat or "thermal pollution" around cities, intensify the use of water (drinking-bathing, watering…), electricity (cooling) and these thermal pollutions could cause worldwide, not just local climatic consequences (Meadows, et al., 1972, p. 73), ((SMIC), 1971, pp. 151-154)). The question of energy is crucial in case of cities too. Higher life standard requires more energy, however the infrastructure is not upgraded to the increased demand, or the sources are predominantly non-renewable resources, which contribute significantly to the GHGs emission of cities. These emission from mainly electricity, transportation, heating, buildings, urban industrial activities, contribute to climate change.

Finally, as the number of extreme weather events increase and their negative effects on habitable land and well-being of people (Piao, et al., 2010) (Shilu, et al., 2016) (Schmidhuber & Tubiello, 2007) become more absorbable, the frequency of potential conflicts within and / or between countries and regions are increasing likewise. The Syrian civil war, which began in March 2011, could be seen as an example. It was a result of a complex interrelated problems including environmental ones (Gleick, 2014). This socio-economic condition change strengthened the tensions between citizens and the government. There were several droughts and water shortage as a result of climate change, which caused considerable drop in crop production (Nabhan, 2010). While Syria, as other developing countries, depends on agricultural production, millions were affected by losing their livelihoods or become indigent or forced to live their home[25] (Erian, et al., 2010) (Worth, 2010). More than a million people travelled across the sea to arrive Europe mostly illegally (Kocsis, et al., 2016). This failure was resulted by three main factors: climate change without appropriate adaptation processes, natural resources mismanagement and demographic pressures (Johnstone & Mazo, 2013).

To avoid or minimalize potential inner state conflicts because of climate change, a well-functioning government, (in a smaller scale, local government - city management) is needed. Beside the sectoral adaptations, urban adaptation plans are needed to tackle the impacts of change and for that reason the transfer of authority and resources to the city level is also needed. However, there is a 'knowledge gap' between national – local

[25] However, people were always compelled by inner state or interstate conflicts to leave their homes / lands or even homeland and become refugees. Now, a new phenomenon is needed, those who are forced by the consequences of climate change to leave their home. They become environmental refugees (McAdam, 2010, p. 133).

government and scientists (Sánchez-Rodríguez, 2011), which could boost the overrating of national mitigation processes compare to regional or sectoral adaptation (Bulkeley, 2010). The local government responsibility to maintaining, upgrading, extending infrastructure, services and reducing risk through building constructions, appropriate land use and waste and resource management (UNISDR, 2009, p. 207), (UNISDR, 2011, p. 178) even though its investment not always covers the whole expenditure of disaster risk reduction or climate change adaptation[26]. The main fields that a local government's adaptation plan should include are the followings (IPCC, 2014b, pp. 563-575):

- Adapting the Economic Base of Urban Centres: climate change can modify the comparative advantages of cities, by effecting availability of resources, feasible risk, quality of infrastructure[27],
- Adapting Food and Biomass for Urban Populations: promoting green roofs, local – urban markets, farmers' markets and enhanced safety nets, infrastructure and technology in urban and peri-urban agriculture (Cohen & Garrett, 2010),
- Adapting Housing and Urban Settlements: urban built environment should secure people, economy and heritage. It should consider within old buildings renovation and the new constructions should be safe and resilient (e.g. reliable electricity, passive cooling systems),
- Adapting Urban Water, Storm, and Waste Systems: the infrastructure of water, sanitation, and drainage,
    - Urban water supply, storm water and water waste management system,
- Adapting Transport and Telecommunications Systems: it is needed to a daily basis at regional, national, and international level as well,
    - Transportation: the four main functions are: maintain and manage; strengthen and protect; enhance redundancy; relocation in case of surface and underground railway, roads, and ports,
    - Telecommunication: A wide range of components such as telephone poles, exchanges, cables, mobile telephone masts and data centres (Engineering the

[26] Climate change adaptation needs to consider the variability of hazards, risks, and vulnerabilities.
[27] Two connected theory can be mentioned, 'waste economy' contribute to waste, GHGs emission (Ayers & Huq, 2009) and livelihood (Nzeadibe & Mbah, 2015); and 'green economy', which promote the shift of economy and employment with green infrastructure to a low carbon, resilient patterns (IPCC, 2014b, p. 567).

Future, 2011, p. 107), (Chapman, et al., 2013) should be relocated or upgraded to prevent from the consequences of climate change e.g. floods or storms,

- Green Infrastructure and Ecosystem Services within Urban Adaptation: implementing green places, green or white roof solutions,
- Adapting Public Services and Other Public Responses.

However, anthropogenic climate change is more detected and researched, the direct and indirect consequences of the change in the natural and the human systems (in our institutions and socioeconomic processes) are remaining mainly uncertain. This uncertainty comes from the fact that, even though, the impacts of climate change (Table 5.) are globally observable, there are differences between the magnitudes of the outcomes / consequences (floods, drought, heatwaves, extreme weather events, hurricanes, average temperature increase, more hot days, etc.) from region to region.

According to the FAO (Tubiello, et al., 2014), IPCC (IPCC, 2014b, p. 6) (Pachauri, et al., 2015) researches, the most vulnerable people to its consequences, those who are either socially, economically, culturally, politically, institutionally, or any other way are marginalized, they sustained the most intensive negative effects of the change and they are mostly live in developing countries, cities. Rockström (Rockström, et al., 2009) added that the dependence on the productivity of the agricultural sector and natural resources further increase these locations disparity with the developed ones. According to Patt (Patt, et al., 2009), these regions have less competitive economic power, weak institutional background and vanishing social protection and they have to face with high environmental stress caused by growing demand on resources, pollution generations, deforestation, soil exploitation as a consequence of poverty (United Nations, 1987, p. 29).

5. Table: Impacts of Climate Change

System	Impacts	In cities
Natural System	Shrink of cryosphere (glaciers, ice sheets, and floating ice shelves; sea, lake, and river ice; permafrost and snow) o change in the groundwater storage, o increase in glacial lake area, o river flow, flood frequency and intensity,	o irregular water supply, water shortage, o infrastructural damages, o change in quality and quantity of the consumed nutrition.

	o increasing erosion, o increasing frequency of high-mountain rock failures, o change in ocean temperature, salinity (acidification), pH, sea level, o shoreline erosion and change in abundance and distribution of a range of coastal species.	
Human System - Food production, Health, Security	Agricultural crop production change o genetical modification of crops to improve adaptation to the extreme weather events, o drop of nutrition, vitamin level, o new species development. Change in distributions of marine fishes (Perry, et al., 2005), timing of events (spawning, migration) (Sydeman & Bograd, 2009)[28], Easier spread of human infectious diseases, allergenic pollen, Exposure to higher temperatures, increasing heat-related mortality, Human security – Livelihood and poverty.	o deepening dependence on the Hinterland, o food security issue, o health issue (epidemic, heat strokes etc.), o infrastructural damages, o declining well-being.
Economy System	Low(er) economic growth o according to Dell (Dell, et al., 2009) 1°C of warming reduces income by either 1.2% in the short run and by 0.5% or 3,8% in the long run as Horowitz added (Horowitz, 2009), Rapid growth of energy generation and consumption (heating and cooling periods), Change in climate sensitive economy sectors (tourism – winter sport), Increase of the economic costs of extreme weather events.	o economic decline, o extra governmental expenses, o energy security issue, o realignment in cities' main sectoral contribution to GDP, o life will be more expensive in cities, which generate conflicts, o lower charm of cities.

Source: own edition based (IPCC, 2014b, pp. 987-1003)

These impacts have strong consequences on the cities infrastructure and create new surrounding where the previously provided services and lifestyle should be maintained or even improve. This new circumstances and potential risk depend on the location of the

[28] The change in the stocks and fishery yields is caused mainly the development of the harvesting technology, the intensity, not as an impact of climate change (Brander, 2010).

city. However, the most significant risks and challenges, that cities must face with are the followings (IPCC, 2014b, pp. 552-556) (Table 6.):

6. Table: Impacts of Climate Change in Cities

Urban temperature variations: increasing number of heat days and more frequent warmer period.	- heath island effects, - increasing heat related health problems (Hajat, et al., 2010) and decreasing cold mortality, - use of energy in warm period will increase (cooling systems) (Lemonsu, et al., 2013), while in cold period will decrease (heating) (Mideksa & Kallbekken, 2010).
Drought and water scarcity (Vairavamoorthy, et al., 2008), (Herrfahrdt-Pähle, 2010), (Farley, et al., 2011):	- water shortages (71 % of the world population using safely managed drinking water services, while the consequences of urban growth the number of city inhabitants increased more than 50% (since 2000), who is lack of safely managed drinking (UN-Water, 2020, p. 12), - electricity shortages during the use of hydropower, - contaminated water as an outcome of a climate change related disaster, - food supply reduction (indirect food prices and insecurity increase and migration motivation).
Coastal Flooding, Sea Level Rise, and Storm Surge	- coastal and riverbank erosion, - negative effects on populations, property, ecosystems, business, and livelihoods (Nicholls, 2004) (Dossou & Gléhouenou-Dossou, 2007), - risk of port facilities and energy-related industries.
Heavy rainfall and storm surges	- creating inland floods, which can damage properties, urban infrastructure, water contagion, - the created pluvial flooding overloads urban drainage systems (Willems, et al., 2012).
Human health	- air pollution, - the distribution, quantity, and quality of pollen in the new modified timing and duration of pollen seasons in urban areas, - easier spread of disease (WHO; WMO, 2012).

Source: own edition based inner citations

These facts made cities a potential platform to tackle climate change as well. According to the UN Habitat (United Nations, 2020b), cities, despite the fact that representing just 2% of the Earth's surface, are major contributors to climate change by consume 78 % of the world's energy and produce more than 60 per cent of greenhouse gas emissions. According to the UNEP they are responsible for the 75 % of the global emission, mainly from energy sector and more precisely transportation and building (including heating)

(UNEP, 2021b). According to the UN SDG report cities contribute to 80% of the global GDP, 70% of global energy consumption and 70% of GHGs emission (United Nations, 2018). According to Hoornweg (Hoornweg, et al., 2020) cities' contribution to the GHGs emission with production- and consumption is more than 80%, but according to Satterthwaite (Satterthwaite, 2008) the role of cities in case of GHGs generation was just around 30-40% in 2008[29]. As Hoornweg (Hoornweg, et al., 2020) concludes, GHGs emission contributions are usually low in low or medium-income countries and especially low for the urban poor in their cities. While, as a contrast, the C40 countries[30] are representing significantly higher contribution to the emission. According to Doust and the C40 organisation (Doust, 2018), the C40 cities' average of GHG emissions (Figure 8.) from building energy use was 63%, 28% from transportation and 9% was waste related (treatment, disposal). In every investigated year (2005-2015), the most significant sector was the 'non-residential' building energy' sector, followed by the 'residential' building energy' sector, 'on-road transportation' sector, 'other transportation' sector and finally the 'waste and wastewater' sector (Figure 8. shows the sub-sectoral division) However, the city-by-city data shows a significant standard deviation between 5% to 40% of waste emission compared to the city-wide total.

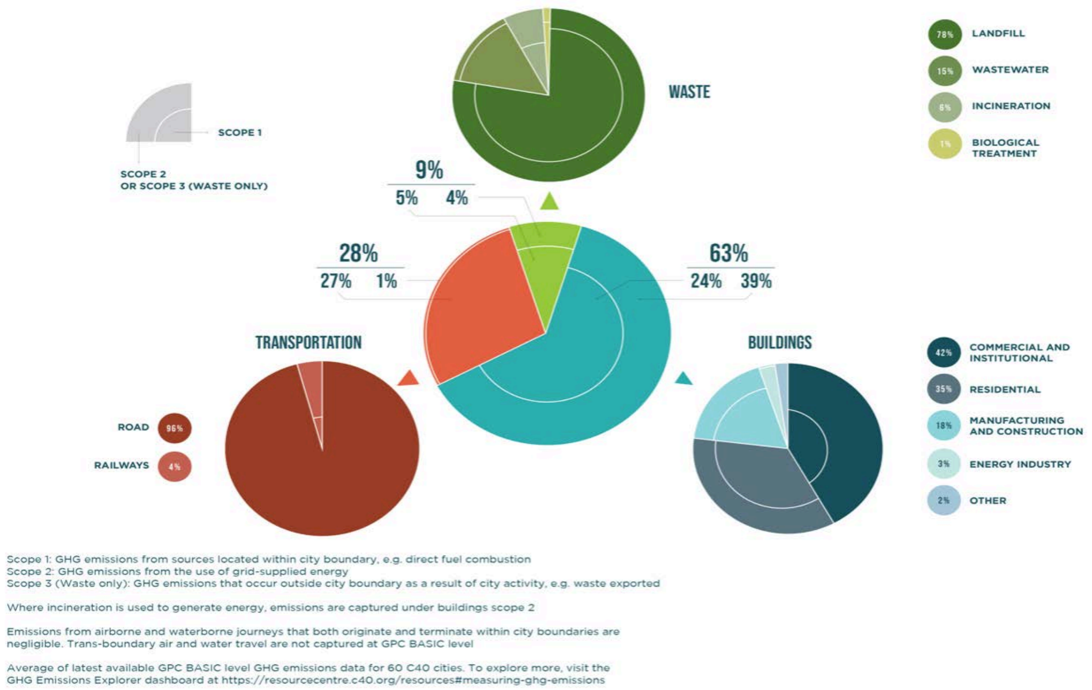
According to Angel and fellows (Angel, et al., 1998), (Collier, 1997), (Collier & Löfstedt, 1997), (DeAngelo & Harvey, 1998), (Feldman & Wilt, 1993), (Harvey, 1993), (Lambright, et al., 1996), (McEvoy, et al., 1999), (Wilbanks & Kates, 1999) although, cities represent significant share in consumption of energy and production of waste, they have also the local authorities, which can control these segments (energy use, waste

[29] However, these numbers can be misleading. They show the average of once mega and small cities, and secondly city centres and suburban regions, and finally rich and poor cities. They once represent the cities carbon dioxide emission not the total greenhouse gas emission and thirdly there could be huge difference according to the source of the generation of the GHGs. Finally, the emitted GHGs could be calculated based on the production or the consumption (UN-Habitat, 2011).

[30] Megacities: Abidjan; Accra; Addis Ababa; Ahmedabad; Amman; Athens; Bangkok; Barcelona; Bengaluru; Berlin; Bogotá; Boston; Buenos Aires; Cape Town; Chengdu; Chennai; Chicago; Ciudad de México; Curitiba; Dakar; Dalian; Dar es Salaam; Delhi NCT; Dhaka; Dubai; Durban (eThekwini); Ekurhuleni; Fuzhou; Guadalajara; Guangzhou; Hangzhou; Hanoi; Ho Chi Minh City; Hong Kong; Houston; Istanbul; Jakarta; Johannesburg; Kolkata; Kuala Lumpur; Lagos; Lima; Lisbon; London; Los Angeles; Madrid; Medellin; Melbourne; Miami; Milan; Montreal; Mumbai; Nairobi; Nanjing; New York City; Paris; Philadelphia; Phoenix; Qingdao; Quezon City; Quito; Rio de Janeiro; Rome; Salvador; San Francisco; São Paulo; Seattle; Seoul; Shenzhen; Sydney; Tel Aviv-Yafo; Tokyo; Toronto; Tshwane; Warsaw; Washington, DC; Wuhan; Zhenjiang.
Innovator: Amsterdam; Auckland; Austin; Copenhagen; Freetown; Heidelberg; New Orleans; Oslo; Portland; Rotterdam; Stockholm; Vancouver (C40 Cities , 2022).
Observer: Beijing; Shanghai; Singapore. Inactive: Karachi; Moscow; Santiago; Yokohama.

generations, transportation, etc.). Hoornweg added that they have the ability to mediate between different social levels, stakeholders, they have the platform for communication. He sees cities as the biggest platform for social change as a centre of innovations, technology, and the flow of resources (Hoornweg, et al., 2020).

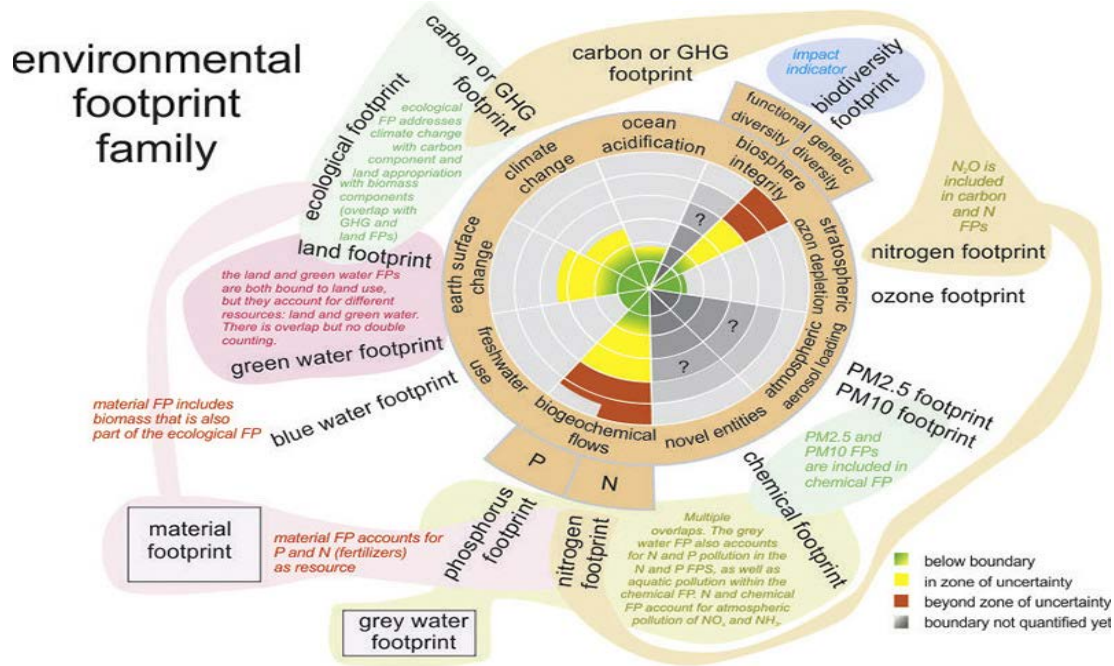
8. Figure: C40 cities sub-sectoral GHGs emissions



Source: C40 (Doust, 2018)

To further investigate the cities' role in GHGs emission and / or the climate change related ecological degradation, beside the previously presented sectoral emission in CO_2 equivalent, a new definition - methodology should be reviewed. This term is 'Carbon footprint', which has three approaches. One shows, according to Wiedmann and Minx (Wiedmann & Minx, 2008), how much CO_2 is expressed directly or indirectly into the atmosphere during the full life cycle of a product/lifestyles of people/activities of companies/cities in a given year in CO_2 equivalents by considering the avoidance of double counting. In the second approach, Vanham (Vanham, et al., 2019) argues that the whole GHGs emission should be calculated, which is labelled as 'climate footprint' according to Wiedmann and Minx. However, the name of the term is different, the representation is the same, even Vanham sees it as a good index for the SDG 13. goal "climate action". Finally, both approaches classify the term as part of the environmental footprint family[31] (Figure 9), the side of 'ecological footprint'[32]. Whistle, the third approach is representing the term as subset of the ecological footprint and uses as synonym for 'Burning fossil fuel – Carbon' category in the work of Monfreda (Monfreda, et al., 2004), in the Global Gridded Model of Carbon Footprints (GGMCF) model of Moran (Moran, et al., 2018) and the City Carbon Footprint.

9. Figure: Environmental footprint family



Source: (Vanham, et al., 2019, p. 4)

According to the GGMCF model (City Carbon Footprint, 2018) the TOP 10 cities with the largest carbon footprint in 2018 was Seoul -South Korea, Guangzhou -China, New York -USA, Hong Kong SAR -China, Los Angeles -USA, Shanghai -China, Singapore -Singapore, Chicago -USA, Tokyo/Yokohama -Japan, Riyadh -Saudi Arabia. In the rank of the largest carbon footprint per capita (all collected in Table 7.) Hong Kong Sar and Country of Singapore are in the TOP 10 cities as well.

[31] Umbrella term.

[32] According to Vanham 'Ecological footprint' is related to SDG 15. goal "life on land" and SDG 11. goal "sustainable cities and communities" (Vanham, et al., 2019)

7. Table: TOP 10 cities by absolute Carbon Footprint per capita

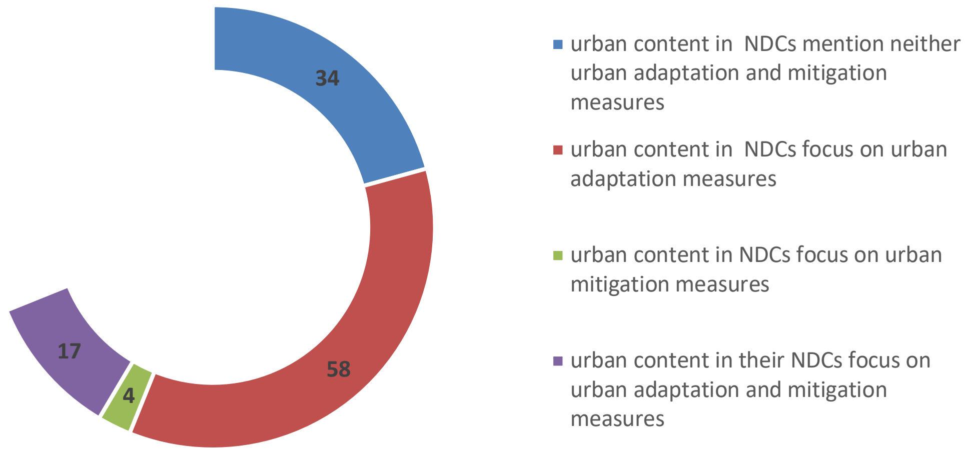
Urban Cluster	Country	Footprint ($Mt\ CO_2$)	Footprint / Capita (tCO_2/cap)	Global Ranking
Hong Kong Sar	China	208.5 ±37.8	34.6 ±6.3	1
Mohammed Bin Zayed City	UAE	6.2 ±5.3	32.9 ±27.9	2
Abu Dhabi	UAE	29.9 ±15.6	32.9 ±17.1	3
Country Of Singapore	Singapore	161.1 ±34.1	30.8 ±6.5	4
Hulun Buir	China	6.0 ±6.4	30.0 ±32.3	5
Al-Ahmadi	Kuwait	80.6 ±19.3	29.9 ±7.2	6
Doha	Qatar	32.4 ±11.5	28.7 ±10.2	7
Hinggan	China	6.9 ±7.1	28.6 ±29.3	8
Chifeng	China	19.0 ±11.0	28.0 ±16.2	9
Al-Jahrah	Kuwait	4.8 ±3.3	27.2 ±18.4	10

Source: Own edition based (City Carbon Footprint, 2018)

As Moran (Moran, et al., 2018, p. 6) stated “Cities represent intense concentrations of populations and consumption … it is clear that footprints are highly concentrated.” The TOP 100 biggest emitter cities represented the 18 per cent of the global carbon footprint in 2018. However, one quarter of the TOP 200 cities were in low-emitter countries, but they act like the affluent high-emitter cities. For that reason, he argues, that there is significant opportunity of cutting global carbon contribution by focusing on few hundred cities.

Mankind is in the last moment to act and to slow down the critical climate change. Despite all the effects and impacts of climate change, it seems majority of people and the decisionmakers are not frightened enough even when we are so close to the irreversible point of time, and when some impacts have already can be seen. It seems, most of the time the present value of future well-being is lower than the current well-being. Since 2015, COP Conference in Paris, according to the Climate Watch research institute data (Climate Watch Data, 2022), globally 32 countries did not submit any Intended Nationally Determined Contributions (INDC), but finally just 3 countries (Libya - 0.25% of global GHGs emission, Iran - 1.80%, Yemen - 0.05%) did not submit the Nationally Determined Contribution (NDC) pledges, and only 16 countries have submitted its second NDC. Out of the 164 countries 51 have not mentioned neither mitigation nor adaptation in case of urban content in their NDCs (Figure 10.) (United Nations Human Settlements Programme, 2017, p. 12). Nevertheless, there are cities, which have been made their own climate pledges.

10. Figure: Urban content of NDCs



Source: own edition based (United Nations Human Settlements Programme, 2017, p. 12)

Furthermore, 1,049 cities have joint to the 'Cities Race to Zero' campaign to achieving net zero carbon emissions by 2050. These cities representing nearly 25% of the global CO_2 emissions (UNFCCC, 2022), and two Hungarian cities are represented, Budapest and Kaposvár (C40 KnowledgeHub, 2022).

1.5 Smart City Solutions, the focus of the theoretical framework

"At a time when our world is undergoing profound change as a result of major technological, economic, societal, environmental and political changes, urban spaces are crystallizing all the challenges of our future development. And yet the city of tomorrow, like the one of yesterday, must be a place of meetings, exchanges, life, a city for the women and men who live there and bring it to life."

-- Carlos Moreno -—

If there is one thing that we could learn from the last, almost one century is the role of environment. There is no sustainable development without considering the environment beside the economic and social factors and there is no human health, prosperity, and well-being without proper environmental circumstances. Economies are no longer the only and most important considerations of the decisions, thanks to the rapid development of new technologies in digitalization. Strong economical and institutional background combined with advance technology increase the resilience and potential recovery capability of cities. However, the innovation by local leadership solution is not given to every city, as specially developing world's, but those which has it, it should live with it because it's not just an economic, but a political and social choice as well (United Nations, 1987, p. 168).

Meadows stated (Meadows, et al., 1972, pp. 149-150) the importance of technology in the economic development, they thought until a certain point each problem can find its technological solution. In case of cities the first phase was skyscrapers and the elevators to limited place, that followed by the expressways, mass transit systems, helicopter ports to travelling and delivery duration. In the industrial production, the first industrial revolution provided development (around late 18th – early 19th century) through mechanization by using steam power; in the second (late 19th – mid 20th century) through the mass production by using electricity in more effective way and the labour division; in the third (late 20th century) through the automatization by using electronics and information technologies (IT), computers and the rapid development of the internet; and finally the current fourth revolution is based on the digitalization use of AI, IoT, Big Data, Cloud, robotics, other cyber-physical systems (CPS).

If we look at the technological development of smart city solutions, a parallel theoretical development of the concept (increasing importance of sustainability) can be seen and the development of the applied the technology (4th industrial revolution). In the end of the 20th century mostly all the cities were 'conventional cities', simply because of the lack of Internet. With the rapid improvement and fast spread of the Internet, the smart city concept could be emerged.

The first use of 'smart city' is dated in 1974, Los Angeles (Table 8.), where the first urban big data project was held, while the next project just emerged in 1990s, in 1994 De Digital Stad project in Amsterdam. In the 2000s the development of 'smart city' reached the next level, when international organisations, government institutions started to invest in research and innovation. The leader investors were IBM, Cisco as a representative of the private sector and the US, Japan, and EU as countries' government. With the first Smart

City Expo World Congress in 2011 the global awareness and widespread of the concept has begun. In 2019, the G20 Global Smart Cities Alliance was founded to set of principles for the responsible and ethical use of smart city technologies (G20 Global Smart Cities Alliance, 2020).

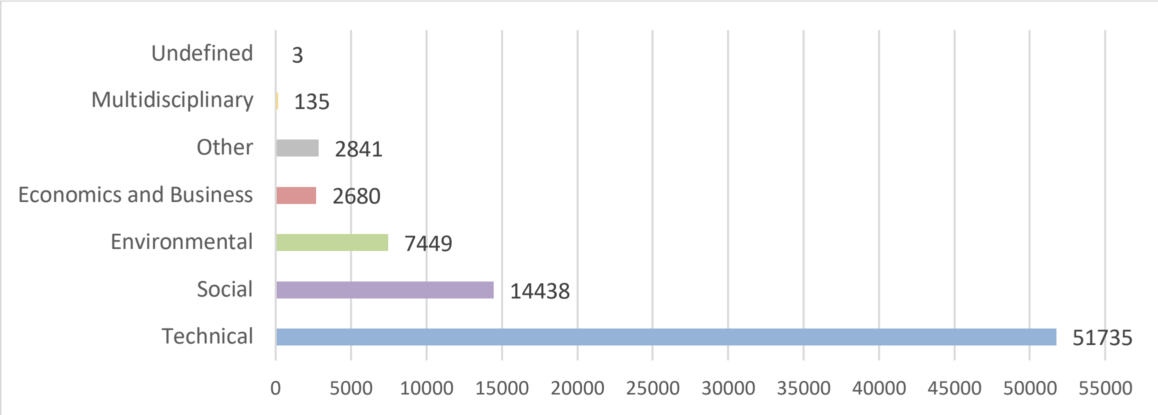
8. Table: Timeframe of smart city development

Year	Progress
1970s	The first urban big data project: "a cluster analysis of Los Angeles". (Los Angeles Community Analysis Bureau, 1974)
1994	A virtual 'digital city' (De Digital Stad -DDS) in Amsterdam (Rommes, et al., 1999)
2005	Cisco invested in a 'smart city' research.
2008	IBM investigated sensors and networks for urban issues in the 'Smart Planet' project.
2009	IBM promote city efficient by a 'Smart Cities' campaign; The USA provided funds for smart grid projects; EU Electricity Directive (80 % of the consumers should use smart meters by 2020).
2010	Japan – Yokohama (smart city demonstrator project)
2011	IBM selected TOP 24 cities (out of 200) as Smart City; 1. Barcelona Smart City Expo World Congress.
2012	Barcelona – Data-drive urban system (parking, lighting system, public transport)
2013	China – 90 Smart City Pilot; London – 'Smart London Board'
2014	Soul – the first Smart City China – 103 Smart City Pilot; Vienna – 'Smart City Wien Framework Strategy' until 2025; Budapest – 'Smart City Budapest' civil project
2015	China – 84 Smart City Pilot; India – 100 'Smart Cities Mission'
2016	Increasing number of 'Smart City Challenge' e.g. US – $105 m
2017	UK – 5G testbeds and trials programme; Hong Kong – 'Smart City Blueprint'
2018	In the Smart City Expo World Congress – Singapore won the Smart City of 2018 award; London – 'Smart London Together' roadmap
2019	G20 Global Smart Cities Alliance was founded; Budapest – 'Smart Budapest Framework'; Budapest - '1. Civitas Sapiens Conference' Smart City Conference

Source: own edition based on (GlobalData Thematic Research , 2020), (U.S. DOT, 2017), (Kumar & Rattan, 2020)

According to (Stübinger & Schneider, 2020) the oldest research area of smart city is connected to technology, while at the biggening 'smart' and technologically developed terms were used parallel.

11. Figure: Distribution of Scientific publications of smart city, 1971-2021



Source: own edition based on (frequency in Scopus articles)[33]

By analysing[34] the number and distribution of scientific publications in case of smart city, it can be declared that the main fields of the topic (Figure 11.) are connected to mainly still to Technological approach such as Computer science (use of big-data, IoT, etc.), that followed by Social approach (Social science, Psychology), Environmental approach (Environmental science, Agriculture) and Economic approach (Economics, Business) and finally health and medicine.

9. Table: Number of scientific publications in 'smart city' theme

	2014	2015	2016	2017	2018	2019	2020	2021
Scopus	1 180	1 632	2 516	4 807	6 216	7 652	7 162	2 981
Google	47 073	45 594	53 058	70 560	89 524	102 195	135 097	56 950
ScienceDirect	2 712	3 440	4 159	4 950	5 819	6 848	8 693	10 629

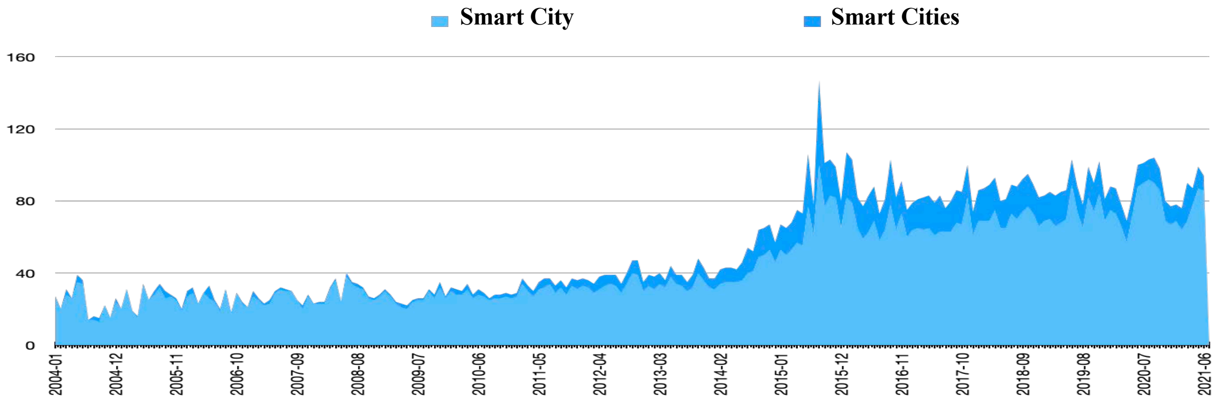
Source: own edition based on (frequency in Scopus articles, ScienceDirect and Google Scholar)

[33] Other: Chemistry, Medicine, Biochemistry, Genetics and Molecular Biology, Chemical Engineering, Health Professions, Pharmacology, Toxicology and Pharmaceutics, Neuroscience, Nursing, Immunology and Microbiology, Veterinary, Dentistry. Economics and Business: Business, Management and Accounting, Economics, Econometrics and Finance. Environmental: Environmental Science, Physics and Astronomy, Earth and Planetary Sciences, Agricultural and Biological Sciences. Social: Social Sciences, Decision Science, Arts and Humanities, Psychology. Technical: Computer Science, Engineering, Energy, Mathematics, Materials Science.

[34] Based on Scopus and Google Scholar trend.

In the meantime, parallel with the increasing scientific research (Table 9.) and awareness, this phenomenon became a well-known and commonly used phrase in the private sector and in civilian circles as well. The number of hits for ‘smart city’ (Figure 12.) has a huge increase since 2015 in case of searches. According to the Google Scholar there are more than 2,500,000 studies in the field of “smart city”, which covers from theoretical models to empirical frameworks (Stübinger & Schneider, 2020). This could be achieved by the increasing presence of private sector, through innovations and research funding[35], that could help to launch new technological solutions to the market, and with the increasing number of Internet access, and the use of smart solution in households.

12. Figure: Relative number of hits for Smart City searches in Google between 2004 and 2021



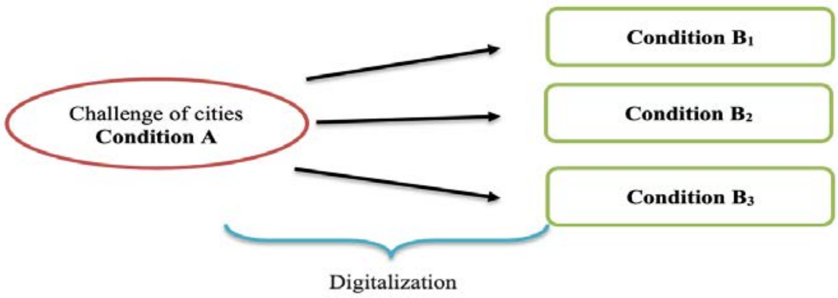
Source: own edition based on (Google, 2021), (Allam & Newman, 2018)

For nowadays, the concept ‘Smart City’ became more complex, it gained and lost elements compare to the first use of the term. However, it still not has a single, globally accepted and used definition. It puts into practice in varied ways (Caprotti, 2016), (Cugurullo, 2016), (Cugurullo, 2017), (Rapoport, 2014). For that reason, the definition of ‘smart city’ become different by time, involved tools and actors, role of ICT, relation with different stakeholders and aims (Table 10). There are different approaches, some think that a city become ‘smart’, when its infrastructure depends on ICT and IT technologies. Other sees, that a ‘smart city’ should utilize the benefits of the ICT based applications. Other one, think that a ‘smart city’ is a complex phenomenon, which support liveability within cities through complex interrelated systems. According to Couclelis (Couclelis,

[35] The technology spending on smart city initiatives worldwide in 2018 was 81 billion U.S. dollars, in 2019 104,3 b US$ in 2020 124 b US$ and this increasing trend is prognosed also for the 2022 (158 b US$) and 2023 (189,5 b US$) years (Statista, 2021).

2004), there is always common parts in each definition, and these are the two factors 'function' and 'purpose', to measure smart city, the 'function' is the appearance and the operation, while the 'purpose' is the benefits that users expect. By adding to that, digitalization is inevitable in the 'smart' concept, to reach Condition B from Condition A (Figure 13).

13. Figure: Smart conception



Source: own edition based on (Sallai, 2016)

Mora and Deakin (Mora & Deakin, 2019) identified two paths by considering the definitions, one is the holistic perspective of smart city development, and the other one a more techno-centric understanding of the smart city subject. More precisely, there are two approaches connected to smart city, a human-driven method (HDM) and a technology-driven method (TDM) (Letaifa, 2015). TDM sees, smart city as a networked space, where ICT is involved in every activity within cities and through this the dwellers' life standards would improve and promote the community's involvement. The HDM argues, that ICT by itself is not sufficient enough to reach improvement in living standards, there is a need for human capital involvement and development (Neirotti, et al., 2014).

10. Table: Definitions of smart city in the literature

SOURCE	DEFINITIONS
(HALL, ET AL., 2000, P. 1)	"is the urban centre of the future, made safe, secure environmentally green, and efficient because all structures--whether for power, water, transportation, etc. are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms."

(GIFFINGER, ET AL., 2007)	"A city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens."
(HOLLANDS, 2008, P. 307)	"utilization of networked infrastructures to improve economic and political efficiency and enable socio, cultural and urban development".
(WASHBURN, ET AL., 2010)	"A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better organize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens."
(HARRISON, ET AL., 2010)	a city connecting the physical infrastructure, the IT, the social and the business to leverage the collective intelligence of itself
(CARAGLIU, ET AL., 2011)	smart city can be achieved when there is complex resource management and governance, and there is investment in human, social capital, infrastructure and modern ICT to boost sustainable city and well-being.
(SU, ET AL., 2011)	Smart city is the combination of smart sensor, control and safety network (IoT).
(BAKICI, ET AL., 2012)	"a smart city is a high-tech intensive and advanced city that connects people, information and city elements using new technologies in order to create a sustainable, greener city, competitive and innovative commerce and an increased life quality"
(DAMERI, 2013)	smart city is a bottom-up phenomenon, which main driver is technology (ICT). It links different actors (both private and public) to improve logistic, mobility and environmental sustainability in the city. It should create public value, for that reason citizens are crucial elements.
(GLASMEIERA & CHRISTOPHERSONB, 2015)	use of technologies to coordinate urban sub-systems (energy, water, mobility, built environment) by creating new employment opportunities, wealth and economic growth. Smart city is an urban place where dwellers experience a new reality.
(MARSAL-LLACUNA, ET AL., 2015)	using data, information, and IT to achieve a more efficient services level to citizens, monitories and optimize infrastructure and boost cooperation between different actors
(UN-HABITAT III, 2017, P. 19)	"makes use of opportunities from digitalisation, clean energy and technologies, as well as innovative transport technologies, thus providing options for inhabitants to make more environmentally friendly choices and boost sustainable economic growth and enabling cities to improve their service delivery"
(OECD, 2018)	"initiatives or approaches that effectively leverage digitalisation to boost citizen well-being and deliver more efficient, sustainable and inclusive

	urban services and environments as part of a collaborative, multi-stakeholder process”
(KUMAR & RATTAN, 2020)	key element of ‘smart city’ is *smart*, which means *digital, intelligent, sustainable* city, and the city should be *green, accessible*, and more *liveable*
(EUROPEAN COMMISSION, 2021B)	“a place where the traditional networks and services are made more efficient with the use of digital and telecommunication technologies, for the benefit of its inhabitants and businesses. … for better resource use and less emissions.” The involved fields are urban transport networks, water supply, waste disposal facilities, light and heat buildings, more interactive and responsive city administration, safer public spaces, elderly care.

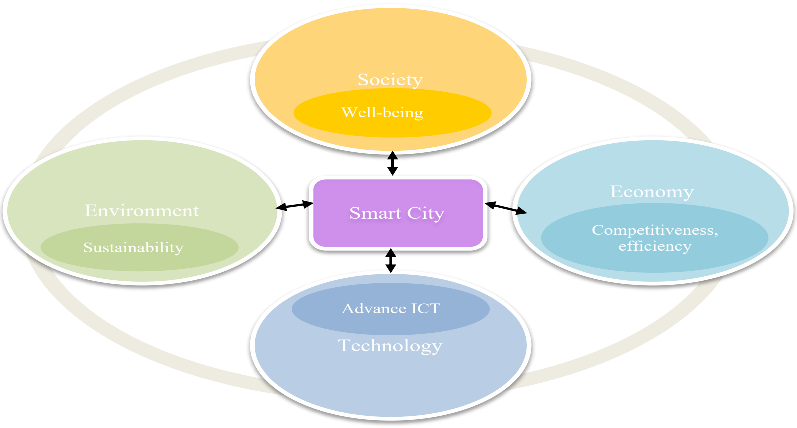
Source: own edition based the listed sources

It is already known that there is no universal definition for the phenomenon ‘smart city’ (Table 10.), but at the same time there were many connected and later on partly merged phenomena during the development of ‘smart city’ (Freeman, 2017), such as:

Learning city Knowledge city	Virtual city Digital city Information city	Green city Eco city Low carbon city	Liveable city

which led the approach from ‘digital city’ to ‘smart city’. Since 2009, the interest of ‘digital city’ started to decline and it was mainly replaced by ‘smart city’, which was seen as generally a ‘green’, ‘socially inclusive’, ‘sustainable’ idea which use the latest technological achievements (Deakin, 2012), (Eremia, et al., 2017). In harmony with that, from the late 70s to nowadays, the importance of data about buildings, citizens, devices, assets, and habits are increasing to efficiently manage urban flows via real-time responses (Stübinger & Schneider, 2020). The connections and communication between different actors and devices getting easier. Bibri and Krogstie (Bibri & Krogstie, 2017) see, that the use of ICT is now considered as a conducive, necessary tool for effective city planning and management, which is key to sustainability as well. Kumar and Rattan (Kumar & Rattan, 2020) added by the adaptation of the latest technology (tools of digitalization) in case of institutions, infrastructure, traffic arrangement, housing, electricity availability and usage, waste management, care systems, beside the economic efficient operation, can be increase people’s wellbeing. According to several supporters of the concept (Garau, et al., 2016), (McLean, et al., 2016), (Vanolo, 2014), (Viitanen & Kingston, 2014), (Cugurullo, 2018), the purpose of the use of integrated technological solutions (smart city solution - such as sensors[36], grid system, big-data networks, generators, storages) should be multiple. Once it should increase competitiveness and efficiency by reducing the costs (economic and environmental), secondly it should improve energy use, thirdly decreases all kinds of emissions, and finally increases the well-being of the dwellers. Gibbs (Gibbs, et al., 2013), see a potential for economic prosperity, ecological integrity, and social equality toward to sustainability. Smart city solutions should consider and serve sustainable aims, which means economic, environmental, social factors in a same time by adapting the latest technological solutions (Figure 14.).

14. Figure: Central role of Smart City



Source: own edition based on (Kumar & Rattan, 2020)

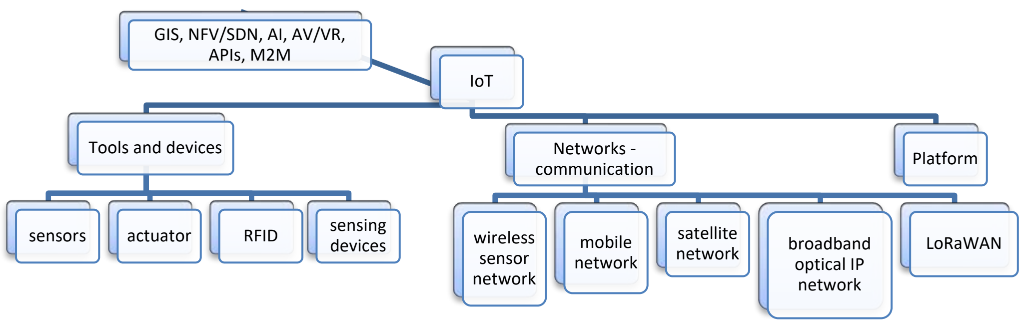
However, opponents such as Calzada and Cobo (Calzada & Cobo, 2015) criticize the operation and questioning the actual contribution of the concept, while as its consequents there is potentially deepening the exciting inequality, while Datta (Datta, 2015), sees the whole 'smart city' concept rather a business model than a development approach. The mainstreaming of the term intensifies the misunderstanding or misuse of it, too. According to Vincent Mosco (Mosco, 2019), the 'smartness' of a city does not come just with the use of ICT and the adaptation of technological solutions, it should come with the dwellers and citizens. A city is smart (beside the other factors) if its dwellers are able to use adequately the opportunities of the new solutions and they are aware of the potential risks.

[36] A sensor could measure temperature (in-outside), luminance, UV radiation, blast, condition (close-open), health condition, production parameter (quality, quantity, speed, etc.), lightning (% of the luminance), quality of air, water, soil, etc

Smart city is a framework, which uses the platform of ICT[37] to achieve sustainability for cities based on digitalization. According to Samih (Samih, 2019) and Balakrishna (Balakrishna, 2012), a 'smart solution' should have three building blocks (Figure 15.). The basic layer, Perception Layer, is the large-scale tools of the city's utility, transport, environmental and government infrastructure. Namely, the sensors, actuators, RFID and other sensing devices. This layer identifies the objects and collects information through readers, cameras, sensor networks. The next layer is the Network layer, which serves as a high-speed network infrastructure to connect and to ensure the communication and the huge amount of data transfer between the devices. The last layer is the Application Layer, which manages (analyses and processes) the collected and transferred data and information.

An efficiently functioning smart city solution works in a complex setting to collect real time data to tracking and boost accountability, the collected data is analysed and according to the received information, the smart solution controls further devices. Its advantage, that through the widespread and large-scale tools and devices, which could communicate in a high-speed network infrastructure these solutions can send alert in case of errors and makes immediate actions possible. These elements make possible to operate a data management system, which could promote autonomous decision and support smart services and applications.

15. Figure: Structure of ICT



Source: own edition based on (Samih, 2019), (Jakab, et al., 2018)

[37] Its development was the following IPv4 (homogenous digital communication) – IoP (PC and mobile phones) – IoT (link between devices and tools) – FI/Next Generation Internet (future of internet).

IoT is the technology (which could communicate, senses and interfere with its environment through tools and devices) which serves the needs of 'smart solutions'. A well-functioning 'smart solution' should operate in a horizontal system, where more technological options and platforms are available to solve complex problems (Jakab, et al., 2018).The use of IoT generates a massive amount of real-time information and data, which should be properly stored, managed, analysed, and protected. All the devices, which communicates with each other, should be interconnected to a smart city management system to boost innovations, environmental protection, well-being, infrastructural revival. The created solutions could be sorted into three dimensions: technology, human and institution. These dimensions contain fields like business, culture, sport, tourism, environment, energy, logistic, healthcare, mobility – transportation, social service, education, industry, agriculture, media, public administration and so on (Sallai, 2018), public safe, waste, traffic management, lighting, alert management.

While this system works with significant data, security and trust is a crucial point of this development. Citizens should be involved, and their engagement should be achieved. For that reason, city dwellers need a security system that they can trust. To ensure the security of the integrated solution, it should have the following objectives (TWI, 2021), (Thales, 2021):

- Need of real-time data with reliable access,
- Need of accurate and reliable data,
- Protection of sensible data,
- Accountability for actions and interaction with sensitive data systems.

Despite the advantages that smart city solutions can promise, it could also cause harm in the social, environmental, and even economic sector through lack of information, education about the system and its mismanagement or inappropriate integration. It could be responsible for increasing inequality by unevenly distributing the benefits of smart technologies (Colding & Barthel, 2017), (Cugurullo, 2018b), (Wiig, 2016). Accident could happen, which decrease the trust toward the smart systems. Without proper preparation the fear can increase about the potential loss of human relations caused by the dominant use of digitalization. Moreover, with the mismanagement of the smart system the biodiversity can deteriorate, emission – pollution can increase (Cugurullo, 2018b), (Kaika, 2017) or even economic inefficiency could be resulted by the increasing use of electricity.

To take a closer look of the different approaches toward 'Smart City', various distinguish can be made (Kocsis & Gere, 2021), such as technology-driven vs. human-driven approaches (who/what is in the centre of the Smart development), pro-smart city vs. anti-smart city approaches (based on the attitude) and division of approaches based on smart categories/ sectors (Malchenko & Smirnova, 2019). In this dissertation Kummitha and Crutzen (Kummitha & Crutzen, 2017) 3RC Framework, Restrictive – Reflective - Rationalistic or pragmatic - Critical schools of thought, are used, while it is seen as the most comprehensive approach. Their methodology used systemic analysis of the literature to evaluation of smart city approaches into four schools of thought. During their research they identified two trends, one in favour of smart city development, which is offered by three different schools:

- **Restrictive school** (appeared in 2012): gives high importance on technology and low priority on humancentric orientation. According to this school, the key element of transformation is technology and ICT, and the human aspects (social inclusion, justice) are not considered in becoming a smart city.

- **Reflective school** (appeared in 2010): involves more human elements and sees citizens as direct beneficiaries of the technological interventions, while keeps ICT as the core element.

- **Rationalistic or pragmatic school** (most popular in 2015): a holistic smart city can be created by the advancement of human-centric approach, which results technological advantages. The key element is no longer the technology, instead of them the community and the human capital.

While the other trend has one strong pessimistic note in common, which is questioning even the basic concept of the phenomenon and its existence. This is the **Critical school**, which appeared in 2008, emphasis that there is neither technological advancements nor human centric approaches in smart city, it is simply a neoliberal lobby by big corporations such as IBM to privatise urban places (Calixto, et al., 2019). It is claimed that smart city failed to create utopian city context.

Furthermore, there is another distinction according to Neirotti (Neirotti, et al., 2014) and Baji (Baji, 2017), once there is a Hard, a more technical subsystem (Reflective school), which includes the energy system, street lighting system, natural resource utilization, water system, waste management, environment protection, transportation, buildings, health and safety. The other one is the Soft (Rationalistic or pragmatic school), a more social oriented subsystem, which includes culture and education, connectedness and well-being, governance, economy.

Restrictive school of thought

This school gives a significant big focus for technology and ICT-based integrated development in case of connectivity and data. To be considered as a 'smart city', a city should have an ICT-based integrated system, which concludes the IoT implementation in the urban infrastructure and must assist effectiveness and efficiency. In practice, as (Kummitha & Crutzen, 2017) see, city planner and ICT provider working together to provide ICT solutions for urban services and communication between local government and citizens. According to Caragliu (Caragliu, et al., 2011), the services via ICT adaptation, provided by the government, can be reached easier, while the burdens are reduced by the technology. According to the school, 'smart city' is the target, which is, as Richter listed (Richter, et al., 2015), efficient, reliable, secured, suited to tackle climate change and control energy usage. Datta (Datta, 2015) added, through technology implementation (access to ICT) a more holistic social order is created.

Still, there are some aspects of 'smart city', which are excluded from restrictive school's approach:

- According to Kummitha (Kummitha & Crutzen, 2017) the relation between 'connected' and 'smart' is not well discussed,

- and whether the adaptation of technological advancement upgrades human experience, involvement,
- according to Graham (Graham, 2002), the question of social inclusion is not detailed, the who and which social fields are involved in empowerment of ICT implementation,
- Caragliu (Caragliu, et al., 2011) and Leydesdorff (Leydesdorff & Deakin, 2011) consider Graham idea on to what is the level of inclusion that can be achieve via 'smart city'.

Reflective school of thought

This school was formed from the restrictive school and tries to fill its incompleteness in case of social inclusion and justice. This school focuses on the why and how ICT can enrich human well-being. The concept core element is still technology, while it is seen as a tool for human capital development, boost of innovative ecosystems and spirit, participation improvement (Angelidou, 2015). According to (Letaifa, 2015) 'smart city' creates a new socioeconomic environment, where citizens, public and private actors can use services and resources in a more effective way without any limitation of the public or private sectors. Furthermore, in the smart city building, Kummitha (Kummitha & Crutzen, 2017) sees the private sector as the key stakeholder. This school is still techno-centric, while it considers the directly and indirectly collected data from citizens as treasure. It involves 6 segments to ensure higher inclusiveness and human approach, namely smart -economy, governance, environment, people, living and mobility (Caragliu, et al., 2011). These six segments called the characteristic of 'smart city'.

Critical aspects of reflective school:

- according to Kirkpatrick (Kirkpatrick & Smith, 2011), the technologically improved infrastructure requires a notable investment, which make achieving efficiency more difficult,
- Peck (Peck, 2012) sees, through this development a rigid urbanism can be created, where the role of government is reduced and in a meantime market interest is followed and dominates,

- as Kummitha (Kummitha & Crutzen, 2017) stated, it is hard to identify the leading interest of the stakeholder, while the society is complex.

Rationalistic or pragmatic school of thought

The rationalistic or pragmatic school puts the people and their capabilities before technology (ICT or IoT). Despite of the reflective school, they see the community for the key stakeholder of 'smart city' building (Kummitha & Crutzen, 2017). According to Orlikowski (Orlikowski, 2000) who emphasise that citizens, communities' usage of ICT create technology development, and for that reason the common knowledge of technologies and tutoring skills for the effective application are needed. These 'smart communities' are essential pre-conditions for 'smart city'. In line with this, Neirotti (Neirotti, et al., 2014) sees 'smart initiative' as an investment in human capital, which modifies the way of living, communicate within urban community and that improves technological development. As contrast of the other previous two school, according to Waart (Waart, et al., 2015) community- level (bottom-up) initiatives should be in the focus, which means in 'smart city planning' the concerned stakeholders should cooperate and interact by created 'living lab' or 'urban lab', and innovation (Kummitha & Crutzen, 2017). This school follows a more human-centric approach by putting citizens and community's education before technology investment (Eger, 2003). They see innovation in the cooperation between university, industry and government (triple-helix model) (Leydesdorff & Deakin, 2011) or in a quadruple-helix model with the public – civil society involvement (Lombardi, et al., 2012). By putting human capital and skills in the centre, education, culture and knowledge valorised, ICT and other infrastructure become complement, and economy instead of labour intensity is going to be based on knowledge. Thus as Angelidou (Angelidou, 2015) stated, there is a significant shift from physical capital (ICT infrastructure) to an intangible capital (knowledge and skill).

Critical school of thought

The proponents of this school are sceptic with the concept and practice of 'smart city'. They are questioning the 'smartness' of the concept as a basis, as Hollands summarized (Hollands, 2008), and claim that during 'smart city' development a huge proportion of the society leaves behind (mostly unskilled and IT illiterates people (Peck, 2005) such as elderly[38]). There is no total social inclusion or justice. They, as Datta (Datta, 2015), see 'Smart city' as a business model not a development approach. According to the scholars of the school there are abundant areas, where the concept of 'smart city' is not sufficient or even predacious, such as social capital, addressing inequality (Carvalho, 2015), grabbing land (Datta, 2015), smart city branding (Hollands, 2008) etc. They claim (Hogan, et al., 2012), that the winners of building 'smart city' are corporations by privatising the urban lands and promote economic pressure over social and environmental demands of the cities (Gibbs, et al., 2013), (Waart, et al., 2015). The utter losers of 'smart' deals are citizens and communities by excluding them in the planning and adaptation (Kummitha & Crutzen, 2017) by the suppress of possible bottom-up innovations (Calzada & Cobo, 2015).

The supporters of the school such as Mudler (Mudler, 2014), are questioned whether a well-managed efficient energy system, public transportation and traffic system could improve lifestyle of citizens. It is seen that regroup of national budget for ICT investments endangers the needs of dwellers for sanitation, water system, housing (Begg, 2002), (Moser, 2015) even though 'smart city' technology provides solutions for them as well. According to Datta (Datta, 2015) and the academic representative of this school, 'smart city' is an entrepreneurial urbanization process under technologies, that are forced into communities without considering their needs. Additional to that, the biggest problem with 'smart innovations' is, they are materialized mostly in the developed/ global North/ rich countries'[39] cities instead of the developing/ global South/ poor countries' cities, where the exposure for the impact of climate change or inequality is more significant. According to Atkinson (Atkinson & Bridge, 2005), the main motivation of the ICT based development is purely market mechanism or in case of going to extremes it is even colonialism.

[38] As it is declared in Kenesei et all study (Kenesei, et al., 2019), for the elderly people different way of planning and execution is needed in case of ICT to promote their well-being and utilization capability. In the developed world most of the societies are aging, thus, during 'smart city' building this heterogeneous group's need and opportunities should be also considered. The key factors of involvement are the people itself (demography), health condition, autonomy, anxiety from technology, environment (family, workplace), in case of technology: efficiency, simplicity, design, physical and financial availability, safety and supported.

[39] Cities of these countries such as London, Madrid, Wien, Aspenseestadt, Stockholm etc.

How the technological solutions of smart city developed and its potential role in urban sustainability became stronger the ‘smart sustainable city’ concept emerged[40]. This concept usually deals with commodities and resources such as electricity, water, waste, lighting. According to Ahvenniemi (Ahvenniemi, et al., 2017), ‘smart city’ frameworks focus more on technology and social - economic aspects, while ‘sustainable city’ structures emphasis the environment and sustainability. A ‘smart sustainability’ is the combination of these to framework. Falconer and Mitchell (Falconer & Mitchell, 2012) assume that a smart city framework helps stakeholders and city dwellers to understand the operations of cities, the role of ICT, and define objectives and roles to become smarter and more sustainable (Stübinger & Schneider, 2020).

However, Smart Sustainable Cities (SSC) are a combined concept of three factors: smart, sustainability and cities. They must be present at the same time, otherwise it is just a smart city or sustainable city or a smart suitability, while a city can be sustainable without the use of smart (ICT) technology, or smart technologies can be used in cities without contributing to sustainability and smart technologies can also be used for sustainable development outside of cities. According to Höjer (Höjer & Wangel, 2014), we can speak of ‘Smart Sustainable Cities’ (SSC), only when all these three aspects are combined, when smart technologies are used for making cities more sustainable, with no exceptions. He stated that SCC is not equal with ‘smart city’ concept, while it prioritises the involved field according to sustainability, which term is not even defined by the ‘smart city’ concept. Kramers (Kramers, et al., 2014) added, while suitability and environmental approach is core element of SSC, until in case of ‘smart city’ some of the definitions are not even mentioned it. While the definition of SCC according to (Höjer & Wangel, 2014, p. 10) is based on the Brundtland report sustainable development definition:

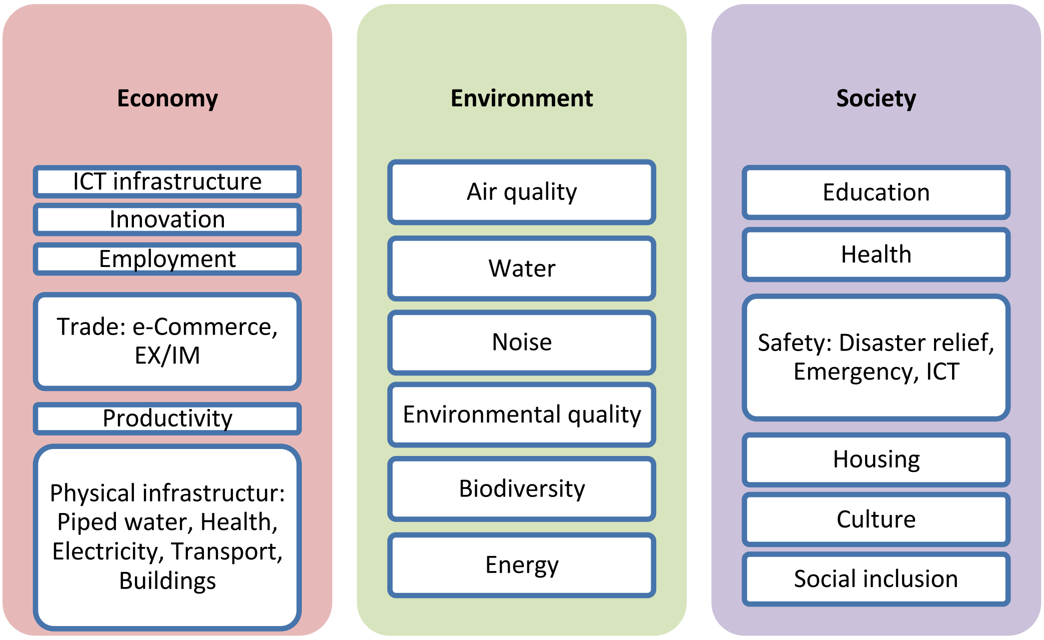
“*A Smart Sustainable City is a city that — meets the needs of its present inhabitants — without compromising the ability for other people*[41] *or future generations to meet their needs, and thus, does not exceed local or planetary environmental limitations, and — where this is supported by ICT.*”

[40] There was an exponential growth in the academic publication in the topic of smart sustainable city between 2015 and 2020. This could be interpreted by the increasing role of climate change and green movements. According to estimations, the number of smart sustainability publications will be 175 times that of 2000 level by 2030 (Stübinger & Schneider, 2020).

[41] To emphasise the global responsibility.

This definition shows that in the 'smart sustainable city' the smart ICT technology is used to support well-being and prosperity while solving environmental problems by using smart technology. The United Nations in 2014 implementing a smart sustainable city definition and program likewise. It has 3 areas (economy, environment and society), 18 topics and in total 71 indicators (Figure 16.), (Appendix 4.), (United Nations, 2015b):

16. Figure: Framework of Smart Sustainable City concept



Source: own edition based on (United Nations, 2015b, pp. 4-9)

Smart Sustainable City concept has not evolved full jet, for that reason it faces with some challenges (Höjer & Wangel, 2014), such as the misuse of ICT can boost the exploitation of Earth more efficiently, rather than support a resource-efficient sustainable society development. Also, mostly big IT companies (IBM, Cisco, etc.) have the necessary capital to support smart solution implementation, which can endanger the creativity, innovation in the bottom-up approach. Additionally, these IT enterprises' ICT knowledge are much higher than the city government, for that reason they are 'weak customers[42]', which fact can cause bad decisions. According to ITU (ITU, Geneva) and Anthopolous (Anthopolous & Vakali, 2012), these elements require the rethinking of stakeholders in urban planning and governance to provide complex thinking during SCC solution adaptation.

[42] In case of defining the problem, asking solution for it, evaluate the offered solution.

The ITU and Anthopolous statement is adaptable for the smart city development. It requires a complex strategy, which includes well-defined targets, combined with the present infrastructure, tools and devices to serve efficiency and sustainability. These plans[43] could vary from countries, regions, cities or even projects. Accordingly, there is no global or EU or Hungarian 'Smart city' regulation, however, the subfields are received laws.

The European Union pays attention to this field, although in generally the 'smart city' does not have a homogenous regulation framework within the EU, but it has guiding lines and targets such as the EUROPE 2020, A European strategy for smart, sustainable and inclusive growth (European Commission , 2010), which defines smart growth as a knowledge- and innovation-based process. The Urban Agenda for the EU (2011), which includes Digital Transition, Urban Mobility, Climate Adaptation, Energy Transition beside other topics, to promote energy efficiency, innovation, and social inclusiveness to reach sustainable city management. Furthermore, in 2011 the EU set its Energy roadmap (European Commission, 2012) to boost the use of renewable energy sources (and since 2014 decrease the energy dependence outside of the EU (European Commission, 2014) and the cut of GHGs emission, the White Paper on transport (European Commission, 2011) to growing transport and supporting mobility while achieving the 60% GHGs emission reduction target by eliminate the use of 'conventionally fuelled' cars in the city. Since 2014 the Commission has taken actions to facilitate the development of a data-agile economy. It regulated the free flow of non-personal data and general data protection and made action in case of Cybersecurity and Open Data. In 2020 it presented its AI framework and ethics guidelines (2019) as well (European Commission, 2021c). In the EU climate action, European Green Deal (European Commission, 2019) and EU Climate Adaptation Strategy (European Commission, 2021d), the target is to increase the resilience of Europe through adequate climate adaptation, which includes smart interventions in the fields of energy efficiency – smart grid system, smart mobility –

[43] In general, regional planning focuses on the coordination of human activates in a determined space by considering the available natural resources and financial preconditions. Urban planning is regional planning in a residential area. They both policy frameworks to represent governmental urban management of land use and development (Campbell, 1996), (Handy, et al., 2002), (Kiernan, 1983), by including indicators such as "environmental capacity, population, financial cohesion, and transportation and other public service networks" (Anthopoulos & Vakali, 2012, p. 178). While spatial planning is a comprehensive phenomenon (Salamin & Péti, 2019), which consider spatial development coordinating projects by harmonizing of relevant national policies such as regional, urban, environmental, transportation infrastructure planning etc (Allmendinger, 2009).

traffic system, smart integration - infrastructure, smart adaptation – smart decarbonisation, fostering locals, smart water management. According to Dobos (dr. Dobos, et al., 2015) ,there is cooperation between stakeholders, while there are partnerships (European Innovation Partnership - EIP), platforms (URBACT, Smart Cities Marketplace[44]) and supporting (European Network of Living Labs systems) in the field of smart city.

[44] It is a platform of the former “Marketplace of the European Innovation Partnership on Smart Cities and Communities” (EIP-SCC) and the “Smart Cities Information System” (SCIS).

2 RESEARCH DESIGN

2.1 The aim of the research

The target of this dissertation is to examine, whether smart solutions through a novel approach can be serve sustainable climate change tackling purposes. For that reason, the main motivations will be explored to define, what factors drive the choices and implementations of smart city solutions and to analyse their focuses.

The previously presented chapters, through systematic literature review, provided detailed information about the complexity (operations, effects, impacts, consequences) of climate change and in the field of 'smart city' theory key definitions and approaches were identified to map and discuss the special and dominant role of cities within the climatic change and their exposure to its consequences. As Satterthwaite said (Satterthwaite, 1997), cities are seen as the best representatives of these actions, while urban sustainability is needed to combine local actions and the reduction of the transfer of environmental costs to other people, locations, time. This research links these two mostly separately analysed fields, climate change and smart city, and tries to identify the empirical aptitude of smart (city) solutions and the relation between the two fields, while climate change consequences encompass all aspects of our life. Thus, we expect that an appropriate solution for this urgent problem, provide an answer for how urban mitigation and adaptation processes can reach a higher level, while the levels of well-being of people and the environment are not getting injured.

2.2 The Research question and the sub-questions

The core research question of the dissertation is whether smart solution can serve as a sustainable climate change mitigation and adaptation tool. The dominance of smart solutions started in the 1970s and for the 2000s it is worldwide available in different levels. The development was seen through the adaptation of ICT technology to reach more efficient operation for cities. In the last couple of years (5-10 years), according to (Höjer & Wangel, 2014) and (United Nations, 2015b), a new phenomenon emerged namely the 'smart sustainable city'. This new approach put the environment in the focus and use ICT, smart solutions for solving environmental problems by remain efficient. Therefore, it leads to the purpose to determine if smart solutions are suitable tools for sustainable urban mitigation and adaptation purposes.

For that reason, three sub-questions have been defined (Table 11.) to support the realization of the research objective, which represent the three levels included in the examination. The first level represents the 'city level', where the following question could be asked "What factors motivate smart city development?" to define the tool sets of the cities. Accordingly, the main motivation factors will be determined based on the urban challenges, the unique approaches to 'smart city solutions', and the potential fields to apply smart solutions. The second, projects, level investigates "How does the environment appear in the accomplished smart city investments?" to identify the importance and the appearance of the 'environmental' factor in the already implemented smart projects. During the analysis, the form of appearance (independently or in relation to economic efficiency) and the detected related motivation or compelling force will be highlighted. As the focus of the analysis drills down, the examination of the individual level should be included, too. At this level, through the inhabitants' point of view the urban challenges and their knowledge about 'smart solutions' will be tested to answer the following question: "What is the connection between implemented smart city solutions and the environmental awareness of residents?". Beside the projects (in)direct climate related results, through the education of the dwellers further achievement could be achieved.

11. Table: Research Question and sub-questions

Research Question - What is the role of smart solutions in combatting climate change by increasing the efficiency of urban mitigation and adaptation processes?
S-Q1: Which factors motivate smart city developments?
S-Q2: How does the environmental impact as motivation appear in the accomplished smart city investments?
S-Q3: What is the connection between implemented smart city solutions and the environmental awareness of residents?

Source: own edition

2.3 The methodology

Methodological structure of the research

During the methodology selection the goal was to find a suitable method, which is appropriate for answering the research questions, sub-questions. This dissertation develops a framework to analyse the relevance of 'smart city solutions' in tackling climate change. By examining the environmental aspects headway, it is analysed, whether the phenomenon 'smart sustainable city', which is according to its definition sustainable development through smart technology in cities, is an existing phase in practice of development or just an 'utopistic' scientific concept, which was built up from 'smart city' concept without any experimental existence. Furthermore, the dissertation tries to modulate the importance of complex integrated smart development, and the relation between urban challenges and existing smart solution.

According to Liu (Lui, 2016), if the research question requires descriptive and interpretive analysis, which deepen the understanding of the topic and it is more explorative than explanative, the suitable methodology should be inductive and qualitative. While the inductive approach starts from the individual case and moves towards general laws, which will also be the explanations of the individual cases. At the same time, how Julia Palik (Palik, 2020) summarised the criticism of qualitative case research, it is seen by Maoz (Maoz, 2002) and Gerring (Gerring, 2007), as an unscientific, non-generalizable, method with low external validity and representativeness (King, et al., 1994, p. 34). Qualitative case research replication is complicated and does not provide adequate design to observe the impact of the independent variable on the outcome. However, as George and Bennett (George & Bennett, 2004, p. 31.) said, with contingent generalizations it could be used, and fit well to find the condition and the mechanism how specific outcomes occurred. It could provide a detailed description about a phenomenon and helps to expand and understand casual mechanisms within (George & Bennett, 2004, pp. 19-22).

These reviewed studies mostly applied deductive approach with quantitative methodology to verify the cities' level of smartness. While the other dominant methodology in these scientific papers is the systematic literature review to observe the development of the term on account of the non-existent homogenous definition and approach of the phrase.

Accordingly (Table 12.), this dissertation uses inductive approach and qualitative methodology, which methodology is rare in the field of smart city /solutions (Lindqvist, et al., 2020), (Kirimtat, et al., 2020), (Molnár PhD, et al., 2021). The research uses explorative methodology such as semi-structured interviews (Appendix 8.) and non-probability sampling methods during the questionnaire (Appendix 9.). These two methodologies were selected, because they reach the target groups (local government – representative of city, final users – city dwellers) in the most efficient way and contribute to the triple division (structure of the research), These three different levels, city level, project (environment) level, individual level, have their own target groups. The first one is the local government, who has the task and obligation to develop and maintenance the social services, infrastructure, order of the city. They are the representative of cities. The next level is the project level, where still the local government, or city development specialists, or experts and vendors can conclude their point of view about the various projects' main focuses. Finally, the third level is the individuals', where the city dwellers perspective is relevant. In the first two levels, detailed information is needed and the opportunity to explain opinions, way of thinking. For that reason, interviews have been selected as a methodology to collect specific information at first hand with the least possible chance of distorting information. Additionally, through the interviews, where the individual cases had been discussed, and their results could serve or help to generalisation, and this methodology was used during the IESE Cities in Motion Index (CIMI) (Berrone, et al., 2020) model, which was based on 'best practises', and series of in-depth interviews with different stakeholders. In case of the third level, the questionnaire is the selected methodology, while it can reach a significant number of people within the foreseeable future, if the survey's questions are easy to answer and do not take much time to complete the form. These aspects were considered during the compiling of the relevant questions. While there is a hierarchy between the levels, from wide to narrow – city to person, the research first presents the environment (within the EU and locally) of the cities, then it is applied the interviews to discuss two sub-questions, and then the questionnaire to evaluate the third sub-question.

12. Table: Methodological structure of the research

Aim	Method	Measured Variable	Related research questions	Questions
Context and focus of the research	Systematic literature review	Consequence of Climate Change; Role of cities; Smart city phenomenon and approaches	Provides an overall background for the analysis	What is climate change, and how it affects us? What is the contribution of cities in case of climate change? How can 'smart city' be described?
Conceptual background	Benchmark model analysis	Environmental indicators		What are the most common used environmental indicators?
Analysis of the City-level	Systematic literature review Semi-structured interview	Smart city paradigm; Challenge of cities; Climate change awareness; Applied smart solution	S-Q1 , S-Q2	How would you define 'smart city'? What are the most common challenges of cities? Was climate protection also considered during the decision? What smart solutions have been delivered?
Analysis of the Project-level	Semi-structured interview		S-Q2, S-Q3	
Analysis of the Individual-level	Questionnaire	Challenge of cities; Smart city awareness; Smart solutions	S-Q3	What are the most common challenges of cities? How deep is our general knowledge about smart city? What type of smart solutions are existed?

Source: own edition

Based on the previously presented critique and to strengthen the reliability and validity of the research, the number of interviewees were increased (from 3-3-3 to 4-7-6), and a high number of respondents were collected during the survey (N=550) and different methodologies were applied (systematic literature review, semi-structured interview, questionnaire). The dissertation follows a multidisciplinary approach, therefor it examines the relevance of the research question with a Hungarian (Tamási, Kecskemét,) and an international (Székelyudvarhely, and a Twin city, Sepsiszentgyörgy) cases.

The dissertation based on primer and seconder data sources (under triangulation[45]). The seconder sources can be divided into three groups. The first one is the relevant scientific literature, which includes theoretic information about climate change, cities and smart (sustainable) city, their connection and development. More precisely, the increasing awareness of climate change and how it became one of the 17 significant global challenges (SGDs) that endanger our sustainably existence; the development of IT technology, which introduced the smart city; and the smart sustainable approach to the 21st century by using smart solutions to combat environmental challenges (such as climate change). The second source are the documents, strategies, reports of international organisations, governments, or research institutes about climate change, role of cities, and smart (sustainable) cities. The third source is the different smart (sustainable) city benchmark models' indexes.

Benchmark models comparison

Firstly, the smart city (benchmark) models will be presented, with particular attention to the various indicators, which can be used to frame the main characteristics and thus identify the main motivations during the choice and implementation of individual smart solutions. For that reason nine benchmark models (European Smart Cities 3.0 (2014) (TU - Vienna University of Technology Department of Spatial Planning, 2014), Smart City Wheel (2014) (Cohen, 2014), ISO 37120:2018 Sustainable cities and communities – Indicators for city services and quality of life (ISO, 2018), UNECE-ITU Smart Sustainable Cities Indicators (United Nations, 2015b),which has been developed to the U4SSC model (U4SSC, 2017), EU Reference Framework for Sustainable Cities (RFSC)

[45] Practice of using multiple sources of data or multiple approaches to analysing data (Salkind, 2010).

(European Commission, 2018b), IGC Development Index (Malek, 2010), A.T. Kearney Global Cities Index GCI (A.T. Kearney, 2021), IESE Cities in Motion Index (CIMI) (Berrone, et al., 2020), Cities of the Future Index (CFI) by Easy Park Inc. (Easy Park Inc., 2022), will be compare according to their characteristics, factors and finally indicators, to find those, which appears more than once in these models. These indicators related to the environmental, more preciously climate change, will be the topic of some questions within the interview about environmental focus of the developments.

Semi-structured interviews

In case of the interviews, they were semi-structured online-based interview with mostly indirect open questions to provide opportunity to the interviewees to express their thoughts, they were hold in 2022.The participated interviewees (Table 13.) number was 17 (N=17), a total of 4 local governments such as former city manager and currently Head of the cabinet of Székelyudvarhely, the deputy mayors of Tamási, Sepsiszentgyörgy and smart city project leader of Kecskemét; a total of 7 experts in the field of IT security, mobility, energetics, environment and smart city; and finally total of 6 smart solution provider companies from the market (IoT, safety, solar energy, mobility, water safety). They were contacted by email or telephone and asked to participate in the research, regarding their experiences of the smart market. Participants received information about the purpose of the interview and were informed that participation was voluntary. As preliminary action, an interview draft was created with four topics (personal relevance, climate change, smart city, and smart solution) and 10-10 optional questions, and some pilot interviews were held personally in 2021 under reflexivity[46] with smart city, IT security expert and local government. According to the received feedbacks of the pilot interviews the final questions were created.

The interviews were audio recorded (the Hungarian draft of the interview transcript is attached) and analysed by using an inductive qualitative content analysis. Also, some of the accidentally picked tapescripts of the interviews were revised as a respondent validation[47] by the interviewees. Some of the questions were asked within the

[46] How the researchers, themself, preconceptions, and sensibility influence the research (Haynes, 2012).
[47] Also known as member checking. It is a technique to investigate the credibility of results. The results are returned to the interviewee to check for accuracy (Birt, et al., 2016).

questionnaire and during the interviews to modulate the covered fields, like the most dominant challenges of cities etc., and some of the interviews' questions were based on the result of the comparison of the main environmental related indicators of the benchmark models, such as GHGs emission. The released answers (data) are extractions, not verbatim, upon request of participants.

13. Table: Detailed characteristics of participants

Interviewee	*Representing*	*Position*	*Label*
1. Jakab Attila	Székelyudvarhely	Head of the cabinet, former City Manager	Government
2. Tóth-Birtan Csaba	Sepsiszentgyörgy	Deputy mayor	Government
3. Széles András	Tamási	Deputy mayor	Government
4. Nagy Gábor	Kecskemét	Managing Director of City Development Ltd.	Government
1. Sugár Péter	IT security	IT Security specialist	Expert
2. Németh Balázs	Mobility	Sustainability Manager	Expert
3. Lovász Líviusz	Energetics	Nuclear Engineer	Expert
4. Barsi Orsolya	Environment	Head of Climate and Environment Unit at Budapest Mayor's Office	Expert
5. Mikulák Péter	Smart City	Business Developer, former Head of Smart City Division	Expert
6. Sarkadi Péter	Environment	Environmental journalist	Expert
7. Kurenkov Szlava	Urban development	Settlement development expert	Expert
1. Csenteri Levente	IoT	Executive Director at Combridge	Supplier
2. Kocsis Csaba	ICT tools	R&D engineer at Endrich Bauelemente Vertriebs GmbH	Supplier
3. Szűcs Alfréd	Safety, energy	Sales Manager	Supplier
4. Imrei Attila	Mobility	Project Manager	Supplier
5. Ilcsik Csaba	Water	CEO	Supplier
6. Mátyus László	Mobility / Smart solution	Director of Innovation and Service Development	Supplier

Source: own edition

The cities and their representatives were selected according to three factors. Once, the selected cities have similar historical and infrastructural backgrounds and roughly the same size of dwellers compares to big cities (small cities and settlements, less than 200.000 inhabitants). Secondly, they are town cities of each other like Kecskemét –

Sepsiszentgyörgy. Finally, they are representing the local bottom-up approaches, the small settlement, while as Kent (Kent, 2011) said, they can lift national levels, where they can compensate essential failure of states' interventions, and through this they could become 'best practices'. In case of the experts, their fields should cover the main sectoral contributor for climate change in cities such as energy, mobility or they should work on one of the related fields of IoT or urban design / smart city development. Finally, in case of the companies, they should provide frequently installed smart solutions.

Questionnaire

The online bilingual (HU-ENG) questionnaire was available online for 12 days in 2022 in Hungarian and in English. During the non-probability, accidental sampling, and this timeframe, 550 finished answers were sent, which was composed of three sources, the questions were asked online through social media platforms such as LinkedIn, Facebook, Instagram. Some of them were groups, which connect smart city expert and/ or people, who are interested in sustainable cities. The questions were a mixture of direct and indirect, open and closed ones like, "*Do you live in a city?"; "Please mark all the problems you have experienced in your city"*, to test the general knowledge of 'smart city' and collect generally known 'best practices smart solutions'. The questionnaire has three attribute related questions (gender, age, city dweller status).In case of the cities' challenges, the non-city dwellers were excluded, and the optional challenges were listed based on the literature (Meadows, et al., 1972), (United Nations, 1987), (United Nations, 2012), (OECD, 2010), (UN-Habitat, 2011), (Revi, et al., 2014), (UN-Habitat, 2020), (Kocsis, et al., 2016), (Kovács, et al., 2017). The classification of respondents' knowledge about 'smart city' was based on Molnár's work (Molnár PhD, et al., 2021), and were extended with an additional option to avoid "compulsion to comply". In terms of the known smart solutions, all the participants were asked to answer the related questions, whether they know local or international examples. Detailed characteristics of participants are outlined in Table 14.

14. Table: Sample composition

Attribute	*Attribute versions*
Gender	Female: 59,27% (326); Male: 40% (220); Other: 0,73% (4)
Age	0-25: 7,09% (39);
	26-35: 27,82% (153);
	36-45: 25,09% (138);
	46-55: 22,55% (124);
	56- : 17,45% (96)
City dweller	Yes: 87,45% (481); No: 12,55% (69)

Source: own edition

2.4 Smart city benchmark models

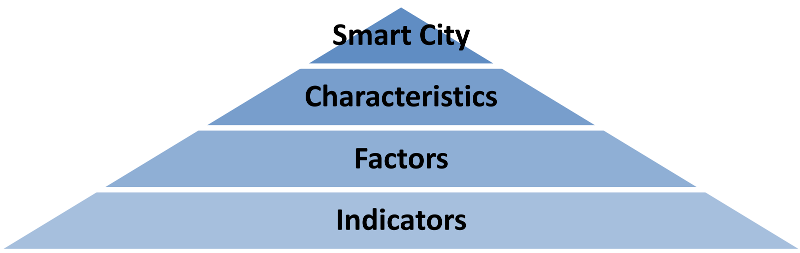
The chapter contributes to the determination of the environmental indicators, which are most often used by the literature and the benchmark models to compare the 'level of smartness', and along these lines, during the empirical investigation, the role of these indicators will be examine during the decision-making process of the smart solution investment. The presence of these indicators during the planning or decision-making process will be considered as the existence of an environmental focus.

There is abundant supply of scientific studies about different smart city models (Haibullin, 2018), (Sikos & Szendi, 2021), (Sallai, 2019) some of them is system based (Lom & Přibyl, 2020), some of them sees citizen as sensors (Cano, et al., 2015), others focusing on motivating factors (Herrera & Fajardo, 2016) or the resilience (Baran, et al., 2022). Based on the literature, (Anthopoulos, et al., 2015), (Anthopoulos, et al., 2016), Anthopoulos collected smart city conceptualization models and aggregated them into groups according to their focuses, Architecture (Naphade, et al., 2011), Governance (Baron, 2012), Planning and management, Data and knowledge (Batty, et al., 2012), Facilities (Calvillo, et al., 2016), Services (Fan, et al., 2016), People (Shapiro, 2006) and finally Environment (Tsolakis & Anthopoulos, 2015). However, in these publications the focuses are different, and, in some cases, there is no overlap between the involved areas. Although with some simplifications, 6 dimensions can be seen common or more frequent in this heterogenetic atmosphere. Henceforward, these 6 dimensions are going to be called characteristic (sector) of smart city and they are the followings: people, government, economy, mobility, environment and living. While the smart city models try to conceptualise the term, define the common part in various theories, approaches, and the involved fields. Until then, the benchmarks try to identify, describe, and analyse a city according to its 'smart (city)' level and compare to each other according to their performance. There are several perspectives within the benchmarking methods like sustainability (Pires, et al., 2014), resilience, (Desouza & Flanery, 2014) global city performance (Kourtit, et al., 2014) etc.

There is a hierarchy structure how the lower levels describe the upper levels and finally the level of 'smartness'. This hierarchic structure, based on the Vienna University of Technology methodology (Vienna UT, 2007), has four levels (Figure 17). At the top of the hierarchy is 'smart city' itself, that is explained by characteristics (sectors, dimensions etc.), which is broken down to factors (domains, themes) and finally indicators (components, indexes). According to these elements, cities' performance could be calculated (by using standardization and aggregation), compared, and ranked.

Within this dissertation according to the following nine benchmarks, the most relevant, commonly used characteristics, and indicators are collected, to emphasise the potential common focuses and the potential strength of the environmental point of view (number of indicators or involved fields) in them. These elements will serve as a framework during the investigation of the four cities, whether they are considering the most common environmental related indicators during their decision-making processes.

17. Figure: 'Smart City' structure



Source: own edition based (Vienna UT, 2007)

The comparative analysis is based on the following smart and/or sustainable city benchmark models (Table 15.):

I. European Smart Cities 3.0 (2014) (TU - Vienna University of Technology Department of Spatial Planning, 2014)
II. Smart City Wheel (2014) (Cohen, 2014)[48]
III. ISO 37120:2018 Sustainable cities and communities – Indicators for city services and quality of life (ISO, 2018)
IV. UNECE-ITU Smart Sustainable Cities Indicators (United Nations, 2015b),which has been developed to the U4SSC model (U4SSC, 2017)
V. EU Reference Framework for Sustainable Cities (RFSC) (European Commission, 2018b)
VI. IGC Development Index (Malek, 2010)
VII. A.T. Kearney Global Cities Index GCI (A.T. Kearney, 2021)
VIII. IESE Cities in Motion Index (CIMI) (Berrone, et al., 2020)
IX. Cities of the Future Index (CFI) by Easy Park Inc. (Easy Park Inc., 2022)

15. Table: Smart city benchmarks

	Characteristics	Factors	Indicators
European Smart Cities 3.0	6	28	81
Smart Cities Wheel	6	18	62
ISO 37120:2018	ND[49]	19	104
UNECE-ITU SSC Indicators	3	18	71
U4SSC Indicators	3	22	91
RFSC	3	16	47
IGC	4	ND	36
Global Cities Index-GCI	5	ND	29
Cities in Motion Index-CIMI	9	101	101
Cities of the Future Index-CFI	4	14	50

Source: own edition based on (TU - Vienna University of Technology Department of Spatial Planning, 2014), (Cohen, 2014), (ISO, 2018), (U4SSC, 2017), (European Commission, 2018b), (Malek, 2010), (A.T. Kearney, 2021), (Berrone, et al., 2020), (Easy Park Inc., 2022) (Appendix 5.)

[48] Smart City Council – Smart City Index
[49] not defined

The European Smart Cities 3.0 approach (TU - Vienna University of Technology Department of Spatial Planning, 2014) suitable to examine medium size cities (100.000 – 500.000 inhabitants) and has 6 characteristics (Smart economy, smart governance, smart people, smart living, smart mobility, smart environment), 28 factors, and 81 indicators. This model does not report the exact indicators, just the numbers of them, which is used during the methodology. Cohen's (Cohen, 2014) Smart city wheel model is used by the Smart City Council as Smart City Index and observes cities in the same 6 sectors as the pervious one, but it operates less and diverse factors (just 18) and 62 indicators. In case of the ISO 37120:2018 (ISO, 2018), it has 19 factors and all together 104 indicators, which can be separated to core (46) and supporting ones (58). Nevertheless, it does not classify its factors (themes) into sectors, but they could fit into the 6 characteristics. Based on the U4SSC Smart Sustainable Cities Indicators (U4SSC, 2017), the UN helps cities to collect data and measure their progress to become smarter, more sustainable and get closer to the SDGs through the provided standardised method. This framework has three dimensions Economy, Environment and Society, and Culture, 22 topics and 91 indicators (55 core and 36 advance). Compared to that, the UNECE-ITU SSC Indicators had 3 dimensions, 18 topics and 71 indicators, which is rarely used. According to the EU Reference Framework for Sustainable Cities (RFSC) (European Commission, 2018b), which is a basic toolkit for European cities to promote sustainability within urban development. The 3 sectors with 16 domains and 47 core indicators and the large number of supplementary indicators (not included) assure the extreme flexibility of the framework. According to Malek (Malek, 2010, p. 112) "From a point of sociologist idea IGC refers to societies that has become the main focus to the development of intelligent cities." For that reason, it puts Human capital in the focus of its observation. During the model 4 dimensions (based on (Baase, 1997), (Bakardjeva, 2005), (Myerson, 2001), (Servon, 2002)) and 36 indicators were set to study the phase of the IGC Socio-Technological Change (5 phases: Innovative, Early recipient, Early majority, End majority, Left behind) within cities.

The analysis of the frequently used indexes by world organisations and research centres is extended by the most common ranking systems (Table 16). These ranking systems collect different data and announce mostly different "winner" to the smartest city title. Based on Toh elaborated work (Toh, 2022) on IESE Cities in Motion Index (CIMI)

(Berrone, et al., 2020), Easypark Cities of the Future Index (CFI), A.T. Kearney Global Cities Index (GCI) (A.T. Kearney, 2021) are added to the research.

16. Table: Characteristics and Indicators of the selected Benchmark models

Benchmarks	pc. / Indicators (Components)
CFI	**50**
Business Tech Infrastructure	15
Digital Life	10
Mobility Innovation	11
Sustainability	14
CIMI	**101**
Economy	12
Environment	11
Governance	12
Human Capital	10
International Projection	6
Mobility and Transportation	13
Social Cohesion Indicators	15
Technology	17
Urban Planning	5
EU - RFSC	**47**
Economy	8
Environment	22
Social	17
European Smart Cities 3.0	**28**
Smart Economy	6
Smart Environment	4
Smart Governance	3
Smart Living	7
Smart Mobility	4
Smart People	4
GCI	**29**
Business activity	7
Cultural experience	6
Human Capital	6
Information exchange	5
Political engagement	5
IGC	**33**
Humanware	9
Inforware	9
Technoware	10
Valueware	5
ISO 37120:2018	**104**
ND	104
Smart City Wheel	**62**
Smart Economy	7
Smart Environment	17
Smart Governance	10
Smart Living	8
Smart Mobility	11
Smart People	9
U4SSC	**91**
Economy	45
Environment	17
Society and Culture	29
Szum	**545**

Source: own edition based on (TU - Vienna University of Technology Department of Spatial Planning, 2014), (Cohen, 2014), (ISO, 2018), (U4SSC, 2017), (European Commission, 2018b), (Malek, 2010), (A.T. Kearney, 2021), (Berrone, et al., 2020), (Easy Park Inc., 2022)

In case of A.T. Kearney Global Cities Index (A.T. Kearney, 2021) is one of the first indexes, it was formed in 2008. It is focusing on the resilience and the connectedness of 156 cities in the global level. During the evaluation five dimensions (business activity, human capital, information exchange, cultural experience, and political engagement) are involved with 29 indicators. While it measures the global connectedness of cities and uses only a few indicators, some fields are shallow, and some are even excluded. Still based on Toh (Toh, 2022), it tries to keep up with the development of the concept, and in its 2021 Global Cities Report, the COVID19 responses of the cities are part of the resilience and capacity evaluation. However, it is excluded the environmental aspect. The IESE Cities in Motion Index (CIMI) (Berrone, et al., 2020) was formed by the IESE Business School in 2017 and since then it evaluate almost 200 cities and the model was based on 'best practises', series of in-depth interviews with different stakeholders like city leaders, entrepreneurs, academics and experts linked to the development of cities. During the evaluation of the cities, this model works with 9 dimensions and 101 factors and indicates compared to the 2017 version, where it was 10 dimensions and 79 factors - indicators (IESE, 2017). Cities of the Future Index (CFI) developed by the Swedish Easy Park Inc. (Easy Park Inc., 2022) as Toh (Toh, 2022) concluded analyses the cities sustainable and liveable present and future through technology. They are ranking the TOP 50 cities in three categories according to their size over 3 million people, between 3 million and 600.000, and between 600.000 and 50.000 inhabitant. This index is built up by 4 dimensions, 14 factors and 50 indicators. However, in the IESE model climate change got involved through some indexes such as CO_2, Methane emission, and future climate, in the CFI model it gets greater attention while one dimension is dedicated to sustainability with its four factors, Green Energy, Green Buildings, Waste Management, and Climate Response, where three connected to the main contributor sectors in case of climate change, and one connected to the adaptation.

While these nine models included several approaches to identify the main involved field of their analysis, some simplifications were made. The 6 classifications topic were used during the analysis, namely Economy, Governance, Living, Mobility, People and Environment based on (Lechner Tudásközpont, 2021), (Vienna UT, 2007). In case of the model does not have them exactly, the Factors and the Indicators were revised and based on them a suitable characteristic were dedicated to the model. In case of the ISO 37120:2018, was the same procedure made, however there were no sector labelled. The result is concluded in Table 17.

According to the result, in GCI and IGC models neither involve Environmental nor Mobility related indicators during their examinations. This is the case with the EU-RFSC and the U4SSC models in the field of Governance and Mobility. If we take a closer look of the distribution of the indicators between the sectors, the U4SSC method has the most (39,13%) Economy related indicators, the ISO 37120:2018 (32%) in the Environmental sector, CIMI with 41,67% in the Governance, U4SSC with 22,64% of the indicators in the Living sector, CIMI (29,78%) is the dominant in the Mobility related sector and finally, IGC has 22,5% of the indicators in the People sector. It can be pointed out if the most relevant sector is observed different result of the models will come out. In case of the CFI model 32% of the indicators connected to the Economy sector. With 29,7% of the indicators analysis the governance sector in the CIMI model, while the Environment sector lead with 46,8% in the EU-RFSC. The European Smart Cities 3.0 model has a quite smooth distribution, but with 25% of the indicators related to the Living field. In both cases, GCI (41,37%) and IGC (54,54%) the People characteristic is the most scanned. Based on the number of connected indicators (38,46%), Environmental sector is leading within ISO 37120:2018, while in the Smart City Wheel model it is representing the 27,41% of the indicators. Finally, Economy sector related indicators are in majority (49,45%) in case of the U4SSC model.

17. Table: Characteristics and Indicators of the selected Benchmark models

pc. / Indicators (Components)	Characteristics (sectors)						
Benchmarks	**Economy**	**Environment**	**Governance**	**Living**	**Mobility**	**People**	**Szum**
CFI	16	14	3	4	11	2	50
CIMI	13	11	30	21	14	12	101
EU - RFSC	8	22		15		2	47
European Smart Cities 3.0	6	4	3	7	4	4	28
GCI	7		4	6		12	29
IGC	1		13	1		18	33
ISO 37120:2018	12	40	9	20	7	16	104
Smart City Wheel	7	17	10	8	11	9	62
U4SSC	45	17		24		5	91
Szum	**115**	**125**	**72**	**106**	**47**	**80**	**545**

Source: own edition based on (TU - Vienna University of Technology Department of Spatial Planning, 2014), (Cohen, 2014), (ISO, 2018), (U4SSC, 2017), (European Commission, 2018b), (Malek, 2010), (A.T. Kearney, 2021), (Berrone, et al., 2020), (Easy Park Inc., 2022)

In the further investigation of the benchmarking models, some sort of simplification was necessary to made to find the most frequently used indicators. While the Factors and the indicators itself were excessively variegated a certain unification was essential to classify , according to the model itself, and (Lechner Tudásközpont, 2021), (Vienna UT, 2007), the indicators into 37 groups like Business Innovation, Economy, (Un)employment, (Inter-)national accessibility, Life; ICT infrastructure; Mobility; Environmental; Air quality; Governance; Education; Inclusion; Cultural; Health; Safety; Housing; Services; Bicycle; Electric car; Apps; Building; Energy supply; GHG emission; Waste; Water and Sanitation; Green spaces; Internet; Gadget; Political; Inequality; Crime – Corruption; Food Security; Climate Response; Happiness index; ISO 37120 certification; Parking Innovation; ePayments.

Additionally, two of the models from basic does not have Governance and Mobility characteristic (EU-RFSC, U4SSC), but during this re-classification of the indicators six of them were mobility related in case of EU-RFSC, twelve of them in U4SSC and three of them were Governance related in the U4SSC model (Appendix 6.).

Within each of the 37 groups the indicators were compared to each other, and the same measures were merge to one description. For example, in the ‘Air pollution’ group the three different labels:

- # of particles in the air with a diameter of less than 10 µm;
- Particulate Matter (PM10) concentration;
- Levels of Particulate Matter (PM10 – mg/m3)

were integrate into one label: Levels of Particulate Matter (PM10 – mg/m3). On the other hand, green area was mentioned four times, but with different measures such as Green area (hectares) per 100 000 population, Green Area Accessibility, Green areas, Green areas per 100.000 (in m2). In this special case, they were used as separate labels. Through this unification, it became possible to find the frequently used indicators (Appendix 7.). From the 545 indicators, which are cover a broad scale (such as Number of McDonald’s and Slavery), 29 indicators could be highlighted, by appearing in the dataset more than once. They represent all six characteristics of the smart city, and the environmental and the directly climate change related ones are highlighted with yellow and green.

- % of population born in a foreign country;
- % of people in full-time employment;
- Unemployment rate;
- Youth unemployment rate;
- Levels of Particulate Matter (PM10 – mg/m3);
- Levels of Particulate Matter (PM2.5 – mg/m3);
- Violent Crime Rate;
- # of museums and art galleries per city;
- # of higher education degrees per 100 000 population;
- % of students completing secondary education;
- Adult literacy rate;
- Share of electricity consumption from renewable sources;

- Noise pollution;
- % of households with some kind of telephone service;
- TV property per household;
- GHG emitted measured in tonnes per capita;
- Total CO2 emissions from fuel combustion;
- Development of eGovernment services;
- % of waterways in relation to total land area;
- Life expectancy;
- Health;
- Open data use;
- Gini coefficient;
- % of households with access to the internet;
- Annual # of public transport trips per capita;
- Average commute time;
- % of city's solid waste that is recycled;
- Total collected municipal solid waste per capita;
- Total water consumption per capita.

This research does not study the methodology and the popularity of these models but combining this framework with the naturally multi-faced smart city concept, based on (Albino, et al., 2015) in-depth analysis, one strong statement can be done. Which is, despite of all the different frameworks and models, the try to measure the quality of people, communities, ICT solutions, environment etc., but the final measurement about the cities' level of 'smartness' should depend on their own special vision, capability, features. These elements make hardly achievable to create universal, fixed system to define and compare cities worldwide. Although, if we still wish Table 18., which summarize the outcomes of the analysis of the different Benchmark models and the UN SDGs, can serve as a tool for the first steps to start a journey in the smart city dimension even to those cities, which number of inhabitants is small.

18. Table: Smart city characteristic, description and most common indicators

Smart economy **Competitiveness** Those ICT, platforms and services, which support entrepreneurship, innovative ecosystems & spirit, productivity, ability to transform, labour flexibility, economic image & trademarks and international embeddedness. Relevant SDG target: - Potential Index: - % of people in full-time employment - Unemployment rate - Youth unemployment rate - % of waterways in relation to total land area	**Smart governance** **Participation** Open, accountable and transparent governance, opportunity of participation in decision-making processes, existence of political strategies & perspectives. Available public and social services. These elements support by ICT. Relevant SDG target: Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning. Potential Index: - % of households with some kind of telephone service - % of households with access to the internet - Development of eGovernment services - Total collected municipal solid waste per capita - Total water consumption per capita - Gini coefficient - Open data use
Smart people **Social and Human Capital** Promotion of lifelong learning, creativity, flexibility, open-mindedness, participation in public life, higher level of qualification through education development and social and ethnic plurality. Relevant SDG target: Strengthen efforts to protect and safeguard the world's cultural and natural heritage. Potential Index: - # of higher education degrees per 100 000 population - % of students completing secondary education - Adult literacy rate	**Smart mobility** **Transport and ICT** Sustainable, innovative, safe transport system and service centred transportation development. Local, (inter)-national accessibility. Promotion of non-motorized and public transportations by complex ICT solutions and connected infrastructural network. Relevant SDG target: By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons. Potential Index: - Annual # of public transport trips per capita - Average commute time

Smart living **Quality of life**	**Smart environment** **Natural resources**
Interventions and ICT solutions to boost liveability, safety, housing quality, health, tourism, social cohesion, cultural and education facilities. <u>Relevant SDG target:</u> By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums. <u>Potential Index:</u> - # of museums and art galleries per city - % of population born in a foreign country - TV property per household - Violent Crime Rate - Life expectancy	Sustainable natural resource management, water and waste management, use of renewable energy sources and energy efficiency, air pollution decreasing, promoting climate change adaptation ability. <u>Relevant SDG target:</u> By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management. <u>Potential Index:</u> - **Levels of Particulate Matter (PM10–mg/m3)** - **Levels of Particulate Matter (PM2.5–mg/m3)** - **GHG emitted measured in tonnes per capita** - **Total CO_2 emissions from fuel combustion** - **Noise pollution** - **Share of electricity consumption from renewable sources** - **% of city's solid waste that is recycled**

Source: own edition based on (Lechner Tudásközpont, 2021), (Samih, 2019), (Vienna UT, 2007), (United Nations, 2015b) and own analysis based on (TU - Vienna University of Technology Department of Spatial Planning, 2014), (Cohen, 2014), (ISO, 2018), (U4SSC, 2017), (European Commission, 2018b), (Malek, 2010), (A.T. Kearney, 2021), (Berrone, et al., 2020), (Easy Park Inc., 2022)

"Politics cannot fix climate change, how it can be solved is through technology and innovations as the way, it always has been…"

-- Jeffrey Tucker -- (Brain Bar, 2019).

3 EMPIRICAL FINDINGS

3.1 Milieu of the empirical research

The anthropogenic climate change endangers not just our future, but our present as well. For that reason, parallel mitigation and adaptation processes needed to tackle climate change and make the change sustainable. At this point, a two-level approach is going to be formed. The country leaders negotiate at an international level through the international organisations, institutions, and conferences, such as Climate Conferences organised by Intergovernmental Panel on Climate Change (IPCC) or United Nations Framework Convention on Climate Change (UNFCCC), or through supported programs & projects from the United Nations Development Programs (UNDP) or the World Bank Group (WBG.) Meanwhile at the national level, the local governmental, private and public sectors create and implement innovative solutions to mitigation and adaptation (bottom-up approach). The dissertation through the interviews examines whether the use of smart solutions with a well-structured, complex city management and development planning could increase the cities resilience. The most accurate question (Figure 18.), that we must ask during the analyse, what is the reason why we take actions right now? The answer determines the direction (GHGs emission decrease and / or an adjustment for the new circumstances), and the field (where the risk arise from) and the level of cooperation. A well scheduled action (mitigation or adaptation intervention) combines with cooperation could boost the economy especially in the field of eco-friendly production, know - how sharing and improvement in the energy sector.

18. Figure: What is the reason why we are take actions right now?

Source: own edition

Accordingly, the European Union (EU, 2020), as a unit of 27 member states[50], set the following GHGs reductive commitments in its updated first NDC to tackle climate change:

- the Member States will act jointly, and their binding target is a net domestic reduction of at least 55% in GHGs emissions by 2030 compared to 1990 level,[51]
- the European Commission adopted its new EU Strategy on Adaptation to Climate Change on 24 February 2021 (European Commission, 2021),
- Under Directive (EU) 2018/410 the EU Emissions Trading System (ETS): EU is going to reduce its emissions from the sectors covered[52] by this legislation by 43% (2005 level) by 2030,
- Under Regulation (EU) 2018/842, Hungary will reduce its emissions from sectors outside the EU ETS by 7% (2005 level) by 2030,
- "The efficiency of the EU's final and primary energy consumption is going to be improved by at least 32.5% by 2030 as compared to an historic baseline" (EU, 2020),
- EU is determined of achieving a climate-neutral EU by 2050.

[50] Hungary, and Romania as a member state of the European Union did not submit a separate pledge.
[51] Domestic emission could be achieved directly by reducing emission from housing and electricity in Energy sector and Waste, while indirectly through Transportation, Agriculture sectors (trough purchasing habit change). This pledge does not cover industrial emission, which represents almost one third of the GHGs emission.
[52] In case of carbon dioxide (CO2): "electricity and heat generation, energy-intensive industry sectors including oil refineries, steel works, and production of iron, aluminium, metals, cement, lime, glass, ceramics, pulp, paper, cardboard, acids and bulk organic chemicals and commercial aviation within the European Economic Area. In case of nitrous oxide (N2O): production of nitric, adipic and glyoxylic acids and glyoxal, and perfluorocarbons (PFCs) from production of aluminium" (EU, 2021).

beside these pledges, the EU promotes the shift with fundamental support, legislation, and guidelines. Between 2014-2020, in Europe 2020 (European Commission, 2020),it was stated that most of the changes should take place in cities, while they are the most significant contributors to the GHGs related emission. For that reason, the EU issued initiative such as Smart City Initiative[53], the Community of Practice on Cities, the City Science Initiative and tried to build an urban development network, through Covenant of Mayors for Climate and Energy, Living-in.EU Movement. With the URBAN2030, its target was promoting the SDGs achievement locally (European Commission, 2022). All these required, expected actions were also supported financially, through the European Structural and Investment Funds, or with funds dedicated to programmes like the Urban Innovative Actions (UIA) to test new and unproven solutions, URBACT to promote know-how exchange and development, LIFE, and Horizon 2020 (European Commission, 2022c).

Beside the European Union's joint binding targets, Hungary set the following pledges in its own National Climate Change Strategy 2008-2025 (Magyarország Kormánya, 2008):

- by 2020: up to 16% of alternative energy from total energy consumption and maximum 18% of green energy for energy consumption,
- Reduction by 16% to 25% (1990 level) of GHG emissions by 2025,
- reduce its GHGs emissions by at least 40% (1990 level) by 2030,
- the aim is to achieve climate neutrality by 2050,
- increase the share of renewable energy sources by at least 21% (gross final energy consumption) by 2030 (About Hungary, 2020).

In Hungary, the first appearance of the development logic of 'smart city' was in the 2010-2014 Digital Renewal Action Plan (Nemzeti Fejlesztési Minisztérium, 2010), which follows the logic of the EU strategic framework. It underlined the need of smart metering to introduce the real-time pricing system, smart network to charge electric and hybrid vehicles, smart metering on the consumer side in the electricity system. In 2014 the National Infocommunication Strategy 2014-2020 (Nemzeti Fejlesztési Minisztérium, 2014) was approved and it supports smart city and sectoral application development and

[53] The former European Innovation Partnership on Smart Cities and Communities (EIP-SCC) and "Smart Cities Information System" (SCIS) was merged into one single platform, the Smart Cities Marketplace (European Commission, 2022b).

encourage green IT. Its aim was to launch a separate ICT specific R+D+I program, which support the innovation of marketable products of technology intensive ICT companies. This program was the Digital National Development Program (DNFP) to improve the digital accessibility, economic competitiveness, civil involvement and the efficient of the governance. In 2015, connected to this program two supportive platform was created, the Lechner Knowledge Centre, which coordinate the physical infrastructure development, classification of the public regulation framework and collect the international smart city solutions. The other one is the National Mobil payment Ltd., which elaborate the National Single Card System (NEK) and the regulated electronic administration services. In 2019 the Smart Budapest Framework, while in 2020, the Hungary's Artificial Intelligence Strategy 2020-2030 was created (dr. Dobos, et al., 2015).

Beside the European Union's joint binding targets, Romania set its own targets, with lack of exact measures, in its Integrated National Energy and Climate Plan 2021-2030 (Government of Romania, 2020). They should among others achieve 30,7% of alternative energy from gross total energy consumption by 2030, developing the power transmission grid, thus reaching an interconnectivity level of at least15.4 % in 2030, decarbonise the energy sector, implementing a long-term renovation strategy, developing, and promoting alternative mobility, renewal of the vehicle stock (Government of Romania, 2020).

In Romania, the 'smart city' term was firstly used by the business environment to which the scientific research closed up. As Ibanescua (Ibănescua, et al., 2022) and (Stoica & Ilas, 2009) said, the smart city concept started with analysation digitalization process in e-governance framework. Since 2016, the concepts "intelligent city" and "smart city", according to Ibanescua (Ibănescua, et al., 2022), were used either alternatively or simultaneously and currently, the main focus is redefinitions of smart city concepts between smart projects and smart vision (Bănică, et al., 2020). According to the dedicated projects the adaptation of 'smart city' should be seen as a success. There were 330 projects in 45 cities in March 2019, 594 Projects In 87 Cities in 2020 (Romania Journal, 2020), while this number increased to 860 projects in 124 cities to July 2021 (URBACT, 2021). As Cornel Bărbuț, CEO, Vegacomp Consulting[54] said, smart city is "proving to be an essential help, especially in difficult contexts. Today's technologies and smart

[54] The company, which made the analysis.

solutions are quickly finding new roles, covering new niches, and contributing, more than ever, to our health and safety" (Romania Journal, 2020). Based on the 2021 report (Vegacomp, 2021), Smart Mobility (260 projects), and Smart Governance (220 projects) are in in the top, while Smart Environment (64 projects), and Smart People (37 projects) are in the bottom of the list. Moreover, Székelyudvarhely (Odorheiu Secuiesc) is in the 17th position with 6 projects (3 mobility-1 living -2 governance related), but 3rd in terms of small cities/ settlements. Sepsiszentgyörgy (Sfântu Gheorghe, Sankt Georg) is also in the 17th position with 6 projects (1 economy- 4 mobility-1 governance related).

3.2 The Smart city concept from an empirical point of view

Kecskemét (HU), Tamási (HU), Sepsiszentgyörgy (RO), Székelyudvarhely (RO)

Table 19. provides information of the analysed two Hungarian cities Kecskemét, Tamási, and the two Romanian cities Sepsiszentgyörgy, Székelyudvarhely. These cities were selected, while their significant similarities, in terms of historical and infrastructure background, size (all of them small city, settlement, however the exact extension (km^2) are diverse) and the population number (under 200.000-), and in case of Kecskemét and Sepsiszentgyörgy, their twin-city status.

19. Table: Cities

	Kecskemét	**Tamási**
Size	32000 km^2	112 km^2 (district 1 020 km^2)
Dwellers	109.000 people	8-9.000 people
Strategy[55]	Sustainable Urban Development Strategy - ZöldKecskemét Smart City concept (non-written)	Climate Strategy, Smart City concept (non-written)
Interviewee	Nagy Gábor -Kurenkov Szlava	Széles András
	Sepsiszentgyörgy	**Székelyudvarhely**
Size	72,9 km^2	47,1 km^2
Dwellers	50.000 people	36.000 people

[55] Most of these strategies includes designed projects, which either have exact calculations, estimations to the GHGs emission decrease, or just the environmental outcome are stated.

Description	"city in Transylvania with the largest Hungarian majority"	"the most Hungarian small town", "Székely capital"
Strategy	Smart projects are highlighted in the Integrated Urban Development Plan Climate Strategy is under adaptition	Sustainable Energetic Strategy Sustainable Mobility Strategy Smart City Strategy is pending
Interviewee	Tóth-Birtan Csaba	Jakab Attila

Source: own edition based on the interviews (Nagy, 2022), (Kurenkov, 2022), (Széles, 2022), (Tóth-Birtan, 2022), (Jakab, 2022) and (Erdelystat, 2022)

Gábor Nagy (Nagy, 2022) director and Szlava Kurenkov (Kurenkov, 2022) urban development expert sees, that Kecskemét is in a good position in terms of urban and economic development and resources. Despite, Kecskemét has lot of potential based on its location (natural resources, good logistic location, industrial partners etc.), it can cause serious difficulties in terms of infrastructural facilities (water, waste management, energy supply). Other challenges are the increasing number of inhabitants, who requires more housing opportunities, which decrease the arable land, and the housing became more expensive. Thus, there are greater pressure in the urban mobility, which faces with traffic jams, lack of parking spots and as a result noise and air pollution.

András Széles (Széles, 2022), deputy mayor of Tamási sees, that Tamási is 'small to be big, and big to be small', which means territorially it is small, but with the other 32 settlements as the centre of the district there are plenty of tasks to manage which for the financial resources are finite. Nevertheless, Tamási is stated in a unique and natural resourceful environment, and the size of the city and the community make it a good testing ground to modelling new solutions.

The Transylvanian (Romania) Sepsiszentgyörgy has Hungarian majority, with around 75% Hungarian, 25% Romanian of its dwellers. It is surrounded with woods and river, and the main economic sectors are the light industry and services (Tóth-Birtan, 2022). One of its strengths, as Csaba Tóth-Birtan (Tóth-Birtan, 2022) deputy mayor said, that it has the local government, which is willing to develop, open and search new opportunities. Secondly, there are Clusters and professional associations in the city, with whom through the good connection the knowledge exchange can promote. Finally, the city has an efficient ability to assert political interests and gain financial resource. While there is no university or collage with technical focus, external partners should be involved, and it results a challenge to find suitable experts.

In case of Székelyudvarhely (Transylvania, Romania), which can be considered as an educational city with 96% Hungarian majority, the former city manager, and current head of the cabinet, Attila Jakab (Jakab, 2022) sees, once the city strength in the community of the local municipality, who are dedicated to find the sustainable and suitable solution for the city problems to become an alternative to the western cities, where people can get the same services in a same quality. As a weakness, he marked the old and outdated underground infrastructure, which makes the adaptation of smart solutions challenging.

During the interview, the participants were asked how they see their role in the climate tackle. Some of them referred to the climate related development of their own buildings as tool to control the municipal own emission and the importance of collecting data as basis of the decisions (Nagy, 2022), (Kurenkov, 2022). Other's point of view can be concluded in four main factors, such as awareness, implementation, sensitization, and community forming (Széles, 2022). In some cases, the appropriate communication is needed, even if the development project core output is GHGs or pollutant emission reduction the city's liveability improvement should be highlighted as well (Jakab, 2022). And finally, the role has been seen as someone who is securing financing of the investment, while soft intervention is needed through the education of inhabitants to increase acceptance of the projects(Tóth-Birtan, 2022).

20. Table: Smart city definition (local government)

Interviewee	Definitions
(Nagy, 2022), (Kurenkov, 2022)	"For us, the smart city is a **reasonable and sustainable use of existing energy sources** and its system. How to **rationally manage our resources**, how to **operate it sustainably**. So, we don't necessarily consider this to be digital, rather we consider it to be life-like. So, if it's liveable, it's logical and someone thought it through."
(Széles, 2022)	"The smart city is the one that thinks."

(Tóth-Birtan, 2022)	It would be described the smart city as the introduction of technical and organizational solutions that make the city citizen-friendly with the help of computing devices and introduce as many solutions as possible.
(Jakab, 2022)	"Those solutions and developments that lead to the smart city should be tried to be introduced in all areas of life. ... in my interpretation, the smart city is about using the technical achievements at our disposal in such a way to **save time, energy and other resources** and thereby make our city more liveable."

Source: own edition based on the interviews (Nagy, 2022), (Kurenkov, 2022), (Széles, 2022), (Tóth-Birtan, 2022), (Jakab, 2022)

The previously presented 'smart city' definitions (Table 20.), which followed mostly the combination of techno- and human-centric approaches, can be modulated. Based on the participants answers, a smart city development is 'smart' if "you have already planned in your mind, in a complex and integrated way, then there will be no surprises afterwards, and of course finding good partners is also part of this. With smart developments, the goal is to have a uniform overview of the development, we do not just develop point by point projects, but put the elements together in time" as Jakab (Jakab, 2022) said. According to Tóth-Birtan (Tóth-Birtan, 2022) , "it implements a city management service by using and involving IT devices with a very wide community spread, with the widest possible involvement and reach of the population, because this way it can on the one hand, get data on the behaviour of the city's residents, on the city's development proposals, and on the other hand, it can provide very easily accessible services provide to the population. ... Smart projects are more aggressively looking for ways to optimize processes by collecting and using data, i.e. **making better use of the possibilities** provided by computer technology. Many things can be accomplished without them, but those who strive for it can definitely work more efficiently". Others think that the use of (ICT)tools, operational control systems beside the **economic efficiency should lead to long-term sustainability**, which could be seen the solution. By other words, **Sustainability**, economic efficiency, and effectiveness (Széles, 2022). Based on Nagy and Kurenkov (Nagy, 2022), (Kurenkov, 2022) "Smart development is the result of a system-level thinking and analysis. It should be **self-sustaining**, and at the same time can have a positive impact on the city and its liveability and should form the dwellers' consciousness as well." Furthermore, based on the given answers of the cities' representatives, a smart city solution can be implemented both in hard (more technical subsystems) and soft (more social oriented subsystems) fields. The main hard fields were the energy with resource utilization, street light systems, heating, and buildings, and the mobility sector. As a health and safety related ones were the air quality and water management. While the soft ones were the governance (public services), education (sensitization and consciousness) (Table 21).

21. Table List of smart solutions (local government)

HARD	SOFT
Smart pedestrian	"Alfréd" AI based chatbot – information supporter
Smart parking sensor system	e-governance solutions
Smart street lighting system	Interactive municipality budget planning
Smart selective waste collection	"Szólj bele"
e- charging	"Láb-busz" / "Cycle to work"
e-bus	e-tour guide
Traffic management system	City card
e-ticket system	Smart toilette
Smart metering	
Geothermic heating system	
Biomass heating system	
Smart building	
Solar cells	
Rain-water management	

Source: own edition based on the interviews (Nagy, 2022), (Kurenkov, 2022), (Széles, 2022), (Tóth-Birtan, 2022), (Jakab, 2022)

The participants were asked, what the main factors were during the decision-making process of the smart projects and divers answers were formed, but economic efficiency was always a key and dominant aspect:

- make the city more attractive and liveable, and during the **energetic and heating development climate related priorities** (Jakab, 2022);
- urban development and financial factors (Tóth-Birtan, 2022);
- economic efficiency based on cost-benefit analysis, the **aim is to save** and be efficient (Széles, 2022);

- resource-driven developments and **environmental protection through sustainability** (Nagy, 2022), (Kurenkov, 2022).

The environmental perspective usually stated as the second or umpteenth most important factor, while the economic efficiency dominates the decisions. All the investments should be cost-efficient, while this is the main factor in terms of self-sufficiency and savings in the long run. In some cases, (Széles, 2022), economic pressures may force the environmental factor to come to the fore. In spite of that, environmental perspective is appearing, although just as an EU regulatory requirement within all the projects, which are financed by EU funds, they should have contained calculations in feasibility studies / tenders related environment (GHGs emission, energy savings, etc.). Beside this, some of the cities are omitted to the climate related consciousness, and in those of them have either specifically Climate strategy (Tamási, Sepsiszentgyörgy) or related strategies such as Sustainable Urban Development Strategy (Kecskemét), Sustainable Energetic Strategy and Sustainable Mobility Strategy (Székelyudvarhely) or Integrated Urban Development Plan (Sepsiszentgyörgy). Additionally, some cities such as Tamási (Széles, 2022), the associated CO_2 savings are calculated for each smart development, or expert estimates are available in the absence of accurate measured data, (Nagy, 2022), (Kurenkov, 2022),

Beside the local government (investors, or some cases users of the solutions), experts from different fields were asked to contribute the examination. According to their knowledge smart solutions were seen as good direction (Lovász, 2022) to the necessary information, which should be available at the appropriate time, place, and manner (Barsi, 2022) to make decisions.

22. Table: Smart city definitions (experts)

Interviewee	Definitions
(Németh, 2022)	"I call it a smart solution that goes beyond the solutions of the human brain. That is, what man is no longer able to determine and is beyond man's field of vision. That's where smart solutions come into play to expand human intelligence.

(Barsi, 2022)	“I have a system-level vision for this, a system of tools that ensures the **most effective intervention** based on measurements and software analysis.”
(Lovász, 2022)	“**Minimizing wastage** is the primary goal and main motivation, and it provides an alternative.”
(Mikulák, 2022)	“I adhere to the concept defined based on the Lechner Knowledge Center, i.e.: A smart city is a settlement or group of settlements that **improves its natural** and built **environment**, digital infrastructure, and the quality and economic efficiency of the services available in its area by using modern and innovative information technologies, **in a sustainable manner**, with its residents involvement. (Rab & Szemerei, 2018)”
(Sugár, 2022)	“It is not because of the technology that something becomes Smart. Although, because it offers a truly smart solution to a real problem. You don't necessarily have to look for salvation in technology. In the past, there were "Smart" solutions that were built on common sense or **natural laws, chemical and biological relationships** and managed the challenges through this.”
(Sarkadi, 2022)	5G technology is the basis. Anyway, when we connect our devices to a system and **optimize energy use to achieve a very significant energy reduction**.

Source: own edition based on the interviews (Lovász, 2022), (Barsi, 2022), (Németh, 2022), (Sugár, 2022), (Mikulák, 2022), (Sarkadi, 2022)

Table 22. summaries the experts’ definitions about smart city, which can further detail. According to Balázs Németh (Németh, 2022), a smart solution, can work with the data and analyse it so intelligently that it comes to results and solutions that we as humans would not have been able to calculate. Thus, a smart development project goes beyond “how we do things”. It tries to introduce technological solutions and innovations into urban development that fundamentally change how we do urban development, it changes “the way we do things”. As Orsolya Barsi (Barsi, 2022) said, the application of digital tools, data-based planning, modelling, also smart and digital end result on the solution

side, makes a project ‘smart’. It is also important to socialize it, to involve as many people as possible, which is important for acceptance, and to provide solutions for what is needed. In case of the smart development project more detailed preventive examinations, feasibility study, are performed. Líviusz Lovász (Lovász, 2022) added, smart solution should communicate with other people or devices. From the large amount of data, they can draw conclusions that 1-1 devices or people would not be able to see or use, and according to these real-time data they optimize operation/solution/providing alternative to decision. As Péter Sarkadi (Sarkadi, 2022) sees, in any case, smart city solution is based on a rapid flow of information and continuous feedback, and the long-term thinking, along certain basic principles, should have already appeared during planning. According to Péter Mikulák (Mikulák, 2022), smart solutions are a set of IT solutions, which through the use, increases efficiency in everyday life. Two types of smart city development are distinguished, which have welfare and social benefits, e.g., a smart zebra, smart pad. For these developments, it is difficult or more difficult to quantify the savings and "returns". The other category is when a development has a direct economic impact, e.g.: modernization of public lighting or the use of geothermal energy sources for heating purposes. In these cases, we see exactly the economic indicators of the operating costs appeared before and after the improvements.

Beside Mr. Mikulák distinguish, the experts see the smart solutions added value in both the hard and soft fields. The soft ones are resident engagement, better communications platform, elimination (or reduction) of bureaucracy, inclusion, cultural life. In terms of the hard ones, there were waste management, energy supply, rain-water management, emergency management, mobility – traffic management system, heating systems, health.

Those experts, who has been worked on or with smart solution development were asked, what the main factors were during the decision-making process of the smart projects. Primary cost-benefit principle and legal regulations were mentioned by Barsi (Barsi, 2022), while Németh (Németh, 2022) mentioned mainly financial factors. However, they are both working on that environmental weighting should also be part of the decision, but they are facing with the question like, “how you measure the value of a ‘tree’[56]”. According to Sugár (Sugár, 2022) these solutions are all business based, hard to find one

[56] just an example of the author.

that is based purely on social utility or environment and does not prioritize profit. However, there would be a need for solutions where, for example, environmental protection would come to the fore, not profit.

Finally, the supplier side were asked to contribute the examination. According to their knowledge (Table 23.) of smart solutions as Levente Csenteri (Csenteri, 2022) said, just the implementation of an IT solution is a 'fake smart' thing. It should increase efficiency and needs smart people during the planning process. As Attila Imrei (Imrei, 2022) stated, Smartness should not be self-serving, it should have an **utility** that can be measured and also be demonstrated on the cost side. These technological innovations could take the burden off the person, it should provide an organized process without any human intervention. Based on Alfréd Szűcs (Szűcs, 2022) answers, these solutions should result economic efficiency, increasing effectiveness and well-being. According to Csaba Ilcsik (Ilcsik, 2022), smart solutions have two main elements: once they are measure, collection processing data on site, secondly the smart tool should also be able to make decisions based on the received data. While the data become information if it has its own context. Based on Csaba Kocsis, for the widest possible range of data and the aim would be necessary to **improve living conditions** and cost efficiency (Kocsis, 2022). As László Mátyus (Mátyus, 2022) added, a smart intervention is relying on different kind of measurement or info communication tool, it is always an extra step beyond the traditional approach to improve efficiency.

23. Table: Smart city definitions (vendor)

Interviewee	Definitions
(Csenteri, 2022)	"The smart city concept has become quite a fashionable concept, which behind not everyone understands the same thing. According to my understanding, it is a certain digitization, or developments in the IT direction that result in efficiency."
(Imrei, 2022)	"**Application of tools in an environment** and a specific target system".
(Szűcs, 2022):	"This concept is based on data collection, and it is an important element of a **sustainable** city,

	settlement, and environment. It is also core, that we are talking about controlled, supervised, and coordinated systems.”
(Ilcsik, 2022).	“Everything in the city can and should be measured and optimized.”
(Kocsis, 2022)	“We will measure everything, analyse everything, make everything decision-based that affects the **urban living environment** and operations. This requires independent sensor networks, and the data from them must be analysed and decisions must be made based on them … The idea of whether or not it works is what makes something smart.”
(Mátyus, 2022).	“Optimizing efficiency by relying on ICT, it is very important to aim for quality-of-life improvement. A lot of data is generated on which quantified decisions can be made. Forming an attitude is a part of all of them, and communication and the totality of these are essential. A smart city cannot exist without smart residents, and a large part of this is attitude formation, so relying on tools alone is not enough.”

Source: own edition based on the interviews (Csenteri, 2022), (Imrei, 2022), (Szűcs, 2022), (Ilcsik, 2022), (Kocsis, 2022), (Mátyus, 2022).

The vendors point of view about concept of ‘smart city’ is the most ICT based, techno-centric approach. According to them, a smart solution can be used during data collection, such as smart metering, in fields like energy, heating, lighting system, pollution, health, safety. In the same time, the importance of the soft tools through education and increase of well-being as the final consequence of the developments have been mentioned.

In terms of the inhibiting factors during the implementation of an innovative, smart solutions, the following answers were given:

- the data is not availably currently which is the bases of the future decision or intervention (Nagy, 2022), (Kurenkov, 2022),
- macroeconomic changes, unpredictability (Széles, 2022),
- technological difficulties to create/innovate and not sell (Széles, 2022)
- city dwellers not always open and inclusive attitude (Tóth-Birtan, 2022),

- local infrastructural difficulties (Tóth-Birtan, 2022),
- financial limitations (Tóth-Birtan, 2022), (Jakab, 2022), (Barsi, 2022),
- human resource deficit (Jakab, 2022),
- integration of open and closed source code systems (Jakab, 2022),
- the main factors are safety and security, which makes hard to change (Németh, 2022),
- big rejection, "that's not how we used to do it" (Barsi, 2022), (Németh, 2022),
- there is a big gap in terms of knowledge, experience, tools (Barsi, 2022),
- there is no adequate operational background (neither human nor financial) (Sugár, 2022), (Mikulák, 2022),
- fitting a new system to an older, existing one is usually more expensive than installing a new one (Imrei, 2022).

On the other hand, from the vendor prospective the obstacles are the lack of openness or innovative approach in the user side (Szűcs, 2022), the relevant administrative burdens (e.g. public procurement) connected to the developments, and the users often have just intention without knowledge or idea about the needed solution (Csenteri, 2022). Even if the first step is taken, e.g. sensors, and we measure a lot of things, we do not deal with the use of the measurement results (Ilcsik, 2022). This can be seen as waste of opportunities.

Based on (Albino, et al., 2015) and (Kim, 2022) in the past, 'smart city' term represented ICT based urban infrastructural development, which shifted to a more service-based approach with complex operational and maintenance challenges. While the cities understand the opportunities within the ICT and their exposure to challenges, the companies should provide divers services, tools and open to innovative cooperation to improve their skills to give suitable solutions to various needs. These previously rarely merged research areas, such as smart solutions application in tackling climate, environmental motivation guided development and "case study" based corporate innovations. In practice, while the final users, investors prefer demand driven innovation (Nagy, 2022), (Kurenkov, 2022), but they find the multinational vendors are more rigid, although the developer side is open to personalised solutions, which fits to the city' needs and environment (Széles, 2022). There are some cases, when the partners are slow and reclusive to avoid the investor (Barsi, 2022). At the end, the interests of the companies prevail and transform the market (Sarkadi, 2022), where a lot of unavailing "solutions" are (Ilcsik, 2022), which distract the investors. These dominating companies' sales are seen strong and see the smart development projects mostly support driven (EU or national funds) instead of a thoroughly designed concept (Imrei, 2022), but the decision is still in the investors hand (Tóth-Birtan, 2022).

Accordingly, there are four ways in terms of smart solution investment. Once, it can be achieved according to preliminary studies, return calculations and implementation plan[57]. The other way is participating in international projects to booth knowledge exchange (Barsi, 2022) or collaborate with academic, business and governmental stakeholders (Fehér & Boros, 2020), another one is when a temporary solution must be chosen due to necessity (Mátyus, 2022). Finally, if the current system is functional and effective on a market basis, there is no motivation to search a smart solution alternative (Lovász, 2022).

Finally, the cities' representatives, experts and vendors were asked to rank their or the cities challenges. According to their answers (Table 24.)[58], the expert and the cities' representative, with different order, but find two problems as significant as the dwellers (answers source: questionnaire), while the vendor sector give the exact same answers. In term of the smart solutions relevance to these challenges the cities' representatives sees the biggest added value of the smart interventions regarding to **pollution** (air, water, waste, noise, thermal**), energy supply**, and **GHGs emission**, in case of the expert the list was **pollution**, **wate management** and **ecological footprint of the commute**. While the vendors ranked the biggest value added of the smart solutions in **energy, pollution** and **waste management** related problems. However, the cities' main problems are not equal with those problems, according to the interviewees, where the smart solutions can be adapted in the most efficient way, the highlighted four areas, pollution- emission, energy supply, waste management and mobility, are those fields where already has been adapted smart solutions and in an (in)direct way contribute to the climate tackle.

[57] In CEE countries, it is common to focus on the urban issues in the present instead of the implementing a complex, long-term smart development strategies (Borsekova & Nijkamp, 2018).

[58] During the ranking, relative frequencies were calculated as percentage (f/N)*100.

24. Table: Urban challenges

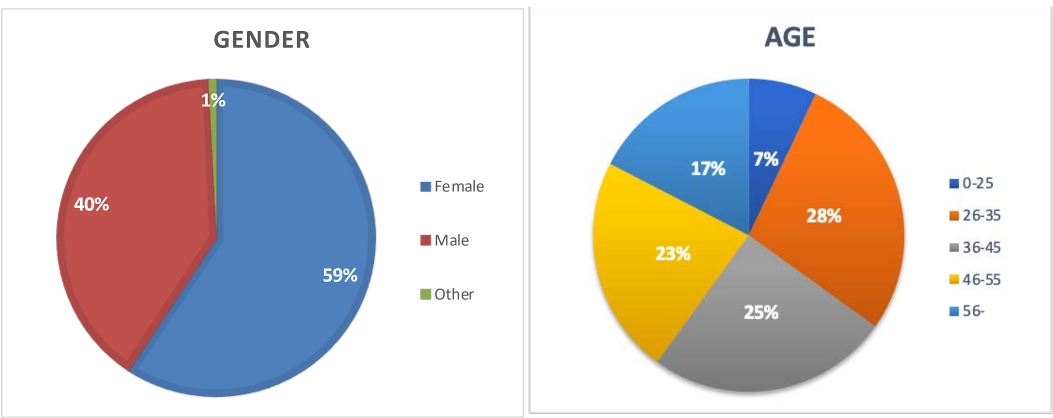
RANK	GOVERNANCE	EXPERT	VENDOR	DWELLERS
1.	More frequent heat waves (**heat island effect**)	Powerful urbanisation	Notable **pollution** (air, water, waste, noise, thermal)	Notable **pollution** (air, water, waste, noise, thermal)
2.	Lack of affordable housing	More frequent heat waves (**heat island effect**)	More frequent heat waves (**heat island effect**)	More frequent heat waves (**heat island effect**)
3.	Notable **pollution** (air, water, waste, noise, thermal)	Notable **pollution** (air, water, waste, noise, thermal)	Intensive **land consumption**, lack of green spaces	Intensive **land consumption**, lack of green spaces

Source: own edition based on the interviews

3.3 Citizen questionnaire on 'Smart city' related knowledge

The object of the chapter is to present the data collected from the bilingual online questionnaire to once answered the following questions, what are the most common challenges of cities according to the citizens, how deep is the general knowledge about smart city and what smart solutions exist and known. Accordingly, can the city dwellers climate awareness increase through adaptation of diverse smart solutions.

19. Figure: Sample composition

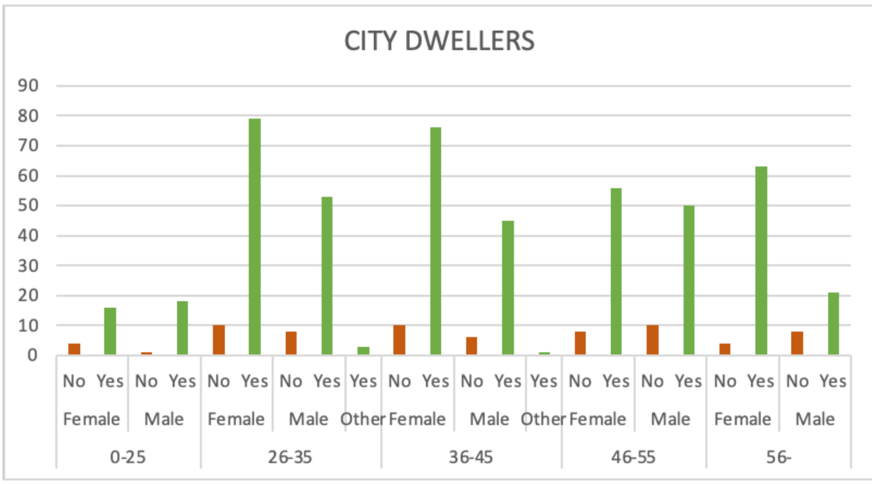


Age	Female	Male	Other	SUM
0-25	20	19		39
26-35	89	61	3	153
36-45	86	51	1	138
46-55	64	60		124
56-	67	29		96
SUM	**326**	**220**	**4**	**550**

Source: own edition

Based on Figure 19., and the previously presented ratio of the respondents (in Table 17), it can be stated that the survey mostly reached female respondent, while the number of female respondents was higher in every age range and in general. This female dominance did not change by adding a new factor, "Q1- *Do you live in a city? If Yes, in which one?"*, in the analysis (Figure 20).

20. Figure: Division of City Dwellers



Source: own edition

The respondent 14,35 % were not city dwellers and for that reason they were excluded from the following observation categories such as city challenges, accordingly the sample size narrowed down to Female: 290, Male: 187, Other: 4 out of N=481, which means 60,29 % female and 38,88% male and 0,83% other. Further 34 (7,07%) respondents did not provide information about their cities but all of them answered for their cities' challenges.

25. Table: Division of City Dwellers by gender, age, and city

	Female					Female SUM	Male					Male SUM	Other		Other SUM	SUM
In City	**0-25**	**26-35**	**36-45**	**46-55**	**56-**		**0-25**	**26-35**	**36-45**	**46-55**	**56-**		**26-35**	**36-45**		
Aichach			1			1										1
Ajka		1				1										1
Amsterdam		1				1										1
Austin, Texas								1				1				1
Baja										1		1				1
Balatonfüred			1			1					1	1				2
Bécs		1				1										1
Békéscsaba								1				1				1
Brussels					1	1										1
Budakalász	1					1				1		1				2
Budaörs		1	1	1		3		1		1	1	3				6
Budapest	9	56	55	38	50	208	10	35	25	29	12	111	1		1	320
Bugyi													1		1	1
Debrecen					1	1										1
Dunaharaszti				2		2										2
Dunakeszi			1			1		1	1		1	3				4
Dunaújváros							1					1				1
Eger		1				1	1		1			2				3
Érd				3		3			1		1	2				5
Fót				1	1	2	1					1				3
Gödöllő		1				1				1		1				2
Gyál									1			1				1
Gyömrő									2			2				2
Győr				1		1				1		1				2
Hajdúszoboszló								1				1				1
Halásztelek				1		1				1		1				2
Heerlen									1			1				1
Hódmezővásárhely							1					1				1
Innsbruck									1			1				1
Kaposvár									1			1				1
Kecskemét	1					1		1	1			2				3
Kisköre							1					1				1
Kiskunlacháza	1					1										1
Komárom			1	2		3										3
Kottingbrunn (Ausztria)									1			1				1
Lisbon								1				1				1
Luzern											1	1				1
Marosvásárhely								1				1				1
Miskolc	2	1				3										3
München								1				1				1
Nagytarcsa					1	1										1
New York								1				1				1
Not filled		4	7	3	6	20	1	1	3	5	3	13		1	1	34
Nyékládháza							1					1				1
Nyergesújfalu		1				1										1
Nyíregyháza										1		1				1
Pécs		2	1			3	1		1	2		4				7
Philadelphia	1					1										1
Pomáz	1		1	2		4										4
Quispamsis New Brunswick. Canada					1	1										1
Sepsiszentgyörgy				1		1										1
Sopron			1			1				2		2				3
Sülysáp								1				1				1
Szeged		3			1	4		2	1			3				7
Székesfehérvár								1				1				1
Szentendre		1				1				1		1				2
Szigetszentmiklós									1			1				1
Szolnok										1		1				1
Szombathely										1		1				1
Tata		1				1		1				1				2
Tatabánya									1			1				1
Üllő		1			1	2		1	1		1	3				5
Vác								1				1				1
Várpalota		1				1										1
Vecsés			2			2										2
Veresegyház			1			1			1	1		2				3
Veszprém		1	3	1		5				1		1				6
Washington, DC		1				1										1
Winnenden													1		1	1
SUM	**16**	**79**	**76**	**56**	**63**	**290**	**18**	**53**	**45**	**50**	**21**	**187**	**3**	**1**	**4**	**481**

Source: own edition

In Table 25. an elaborated analysis is presented about the share of the respondents by age and gender based on their city. The TOP 3 answers came from the female dwellers of Budapest first one is the 25-35 age range, that followed by the 36-45 one, and the third is the 46-55. Beyond the answers of Budapest participants (all of them were 320), the most answers came from Szeged - Pécs (each of them 7-7), Veszprém - Budaörs (6-6), Érd - Üllő (5-5), Pomáz - Dunakeszi (4-4), Eger-Fót-Kecskemét-Komárom-Miskolc-Sopron-Veresegyház each of them provided three answers.

Based on the literature (Meadows, et al., 1972), (United Nations, 1987), (United Nations, 2012), (OECD, 2010), (UN-Habitat, 2011), (Revi, et al., 2014), (UN-Habitat, 2020), (Kocsis, et al., 2016), (Kovács, et al., 2017), 11 areas were identified as urban challenges and examined in our target. The participants were asked to mark all the problems they have experienced in their city to see what they consider as "challenges".

26. Table: Urban problems according to the participant perceptions

Powerful urbanisation	208
Intensive land consumption, lack of green spaces	309
Intensive dependence on Hinterland (agriculture, forestry, mining)	157
Notable pollution (air, water, waste, noise, thermal)	331
More frequent heat waves (Heat Island effect)	314
Security of energy supply	33
Lack of affordable housing	267
No improvement and/ or maintenance of the urban infrastructure	239
Inadequate waste management	148
The ecological footprint of commute	170
Significant greenhouse gases emission (electricity, transportation, heating, buildings etc.)	143
There is no problem in my city	18

Source: own edition

The most important challenges viewed by the respondents (Table 26[59]) is the notable pollution, the heat island effect, and the intensive land consumption. The problem of urban infrastructure is regarded quite considerable, thus the ratio almost reached 50% (it was 49,69%) based on the sample. The participants put the least emphasis on the problems of the energy supply, and placed the Mobility (number of cars, traffic jams, quality and frequency of the public transportation, commute time) and Safety (public security, problem of homelessness) challenges at the end of the list. The water management in terms of quality and supply of water and the physical, mental health of inhabitants (aggression) were also added to the list a few times.

Besides the evaluation of the current challenges of the cities, the participants were asked to determine the type of development, which would be essential in their cities, settlements. Out of the 362 interventions, which were suggested by the participants, the most dominant area was green space related wishes and suggestions, which has strong connection with the third urban challenge, and that followed just the mobility (mainly public transport related), and infrastructural ones, such as:

- ☐ Green space: more green spaces, parks, drinking fountain facilities in them, tree planting;
- ☐ Mobility: through less car, diverse transportation facilities, parking system improvement, development of bicycle paths, more extensive suburb, and night transport system;
- ☐ Infrastructure: development of the pedestrian way, public road, bicycle paths, less pothole
- ☐ Housing: public housing developments;
- ☐ Building: restriction on what, where, which purpose;
- ☐ Living: dog poo management, cleanness in the public spaces, public (recycling) dumpsters, public toilets;
- ☐ Environment aware: energy-saving home renovations, green energy use.

After the detailed discussion of the urban challenges and needed interventions, it was asked whether the participants had heard the term "smart city" and how they consider

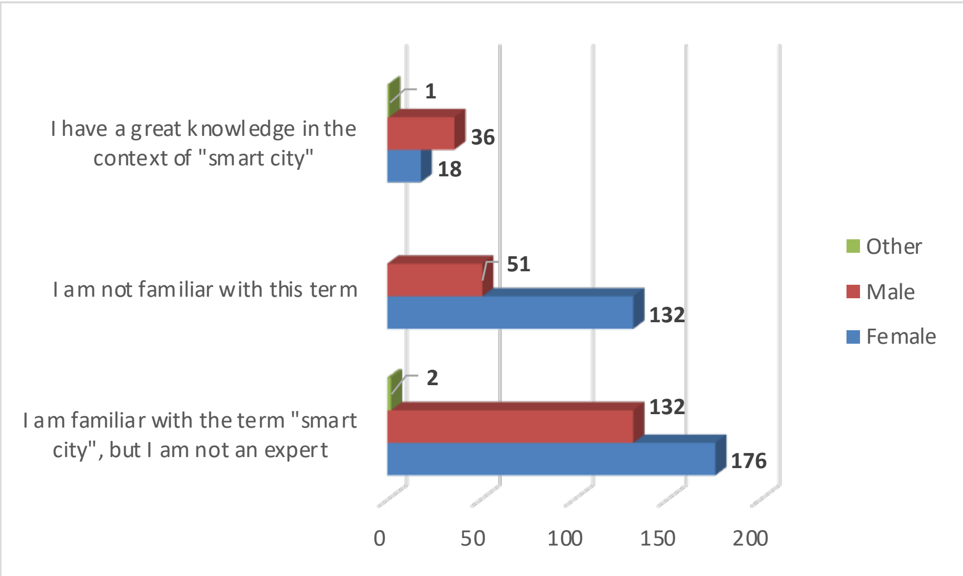
[59] Red- often marked as an existing challenge, Orange- at least half of the participant choose, Green- less then 50% of the respondents picked it.

their knowledge about it. It was expected that the responses will include some "compulsion to comply" based on Molnár's work (Molnár PhD, et al., 2021), and for that reason three statements were formed, and it was asked, which one is true for the respondent:

1. **"Which statement is true for you?"**
   A. "*I have a great knowledge in the context of smart city*" – considered as aware of the term.
   B. "*I am familiar with the term smart city, but I am not an expert*" – considered as they might have heard or know
   C. "*I am not familiar with this term*" – considered as they do not know the term.

All the 550 participants had been asked whether they familiar with the term 'smart city' (Figure 21). Two of them gave non-related answers, but 310 out of the 548 people, more than half of them (56,57%), considered themselves as who are familiar with this term, 183 people, around one third (33,39%), were not familiar with this term at all. Finally, 55 people (10,04%) consider themselves, who have great knowledge about the concept.

21. Figure: Which statement is true for you?



Source: own edition

Although no significant relationship was demonstrated (Chi-Square=3.239; P=0.082) in Molnár's work (Molnár PhD, et al., 2021, p. 15), in this research the relationship can be seen significant (Chi-Square= 28.2185; p-value is < 0.00001, the result is significant at p < .01) between gender and knowledge of the term "smart city". Despite of in Molnár's study, in which more men (70.6%) seem to know the term than women (63.3%), in this analysis (Table 27.) more women were familiar with the term 176 (32,29%) compared to 132 (24,22%) men, but more men, 36 (6,61%) had great knowledge than women, 18 (3,3%). All in all, 194 (35,60%) women and 168 (30,83%) men had any knowledge about "smart city".

27. Table: Do you know any example for a smart solution / innovation? (Local – Global)

Statement	No	Yes	SUM
I am familiar with the term "smart city", but I am not an expert	239	71	310
I am not familiar with this term	177	6	183
I have a great knowledge in the context of "smart city"	25	30	55
SUM	**441**	**107**	**548**

Statement	No	Yes	SUM
I am familiar with the term "smart city", but I am not an expert	246	64	310
I am not familiar with this term	176	7	183
I have a great knowledge in the context of "smart city"	29	26	55
SUM	**451**	**97**	**548**

Source: own edition

As regards the smart solutions, the respondents 19,53% declared that they know a local 'smart solutions', while 17,7% of them would be able to identify a solution in a global level. An interesting outcome is that 6 people said they know local and 7 people know global smart solution despite the fact they are not familiar with the "smart city" term. Out of these 107 people, just 104 could list at least one smart solution, while in case of the global level out of 97 positive answers, just 5 could not contribute to the smart solutions examples collection. These examples will be presented in the 3.4 Chapter – Collection of smart solutions, beside the examples gained from the semi-structured interviews and own research.

It can be stated that the most frequently mentioned smart solutions were different sharing vehicles (car, bike, scooters, rollers), smart bench, smart pedestrian crossing, parking apps, and e-ticket and smart traffic management systems. These solutions (Table 28.) contribute mostly to the individuals' utility (bench, parking app, pedestrian crossing), while the environmental related solutions were mentioned significantly less. They were the solar panels/cells, tools which support the use of renewable energy resources.

28. Table: Distribution of smart solution types

Solution Type	Frequency	Percent	Cumulative %
ENV	13	2.4	2.4
IND	53	9.6	12.0
BOTH	78	14.2	26.2
NONE	400	72.7	98.9
OTHER	6	1.1	100.0
TOTAL	550	100.0	

Source: own edition

Out of the 13 environmental related examples (Table 29., total in Appendix 10.), four (the most) were received from city dwellers, at least 56 years old women, who consider themselves as non-familiar with the term of 'smart city', but can describe a smart solution. This group is followed with three examples by those 36-45 years old female city dwellers, who are also not familiar with the term, despite this, they can still set an example. In case of the solutions with individuals' utility focus, they came (six – the most) from those female city dwellers, who are also not familiar with the term, but can describe a smart solution and their age is between 26-35 years, which is followed with 4 given examples the 26-35 years old female city dwellers, who are familiar with the term of 'smart city' and can give an example. According to those given answers, which conclude both environmental and individual example, the most answers (eight) came from the 'not familiar' group (four out of five cases). In this classification, the male participants are dominate, while the most answer (8) came from 26-35 years old, male city dwellers, who can give an example, even though they consider themselves as 'non-familiar'. Finally, this is the category, where the self-proclaimed experts' answers were significant (6), in the 46-55 age range.

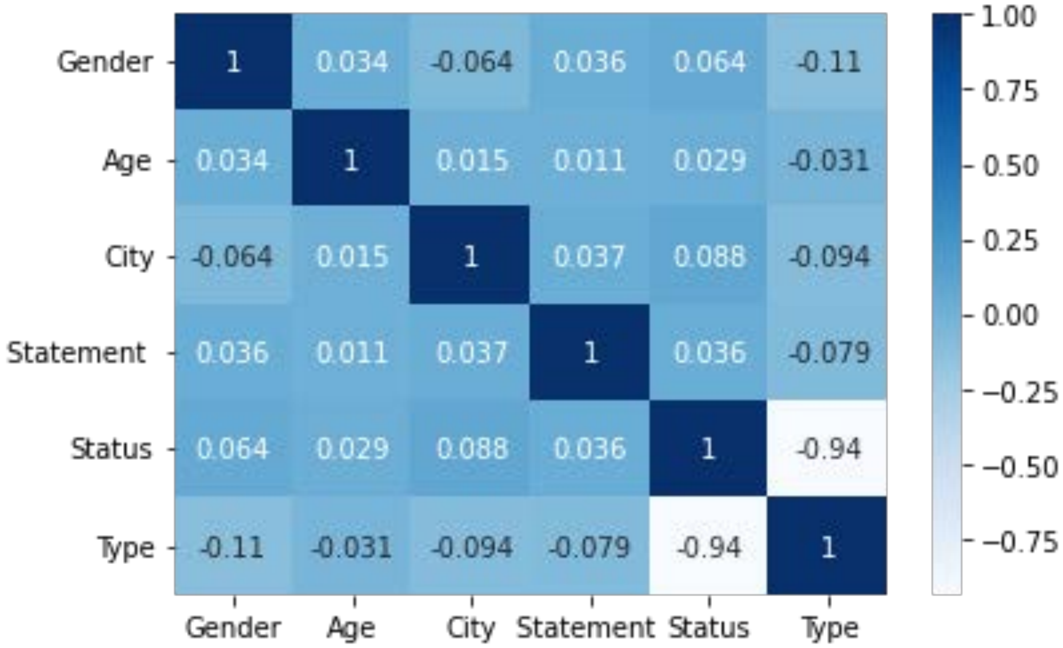
29. Table: Distribution of smart solution types

	Both	Env	Ind	None	Other
City dweller	**75**	**11**	**47**	**343**	**5**
Expert	**24**	**1**	**10**	**12**	**3**
46-55	**7**	**0**	**4**	**1**	**1**
Male	**6**	**0**	**2**	**1**	**0**
Yes	6	0	2	0	0
Familiar	**2**	**0**	**9**	**150**	**0**
26-35	**2**	**0**	**5**	**34**	**0**
Female	**0**	**0**	**4**	**25**	**0**
Yes	0	0	4	0	0
Not familiar	**49**	**10**	**27**	**181**	**1**
26-35	**14**	**1**	**8**	**52**	**1**
Male	**8**	**0**	**2**	**17**	**1**
Yes	8	0	2	0	1
Female	**5**	**1**	**6**	**35**	**0**
Yes	5	1	6	2	0
36-45	**13**	**3**	**7**	**42**	**0**
Male	**7**	**0**	**3**	**22**	**0**
Yes	7	0	3	1	0
Female	**6**	**3**	**4**	**19**	**0**
Yes	6	3	4	0	0
46-55	**12**	**1**	**8**	**37**	**0**
Male	**7**	**0**	**3**	**18**	**0**
Yes	7	0	3	0	0
Female	**5**	**1**	**5**	**19**	**0**
Yes	5	1	5	0	0
56-	**8**	**4**	**3**	**32**	**0**
Female	**7**	**4**	**3**	**23**	**0**
Yes	7	4	3	0	0

Source: own edition

Although, most of the smart solution examples were received from the city dwellers, they were hard on themselves, as they considered their knowledge deficient in terms of 'smart city' (Table 29). However, they were able to provide 10 environmental cases, 27 individuals' utility driven solutions, while in 49 cases both types were represented in the given answers. The strongest correlation is between the 'status' (can provide an example or not) and the given example 'type', although it is not '1', while there were respondents who claim that they are unable to provide a smart example, but they did. Meanwhile, the other categories show weak relations, and for that reason further characteristics, such as educational level, income, etc., should be involved into the research.

22. Figure: Correlation of the characteristics



Source: own edition

3.4 Collection of smart solutions

The target of this chapter is to provide information about existing smart solutions to increase environmental awareness. Whitin smart economy, governance, people, living groups, positive environmental effects can be achieved through the reduction of (paper-based) administration, teaching materials and related commutes. The environmental relevance in case of the mobility is detailed within the group listing, and the target of the smart environment group is supporting environmental development, awareness, and climate tackle. The solutions, which are listed, were collected from once the participants of the questionnaire, the interviewees of the semi-structured interviews and finally they were results of my own knowledge or research. The compiled cases are divided into six groups, such as smart economy, smart governance, smart people, smart mobility, smart living and smart environment, which follows the previous analyses' structure of the research and based on the category definitions, which were formed by (Lechner Tudásközpont, 2021), (Samih, 2019), (Vienna UT, 2007), (United Nations, 2015b) (Table 14.). Some of the cases have description (while they are mostly systems), some of them are unambiguous, that no further explanation is needed (mostly tools). Within each category an (Q) stands for the outcome of the Questionnaire. Not all the below listed smart solutions have equal utility or environmental influence, but they can be considered as the most commonly available or adapted ones in terms of personal or city users and affects one of the six characteristics of a smart city.

Smart Economy: Those ICT, platforms and services, which support entrepreneurship, innovative ecosystems & spirit, productivity, ability to transform, labour flexibility, economic image & trademarks and international embeddedness (Lechner Tudásközpont, 2021), (Samih, 2019), (Vienna UT, 2007), (United Nations, 2015b).

1. **Online payment systems (Q)** (for parking, public transport ticket/ pass): As an example, a smart parking system with an integrated advance payment system operates in Hévíz, which send a notification if a user forget to pay the parking fee instead of sending a fine.
2. **Integrated app**: where the user with one account can manage their bills, parking fee, or they can buy even their cinema ticket (e.g. Simple).
3. **Distance work facility**: the capability to reach the company's internal system through a secured domain.
4. **Smart banking**: managing financial matters through an app, such as money transaction, money exchange, managing savings, portfolios etc.
5. **Online cashier**: the online cash registers send the collected data from each transaction directly to the National Tax and Customs Administration.
6. **e-Vignette**

Smart Governance: Open, accountable, and transparent governance, opportunity of participation in decision-making processes, existence of political strategies & perspectives. Available public and social services. These elements support by ICT (Lechner Tudásközpont, 2021), (Samih, 2019), (Vienna UT, 2007), (United Nations, 2015b).

7. **EESZT**: National eHealth Infrastructure: "the system is to interconnect the earlier fragmented health care data systems in all of Hungary, and … collect all data in a central system, thus the operating services of the Infrastructure would allow the various treatment locations to access the necessary information" (EESZT, 2022).
8. **Cloud based electronic receipts (Q)**

9. **‘Client Gate’**: a system providing a platform for its users with electronic identification to connect with Hungarian State Organizations to manage electronic administration services.
10. **E-SZJA**
11. **Community budget (Q)**: as one of the participants of the questionnaire stated, “city districts hold "townhalls" for the people, who are living there, can submit their own idea as well as discuss proposed new projects for their neighbourhood”. It works in Budapest (Budapest Fővárosi Önkormányzat, 2022a), the 13. district in Hungary (XIII. kerületi Önkorményzat, 2022), and in Székelyudvarhely, Romania (Jakab, 2022) as well.
12. **Online community consultation (Q)**: (Budapest Fővárosi Önkormányzat, 2022b)
13. **Real-time, transparent community Budget**: increase transparency and the city expenditure can be observe, while the optional mis-estimation could turn out and improve future process (Jakab, 2022).
14. **City card**: an opportunity which can be used for several things and can be integrated to tourism with information and discounts, into public transport system, or workplace attendance, or it can take out the admission ticket of cultural facilities etc (Nagy, 2022).
15. “**The virtual civil servant**”, alias Alfréd: this chat-bot works with AI, developed by the staff. It helps to calculate the annual tax of a car or a building, also informs you about local events and alerts regarding the weather (Jakab, 2022).
16. **Intelligent metering system**: automatic send the collected data about measured consumption without any human resource need (Ilcsik, 2022).
17. **Intelligent geospatial information platform**: This technology uses a metering tool, a high-performance computer to the processing and a software to monitor, control the measurement and visualise the collected data. This technology can locate traffic signs, manhole covers, drainage and street furniture and can map illegal landfill sites (INTERMAP, 2022).

Source: (INTERMAP, 2022)

Smart People: Promotion of lifelong learning, creativity, flexibility, open-mindedness, participation in public life, higher level of qualification through education development and social and ethnic plurality (Lechner Tudásközpont, 2021), (Samih, 2019), (Vienna UT, 2007), (United Nations, 2015b).

18. **Living Labs**: Aspen in Wien, Ijburg in the Netherlands (dr. Dobos, et al., 2015), Debrecen – Sopron in Hungary.
19. **Open data source**: a system collects open data of governments as to boost available knowledge by providing available real-time data, an example Smart CitySDK (de Pater, 2016).
20. **Remote monitoring of the elderly's life and needs** (Széles, 2022)
21. **Digital totem**: it is usually used for mostly advertising purpose. Beside this, it can be used to educational targets thanks to the touchscreen to develop movement and logic skills.
22. **Smart metering**: the end users can monitories their energy, water consumption.
23. **Online courses, Distance learning**
24. **Online available library service:** such as the Repository of the Academy's Library or the online library of the Metropolitan Ervin Szabó Library.
25. **Interactive / online exhibitions**
26. **Mental health apps**
27. **Food waste reduction through app**, which connects the different stakeholder (restaurants, delivery, costumer) such as Munch (Q)
28. **Education:** projects, which target is to sensitize the citizen, increase climate awareness. Projects like, "Foot bus", "Cycle to work". (Tóth-Birtan, 2022)

Smart Mobility: Sustainable, innovative, safe transport system and service centred transportation development. Local, (inter)-national accessibility. Promotion of non-motorized and public transportations by complex ICT solutions and connected infrastructural network (Lechner Tudásközpont, 2021), (Samih, 2019), (Vienna UT, 2007), (United Nations, 2015b).

29. **Advanced driver assistance technology**: from front-crash prevention systems, blind-spot detection, lane departure prevention, parking assistant etc. to the Self-driving car (D'Allegro, 2022), (Varga & Tettamanti, 2016). All to make the driving safer and less dependent on the reaction time of the driver.
30. **EV charging infrastructure (Q),** (Imrei, 2022)**;**
31. **Smart Parking (Q):** with the help of this app, you can see and easily find the available parking spaces. There are plenty of solution with cameras or with sensors to identify the free spaces, but it is crucial to find the best solution and the suitable place, where this smart solution potential can utilize (Jakab, 2022), (Mátyus, 2022).
32. **Smart pedestrian crossing (Q),** (Szűcs, 2022): there are different providers with slightly different methodology, but the main point is a sensor perceive the approaching pedestrian, and some LED light will turn on to raise awareness of the potentially approaching cars. This system can be extended by lighting facilities, which increase the strength of the lighting, when the pedestrian is coming near.
33. **Smart passenger information system (Q):** is a Real Time Passenger Information (RTPI) system, such as 'Budapest Go' (Nagy, 2022).
34. **Smart Pole:** beside the lamp, it could have charger spot/station, emergency button, information display, air quality and temperature sensors, CCTV and parking lot surveillance, WI-FI hotspot, solar panels, touch panel (Szűcs, 2022).
35. **Self-driven underground (Q)**
36. **Public transport Mobile ticket system (Q): e.g.** BKK e-ticket

The following examples have (in)direct positive contribution to environmental factors, or even climate change tackle, through the reduction of the unnecessary use of fuels (lower GHGs emission), or reduction in terms of vehicles supply surplus (decrease the emission during the production, logistic, maintenance), the use of (questionable) fully or partly renewable energy-based vehicles and the decreased commuting time (emission reduction).

37. **Aviation with AI:** AI usage during aviation to find the best operational measure, which fits to the conditions and the pilot (Németh, 2022).
38. **Sharing system (Q):** sharing cars, bikes, scooters, rollers.
39. **Electrical and cargo bike pool (Q)**
40. **Electric, hybrid and clean vehicles (car, bus etc.) (Q):** they environmental friendliness is questionable by using battery (Krishna, 2021). It seems postponing the change.
41. **Smart traffic management (Q):** a complex controlling over the traffic lights.

Smart Living: Interventions and ICT solutions to boost liveability, safety, housing quality, health, tourism, social cohesion, cultural and education facilities (Lechner Tudásközpont, 2021), (Samih, 2019), (Vienna UT, 2007), (United Nations, 2015b).

42. **Smart building**: case study in Barcelona, where 2767 MWh energy demand reduction could be achieved by every year thanks to the refurbishment (building envelop, efficient lighting, heat pumps (Garrido-Marijuan, et al., 2017).
43. **Automatized lighting and heating/cooling systems (Q)** within buildings through always measuring sensors, to avoid unnecessary energy use. This solution mostly fits to the newly built buildings.
44. Home safety can increase by **smart door, window sensors**, **cameras** which through the related app send a push notification, when it perceives change in the status (open/closed) or in case of the camera person or motion is detected. They usually use battery (non-rechargeable), which is pollutive.
45. **Smart home: Smart LED Bulb**: they are remotely controllable, beside the on and off status the strength of the lighting can be modified. Additionally, the colour of the light can be changed to promote relaxation. **Smart cleaning kit**: such as a robot vacuum mop, which can be controlled through an app, and saves time for the user (Xiaomi, 2022).
46. **Smart bench (Q)**: phone charging and free Wi-Fi on the solar powered smart benches (Kuube, 2022)
47. **Safe bicycle storage (Q):** in the bicycle storage there is an app based locking system to secure your bike (Köki, 2022). However, it locks just your wheel, which is as safe as a normal chain. It would be more useful if the bikes would be stored in a closed "parking place", where you get a number or QR code if you parked your bike there, that you will get back just with that perilously given identifier.

48. **Smart toilet management (Q),** (Széles, 2022): it is accountable, and sends push notifications when the fundamental tools are out of stock or in case of emergency, immediate intervention is needed (Fekete & Zsóka, 2021)
49. **Online ticket booking systems (Q)**
50. **Online streamed concerts, performance and "video on demand":** opportunities (during COVID), such as Netflix, HBO GO, Disney+ (Hanák, 2018)
51. **Online meeting, conference platforms**
52. **Non-contact (thermometer) panel in hospitals**: temperature, mood etc.
53. **Green wall solution (Q):** it is seen as a "sustainable, breath-taking living walls that are easy to maintain, look extraordinary, improve air quality and are kind to the environment" (GreenWall Solution, 2022). However,
54. **Rehabilitation robot**: helps patients to practice repetitive movements (Hanák, 2018)
55. **Support for people with disabilities or difficulties:**'Cimbi' is an app designed by Máté Kondor (MOME, 2020) to those who has communication difficulties (such as people with autism). Furthermore, there are software, which transform sign language to speech or written text (e.g. Microsoft Kinect), or helps in the movement coordination (e.g. Dowell).
56. **Autóőrszem app:** it is a license plate based messaging platform, where users can contact with each other in case of open window, broken tools, etc.
57. **Tourist app: application, which provide detailed information about the most important sightseeing, or guided tours, such as the Hungarian 'PocketGuide'** (PocketGuide, 2022)**.**

<u>Smart Environment</u>: Sustainable natural resource management, water and waste management, use of renewable energy sources and energy efficiency, air pollution decreasing, promoting climate change adaptation ability (Lechner Tudásközpont, 2021), (Samih, 2019), (Vienna UT, 2007), (United Nations, 2015b).

58. **Green energy**: solar cells, solar panels, wind power station, and innovation uses sand (Limb, 2022)
59. **Smart street lighting**: LED lamp posts as bases for (air)sensors, Wi-Fi, but most importantly these laps can be controlled remotely and one-by-one, immediate intervention can be made, and the lamps' luminous intensity can be modified (Széles, 2022). Through the change of 1.445 pieces of old public lightnings to new

LED streetlights, the nominal energy use dropped by 40-50 percent, and 10-15 percent drop could be achieved by the control over the luminous intensity (Fekete & Zsóka, 2021).

60. **Risk management based on open data**
61. **Neighbourhood energy management system:** Bristol (Garrido-Marijuan, et al., 2017) and there is an effort toward this in Tamási (Széles, 2022).
62. **Air quality, heat, light, noise, humidity metering (Q),**: through sensors, like Mr. Kocsis made available for the research (Kocsis, 2022).
63. **Groundwater and level sensor** (Kocsis, 2022)
64. **Battery energy storage (Q)**: such as Innogy (former Elmű-Elmász) ENTÁR-1 (Antalóczy, 2019)
65. **Heat pumps, Geotherm energy** (Széles, 2022)
66. **Microgrid** (Vida, 2018)
67. **Dustbin saturation sensors (Q) – data driven waste collection** (Humusz, 2016)
68. **Smart rainwater treatment**: complex, well-planed solution to solve the problems of flash flood, but not wasting the water (Nagy, 2022), (Széles, 2022).
69. **PET trekker:** mapping the movement of the river waste (Ilcsik, 2022)**.**
70. **Smart buoy**: among others, it measures the quality of water, the intensity of the alga (Ilcsik, 2022)
71. **SWF Smart water monitoring**: (in-fresh and out-sewage) (Ilcsik, 2022)
72. **Predictive Sewage Shaft Maintenance** (Ilcsik, 2022)
73. **AI to tree tracking: examine the conditions of trees by using AI** (Barsi, 2022)

4 Conclusion

This dissertation was built up as a cone, from the broad global problems it has been narrowed down to the cities level in the focus of their climate change exposure and find a suitable sustainable solution for them. Within the literature review, detailed information was presented about the process of climate change, its consequences and the GHGs current share and amount. Based on the literature, within the sectoral distribution of the GHGs emission 5 main sectors have been identified: Energy (Transportation, Electricity and heat, Buildings, and other energy), Industrial processes, Agriculture, Land use change - forestry and Waste, and from them the most significant contributor with approximately 76,10 percent of the total GHGs emission in CO_2 equivalent in 2016 is the energy sector.

In case of the cities, their general challenges, such as urbanisation, heat island effects, waste management, etc., and their special role in that contest were demonstrated, through their significantly great contribution to GHGs, and in contrast their exposure to the impacts of the climatic change. Despite of all challenges, as Hoornweg (Hoornweg, et al., 2020) added, cities could mediate between different social levels, stakeholders, while they have the platform to communication. Based on that, this platform can serve as a centre of innovations, technology, and the flow of resources to solve or moderate the urban problems.

In terms of ‘smart city’ the rapid development of the term was showed. Through the different definitions and the varied models its complex non-homogenous nature was illustrated. It can be stated that ‘smart city solutions’ has been put into practice in varied ways (Caprotti, 2016), (Cugurullo, 2016), (Cugurullo, 2017), (Rapoport, 2014). For that reason, the definition of ‘smart city’ become different by time, involved tools, stakeholders, targets, importance of ICT. According to the main common factor of the varied definitions or approaches to the term, several grouping can be performed. There is once, the holistic/ human driven (HDM) and the techno-centric/ technology-driven (TDM) (Mora & Deakin, 2019), (Letaifa, 2015). Based on Neirotti (Neirotti, et al., 2014) and Baji (Baji, 2017), another distinguish can be made, which includes a Hard, a more technical subsystem, and a Soft more social oriented subsystem.

In this dissertation Kummitha and Crutzen (Kummitha & Crutzen, 2017) 3RC Framework, Restrictive – Reflective - Rationalistic or pragmatic - Critical schools of thought, are used, while it is seen as the most comprehensive approach. The main statement of the **Restrictive school** of thought, is to be considered as a 'smart city', a city should have an ICT-based integrated system, which concludes the IoT implementation in the urban infrastructure and must assist effectiveness and efficiency. While the **Reflective school of thought** (Angelidou, 2015) sees technology as a core element, which serves for human capital development, boost of innovative ecosystems and spirit, participation improvement. Finally, the **Rationalistic or pragmatic school** of thought (Orlikowski, 2000) citizens, communities' usage of ICT creates technology development, and for that reason the common knowledge of technologies and tutoring skills for the effective application are needed.

Based on the literature and the defined research question and sub-questions inductive methodology was applied, with semi-structured interview and questionnaire. Based on the interviews, it can be stated that the cities (supported by the experts and vendors) main motivations, during the smart solution developments, are to create systems or install solutions that contribute to conscious and sustainable resource management, while they are economically efficient and can operate in a self-sustaining manner (Restrictive school). The main motivations related to these projects were increasing economic efficiency, developing self-sustaining systems, expenditure reduction, sustainable resources management, social inclusion, increasing liveability, and attractiveness of the city, and the decision-making processes should be data-driven. They can provide complex solutions for the exact problems of the city, while also having social utility and increase the cities' appeal (Reflective school). In case of the involved fields, the approach of the 'Reflective school', which considers more techno-centric developments in the fields of the mostly technology focused (sub)systems and see the ICT as core element of the smart city, has been represented itself within most of the answers, however, it stood always together with the elements of the 'Rationalistic schools', such as education, well-being, and economic efficiency. The experts added data-driven efficient decision-making and connectedness as key elements to the approach (Reflective school), while the vendors see it mostly ICT driven developments (Restrictive school).

According to the answers, there were significantly more hard field related solutions, and most of them has (in)direct environmental (climate change) connection, such as emission reduction, reduce the use of energy or increase renewable energy resource generation. Finally, as Table 24. concluded, the main problems of the cities are seen as heat island effect, pollution, land consumption, housing, while three problems out of the four were environmental related. In terms of the smart solutions relevance, the interviewees saw that the biggest added value can be achieved through smart solution implementation in the field of pollution – emission, energy supply and within waste management systems.

The answers cannot be assigned to a single school, they can be seen as a combination of them, but can be summarized with the thought of Vincent Mosco (Mosco, 2019), like the 'smartness' of a city does not come just with the use of ICT and the adaptation of technological solutions, it should come with the dwellers and citizens. A city is smart (beside the other factors) if its dwellers can use adequately the opportunities of the new solutions and they are aware of the potential risks. Which leads to the appearance of 'environment' in the implemented smart cases, as an eco-efficiency goal. Even, if the cities, local governments, are aware of the importance of the climate change, their exposure to it or the importance of the natural resource protection, the environmental factor usually follow the economic, legal factors. In terms of the local governmental level, the city management considering 'environmental' factor during the decision, which is supported with calculations, estimations about the CO_2, GHGs savings or with the creation of climate or related strategies. However, in many cases these steps are regulatory expectations from the EU or the Government, rather than independent conscious decisions. In terms of the vendors, the decision is based on whether the solution has business potential according to the market or not.

Finally, the cities' representatives, experts and vendors ranked their or generally the cities' challenges, and as a result the three most dominant environmental related challenges were heat island effect, pollution (air, water, waste, noise, thermal), intensive land consumption, and they saw the relevance of the smart solutions in case of the pollution – emission, energy related developments.

During the questionnaire (N=550) in this research, mostly female respondents were reached, they were the top answerers in three age range, 25-35 age range, that followed by the 36-45 one, and the third is the 46-55. Beyond the answers from Budapest (n= 320), the most answers came from Szeged - Pécs (7-7), Veszprém - Budaörs (6-6), Érd - Üllő (5-5), Pomáz - Dunakeszi (4-4), Eger-Fót-Kecskemét-Komárom-Miskolc-Sopron-Veresegyház (3-3). The considerable selected city challenges by the participants, which were set based on the literature (Meadows, et al., 1972), (United Nations, 1987), (United Nations, 2012), (OECD, 2010), (UN-Habitat, 2011), (Revi, et al., 2014), (UN-Habitat, 2020), (Kocsis, et al., 2016), (Kovács, et al., 2017, were the notable pollution, the heat island effect, and the intensive land consumption, that followed the urban infrastructure. The participants put the least emphasis on the problems of the energy supply and placed the mobility and safety challenges at the end of the list, while water management and the mental health of inhabitants were added to the problems. In line with that, out of the 362 interventions, mostly green space related developments and that followed just the improvement of the mobility (mainly public transport related) were suggested. Finally, in this research significant relationship can be seen between gender and knowledge of the term “smart city”. This result probably could happen because of the more diverse ‘knowledge options’ (‘no’, ‘little’, ’greatly’). As regards the smart solutions, out of 107 people (19,53% declared to know, 17,7% global solution), just 104 could list at least one smart solution, while in case of the global level out of 97 positive answers (17,7% declared to know), just 5 could not contribute to the smart solutions examples collection. Another interesting outcome of the research is that 6 people said they know local and 7 people know global smart solutions despite the fact they are not familiar with the “smart city” term. In conclusion, the general knowledge about ‘smart city ‘can be considered as good. Although, the main solutions, which reach the final users (city dwellers) are quite limited, and not all have real environmental or economic benefit. There are devices, tools, services, which serve demonstrational purposes, while others, usually hidden, have effect on the efficiency, gain more return, and contribute to sustainability. According to the correlation analysis, there is little connection between the selected characteristics, for that reason further factors should be included within the research to be able to define the defining elements / parameters in case of the environmental related outcome.

Finally, through the collection of 73 existing smart solutions contributed to the improvement of the general environmental awareness. The listed solutions were collected from the answers of the questionnaire, the interviewees and they were results of my own knowledge and research and were divided into six groups, such as smart economy, smart governance, smart people, smart mobility, smart living and smart environment (Lechner Tudásközpont, 2021), (Samih, 2019), (Vienna UT, 2007), (United Nations, 2015b).

Based on the received results, the smart city solutions can serve mitigation purposes in most cases in the field of mobility, energy, and heating, while sustainability seems an always involved aspect. Currently it is not substantially used for adaptation purposes. The smart development core decision point is still economic factors, and just those solution can solve environmental issues, which in the first place economically efficient. The implementation of smart solutions currently based on a more complex, inclusive perspective, where the human and sustainability centric approaches are needed. As a core requirement to support this need is that the smart solution should provide solution to the real problem, challenge of the city, not just a 'fancy ICT based gadget 'without economic and social/environmental contribution.

Accordingly, the contribution of the dissertation to the literature is that in the empirical implementation of the smart solutions cannot be defined by one leading school related to the term. Furthermore, the results show that a motivating, innovative, open local government is needed to plan complex and inclusive projects. Finally, the outcome of the dissertation emphasises the importance of the improvement of 'smart people' characteristic by education and sensitizing to achieve greater results through smart developments.

4.1 Limitation of the research

In case of the comparative analysis of the benchmark models, the limitations were that not all the models published or even have dimensions, factors, or indicators, which made the comparison sluggish. Another point was that Malek (Malek, 2010) did not published in his article 3 indicators, which were mentioned in it. Additionally, none of the four cities have been listed or have been ranked in any of the benchmarks. Finally, the simplification, which would be necessary to analyse the dataset, could be seen as a limitation of the research as well, despite it was made based on the literature.

The limitation through the interviews, could be based on the participant gender, age, number of years spent in their positions, and the fact that not all the participants filled (suitably) the tables or answered for all the questions.

Finally, the limitation of the questionnaire-based research is once that even the number of respondents is 550, the received result cannot be seen as representative one. It can be stated that the conclusions drawn from the sample cannot be expanded to the base population, so the results do not reflect the general opinion of the inhabitants of Hungary. Additionally, the participants were not specifically selected, and the availability of the online questionnaire was limited to a circle of involved people, who have access to Internet, use of these social media platforms, or being able to see the posts. Secondly, the timeframe, 12 days, can be seen as limitation also, but the aim was to reach 550 respondents. Finally, some of the relevant data did not field at all or with relevant information within the questionnaire, and accordingly the correlation analysis further characteristic should be included.

4.2 Further research potential

The further research potential could be seen in the field of expanding the analysis of the general knowledge of 'smart city' to Romania and should be involved Romanian participants in the same sample size as Hungarian ones to the questionnaire. In terms of the investigated smart (sustainable) city models', it could be expanded with further benchmark models' indexes, and as a following step, a smart city profile could be created about the involved cities (Kecskemét, Sepsiszentgyörgy, Székelyudvarhely, Tamási) according to the previously identified most common indexes. However, the collection of these diverse national statistical data is challenging. In terms of the interview, the further research could be expanded to Törökbálint, the twin city of Székelyudvarhely. Based on the interviews, the received 'smart solutions' could be detailed analysed according to GHGs emission reduction, or cost benefit analysis, or other factors.

Glossary

1. *Global risk*: is defined as an uncertain event or condition that, if it occurs, can cause significant negative impact for several countries or industries within the next 10 years" (WEF, 2018, p. 68).
2. *Mitigation*: is an effort to reduce or prevent emission of GHGs. This could be achieved by using new or different technologies, renewable energies, increasing energy efficiency, changing management practices or consumer behaviour. It is more efficient when it is planned as part of a complex action plan (UNEP, 2021).
3. *Adaptation*: is an action or a process to moderate or avoid actual or expected climate change effects (IPCC, 2014b, p. 5). It does not equivalent with maintaining the current regime or institutions.
4. *Resilience*: "the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning, and transformation" (IPCC, 2014b, p. 5).
5. *NDCs*: Nationally determined contributions, including climate related targets and policies. It measures governments interventions to response to climate change in a local and on a global level (UNFCCC, 2021).
6. *Urban sprawl*: "can be defined as urban development with low-density housing, both residential and commercial, segregated land-use, high level of automobile use combined with lack of public transport, which is in high demand for land" (Haaland & Bosch van den , 2015, p. 1), (Johnson, 2001).
7. *Vulnerability*: "the physical attributes of the city and its socio-economic composition that determine the degree of its susceptibility (Mehrotra, et al., 2009, p. 20). How predisposed to "adverse effects of climate change, including climate variability and extremes" (IPCC, 2007b)
8. *Sustainable development*: "is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations, 1987, p. 41) and in the meantime improves the future quality of life by intertwining in balance four dimensions, economic, social, environmental and cultural. Sustainable development became a pathway to sustainability (UNESCO, 2021) by internalising environmental cost (Emas, 2015).[60]

[60] The Brundtland – sustainable development definition was the basis of the nowadays used phrase, which is became extended. The concept of needs, which emphasises the essential needs of the world's poor, which priority cannot be underestimate or overwrite. Secondly, the progressive nature of the smooth economic and social transformation. All the development should consider the costs and benefits of the transformation

References

(SMIC), S. o. M. I. o. C. ed., 1971. *Inadvertent Climate Modification.* s.l.:The MIT Press.

A.T. Kearney, 2021. *Global Cities: divergent prospects and new imperatives in the global recovery.* [Online] Available at: https://www.kearney.com/global-cities/2021 [Accessed 10 05 2022].

About Hungary, 2020. *Parliament passes law on climate protection.* [Online] Available at: https://abouthungary.hu/news-in-brief/parliament-passes-law-on-climate-protection [Accessed 21 05 2021].

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I. & Airaksinen, M., 2017. What are the differences between sustainable and smart cities?. *Cities,* Volume 60, p. 234–245.

Albino, V., Berardi, U. & Dangeli, R. M., 2015. Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology,* 22(1), pp. 3-21.

Albino, V., Berardi, U. & Dangelic, R. M., 2015. Smart Cities: Definitions, Dimensions, Performance, and Initiatives. *Journal of Urban Technology,* 22(1), pp. 3-21.

Allam, Z. & Newman, P., 2018. Redefining the Smart City: Culture, Metabolism and Governance. *Smart Cities,* 1(1), pp. 4-25.

Allmendinger, P., 2009. *Planning theory.* Basingstoke: Palgrave Macmillan.

Amartya, S., 1999. *Development As Freedom.* New York: Random House.

Angel, D. P. et al., 1998. The drivers of GHG emissions: what do we learn from local case studies?. *Local Environment,* 3(3), p. 263–277.

Angelidou, M., 2015. Smart cities: A conjecture of four forces. *Cities,* 47(2015), p. 95–106.

Antalóczy, T., 2019. *Entár – akkumulátoros energiatárolás Magyarországon.* [Online] Available at: https://villanyautosok.hu/2019/07/01/entar-akkumulatoros-energiatarolas-magyarorszagon/ [Accessed 10 08 2022].

Anthopolous, L. G. & Vakali, A., 2012. Urban planning and smart cities: interrelations and reci-procities. In: F. Álvarez , et al. eds. *The future internet.* Berlin: Springer-Verlag, pp. 178-189.

and the role of state is to support the development with care and suitable institutional framework which keeps in mind the limitation of the regions' ecological limit (United Nations, 1987).
This definition, for the 21st century, was extended with the concept of the balanced four dimensions - economic, social, environmental, and cultural – which should be include each and every decision-making process and during the development project. These elements serve as guidelines for inclusivity for all. In additionally, the concept of capital (man-made, manufactured) was enlarged with unique natural resources and finally the generated environmental costs (e.g. pollution) should be internalised and should be paid by the polluter (Emas, 2015).

Anthopoulos, L., Janssen, M. & Weerakkody, V., 2015. *Comparing Smart Cities with Different Modeling Approaches.* Florence, AW4City Workshop - in conjunction with the 24th International World Wide Web Conference (WWW'15).

Anthopoulos, L., Janssen, M. & Weerakkody, V., 2016. A Unified Smart City Model (USCM) for Smart City Conceptualization and Benchmarking. *International Journal of Electronic Government Research,* 12(2), pp. 77-93.

Atkinson, R. & Bridge, G., 2005. *Gentrification in a global context: The new urban colonialism.* London: Routledge.

Ayers , J. & Huq, S., 2009. The value of linking mitigation and adaptation: a case study of Bangladesh. *Environmental Management,* 43(5), pp. 753-764.

Baase, S., 1997. *A gift of fire: Social, legal, and ethical issues in computing.* Upper Saddle River, New Jersey: Prentice Hall, 1997. .

Baji, P., 2017. Okos városok és alrendszereik – Kihívások a jövő városkutatói számára?. *Tér és Társadalom,* 31.(1), pp. 89-105.

Bakardjeva, M., 2005. *Internet society: The internet in everyday life.* London: Sage.

Bakici, T., Almirall, E. & Wareham, J., 2012. A smart city initiative: The case of Barcelona. *Journal of the Knowledge Economy,* 2(1), pp. 1-14.

Balakrishna, C., 2012. *Enabling technologies for smart city services and applications. 2012 6th International Conference on Next Generation Mobile Applications, Services and Technologies (NGMAST).* Paris: s.n.

Bănică, A. et al., 2020. Towards smart (er) resilient cities. Evidences from Romanian urban areas. *Geografie,* 125(4), pp. 397-422.

Baran, M., Klos, M., Chodorek , M. & Marchlewska-Patyk , K., 2022. The Resilient Smart City Model–Proposal for Polish Cities. *Energies,* 15(5), p. 1818.

Baron, M., 2012. Do we Need Smart Cities for Resilience?. *Journal of Economics and Management,* Volume 10, pp. 32-46.

Barsi, O., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Batty, M. et al., 2012. Smart cities of the future. *European Physical Journal Special Topics,* 214(481-518).

Begg, I., 2002. Conclusions and policy implications. In: I. Begg, ed. *Urban competitiveness: Policies for dynamic cities.* Bristol: Policy Press, p. 311–327.

Bell, C., 1989. *The New Palgrave: Economic Development.* New York: W.W. Norton & Company Inc..

Bereiter, B. et al., 2015. Revision of the EPICA Dome C CO2 record from 800 to 600 kyr before present. *Geophysical Research Letters.,* Volume 42(Issue 2), pp. 542-549.

Bibri, S. E. & Krogstie, J., 2017. Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society,* Volume 31, pp. 183-212.

Birt, L. et al., 2016. Member Checking: A Tool to Enhance Trustworthiness or Merely a Nod to Validation?. *Qualitative Health Research,* 26(13), p. 1802 –1811.

BMUB, 2016. *Climate Action Plan 2050,* Berlin, Germany: Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB).

Borsekova, K. & Nijkamp, P., 2018. Smart cities: A challenge to research and policy analysis. *Cities,* Volume 78, pp. 1-3.

Brain Bar, 2019. *Why Can't Politics Fix Climate Change? | Jeffrey Tucker & Vincent Liegey.* [Online] Available at: https://youtu.be/154VwudW3Js [Accessed 20 04 2021].

Brander, K., 2010. Impacts of climate change on fisheries. *Journal of Marine Systems,* 79(3-4), pp. 389-402.

Budapest Fővárosi Önkormányzat, 2022a. *Közösségi Költségvetés.* [Online] Available at: https://otlet.budapest.hu [Accessed 29 07 2022].

Budapest Fővárosi Önkormányzat, 2022b. *Budapest a Tiéd is!.* [Online] Available at: https://kozossegitervezes.budapest.hu[Accessed 25 08 2022].

Bulkeley, H. & Betsill, M. M., 2003. *Cities and Climate Change Urban sustainability and global environmental governance.* London: Routledge.

Bulkeley, H., 2010. Cities and the governing of climate change. *Annual Review of Environment and Resources,* Volume 35, pp. 229-253.

C40 Cities , 2022. *C40 Cities Membership.* [Online] Available at: https://www.c40.org/wp-content/uploads/2022/04/C40-Cities-Membership_July-2022.pdf [Accessed 28 7 2022].

C40 KnowledgeHub, 2022. *Who's in Cities Race to Zero?.* [Online] Available at: https://www.c40knowledgehub.org/s/cities-race-to-zero-public?language=en_US#city-list [Accessed 01 08 2022].

Calixto, V., Gu, N. & Celani, G., 2019. A Critical Framework of Smart Cities Development. *Intelligent & Informed, Proceedings of the 24th International Conference of the Association for Computer-Aided Architectural Design Research in Asia (CAADRIA),* Volume 2, pp. 685-694.

Calvillo, C., Sánchez-Miralles, A. & Villar, J., 2016. Energy management and planning in smart cities. *Renewable and Sustainable Energy Reviews,* Volume 55, pp. 273-287.

Calzada, I. & Cobo, C., 2015. Unplugging: Deconstructing the Smart City. *Journal of Urban Technology,* 22(1), pp. 23-43.

Campbell, S., 1996. Green Cities, Growing Cities, Just Cities? Urban planning and the Contradictions of Sustainable Development. *Journal of the American Planning Association,* 62(3), pp. 296-312.

Cano, J., Jimenez-Gomez , C. E. & Zoughbi , S., 2015. *A smart city model based on citizen-sensors.* Mexico, Smart Cities Conference (ISC2), 2015 IEEE First International.

Caprotti, F., 2016. *Eco-cities and the transition to low carbon economies.* Berlin: Springer.

Caragliu, A., Del Bo, C. & Nijkamp, P., 2011. Smart cities in Europe. *Journal of Urban Technology,,* 18(2), pp. 65-82.

Carlos Moreno La Passion De L'innovation, 2019. *Meeting With Carlos Moreno: Human Smart Cities.* [Online] Available at: http://www.moreno-web.net/meeting-with-carlos-moreno-human-smart-cities/ [Accessed 04 06 2021].

Carvalho, L., 2015. Smart cities from scratch? A Socio-technical perspective.. *Cambridge Journal of Regions, Economy and Society,* 8(1), p. 43–60.

Center for Sustainable Systems, University of Michigan, 2020. *Greenhouse Gases Factsheet.* [Online] Available at: http://css.umich.edu/sites/default/files/Greenhouse%20Gases_CSS05-21_e2020.pdf [Accessed 20 04 2021].

Chapman, L., Azevedo, J. & Prieto-Lopez, T., 2013. Urban heat & critical infrastructure networks: a viewpoint. *Urban Climate,* 3(5), pp. 7-12.

Charfeddine, L., 2017. The impact of energy consumption and economic development on Ecological Footprint and CO2 emissions: evidence from a Markov Switching Equilibrium Correction Model. *Energy Economics,* 65(C), p. 355–374.

Chasek, P., 2020. *Stockholm and the Birth of Environmental Diplomacy.* [Online] Available at: https://www.iisd.org/system/files/2020-09/still-one-earth-stockholm-diplomacy_0.pdf [Accessed 05 11 2020].

Childers, D. et al., 2014. Advancing urban sustainability theory and action: Challenges and opportunities. *Landscape and Urban Planning,* Volume 125, p. 320–328.

City Carbon Footprint, 2018. *Global Gridded Model of Carbon Footprints (GGMCF).* [Online] Available at: http://citycarbonfootprints.info/ [Accessed 27 06 2021].

Clarke, . M., 2018. *University of Victoria Political Science.* [Online] Available at: https://onlineacademiccommunity.uvic.ca/globalsouthpolitics/2018/08/08/global-south-what-does-it-mean-and-why-use-the-term/ [Accessed 20 12 2020].

Climate Watch Data, 2021. *Global historical emission.* [Online] Available at: https://www.climatewatchdata.org/ghg-emissions?breakBy=regions&end_year=2018&source=CAIT&start_year=1990 [Accessed 01 05 2021].

Climate Watch Data, 2021b. *Global Historical Emissions.* [Online] Available at: https://www.climatewatchdata.org/ghg-emissions?chartType=line&end_year=2018&regions=TOP&start_year=1990 [Accessed 03 05 2021].

Climate Watch Data, 2021c. *GHG emission by sector.* [Online] Available at: https://www.climatewatchdata.org/ghg-emissions?breakBy=sector&chartType=line&gases=all-ghg&sectors=agriculture%2Cbunker-fuels%2Cenergy%2Cindustrial-processes%2Cwaste%2Cbuilding%2Celectricity-heat%2Cfugitive-emissions%2Cmanufacturing-construction%2Cother-f [Accessed 03 05 2021].

Climate Watch Data, 2021d. *Data source.* [Online] Available at: https://www.climatewatchdata.org/about/faq/ghg [Accessed 01 05 2021].

Climate Watch Data, 2022. *Compare all targets.* [Online] Available at: https://www.climatewatchdata.org/compare-all-targets?search= [Accessed 08 08 2022].

Cohen, B., 2014. *METHODOLOGY FOR 2014 SMART CITIES BENCHMARKING.* [Online] Available at: https://www.fastcompany.com/3038818/the-smartest-cities-in-the-world-2015-methodology [Accessed 01 05 2022].

Cohen, M. & Garrett, J., 2010. The food price crisis and urban food (in)security. *Environment and Urbanization,* 22(2), pp. 467-482.

Colding, J. & Barthel, S., 2017. An urban ecology critique on the “Smart City” model. *Journal of Cleaner Production,* Volume 164, pp. 95-101.

Collier, U. & Löfstedt, R., 1997. Think globally, act locally? Local climate change and energy policies in Sweden and the UK. *Global Environmental Change,* 7(1), pp. 25-40.

Collier, U., 1997. Local authorities and climate protection in the EU: putting subsidiarity into practice?. *Local Environment,* 2(1), pp. 39-57.

Couclelis, H., 2004. The Construction of the Digital City. *Environment and Planning B: Planning and Design,* 31(1), pp. 5-19.

Csenteri, L., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Csukás, M. & Szabo, R., 2021. The many faces of the smart city: Differing value propositions in the activity portfolios of nine cities. *Cities,* Volume 112.

Cugurullo, F., 2016. Urban eco-modernisation and the policy context of new eco-city projects: Where Masdar City fails and why. *Urban Studies,* Vol. 53(no. 11), pp. 2417-2433.

Cugurullo, F., 2017. The story does not remain the same: multi-scalar perspectives on sustainable urban development in Asia and Hong Kong. In: F. Caprotti & L. Yu, eds. *Sustainable Cities in Asia.* London: Routledge.

Cugurullo, F., 2018. The origin of the Smart City imaginary: from the dawn of modernity to the eclipse of reason. In: C. Lindner & M. Meissner, eds. *The Routledge Companion to Urban Imaginaries.* London: Routledge, pp. 1-20.

Cugurullo, F., 2018b. Exposing smart cities and eco-cities: Frankenstein urbanism and the sustainability challenges of the experimental city. *Environment and Planning A: Economy and Space,* 50(1), pp. 73-92.

D'Allegro, J., 2022. *Investopedia.* [Online] Available at: How Google's Self-Driving Car Will Change Everything [Accessed 25 07 2022].

Dameri, R., 2013. Searching for Smart City definition: a comprehensive proposal. *International Journal of Computers & Technology ,* 11(5), pp. 2544-2551.

Datta, A., 2015. A 100 smart cities, a 100 utopias. *Human Geography,* 5(1), pp. 49-53.

de Jong, M., Joss, S. & Schraven, D., 2015. Sustainable-smart-resilient-low-carbon-eco-knowledge cities: Making sense of a multitude of concepts promoting sustainable urbanization. *Journal of Cleaner Production,* Volume 109, pp. 25-38.

de Pater, M., 2016. *CitySDK.* [Online] Available at: https://amsterdamsmartcity.com/updates/project/citysdk [Accessed 27 07 2022].

Deakin, M., ed., 2012. *Smart Cities: Governing, Modelling and Analysing the Transition.* London: Routhledge.

DeAngelo, B. & Harvey, L. D., 1998. The jurisdictional framework for municipal action to reduce greenhouse gas emissions: case studies from Canada, USA and Germany. *Local Environment,* 3(2), pp. 111-136.

Dell, M., Jones, B. F. & Olken, B. A., 2009. Temperature and income: reconciling new cross-sectional and panel estimates. *American Economic Review,* 99(2), pp. 198- 204.

den Elzen, M. G. J., Olivier, J. G. J., Höhne, N. & Janssens - Maenhout, G., 2013. Countries' contributions to climate change: effect of accounting for all greenhouse gases, recent trends, basic needs and technological progress. November, Volume 121(Issue 2), pp. 397-412.

Desouza, K. & Flanery, T., 2014. Designing, planning, and managing resilient cities: A conceptual framework. *Cities,* Volume 35, pp. 88-98.

dgs, 1001. dgsdg. *sds,* pp. 10-10.

Dijkstra, L. & Poelman, H., 2012. Cities in Europe The New Oecd-Ec Definition. *Regional and Urban Policy,* Volume 1.

Dlugokencky, E. & Tans, P., 2021. *NOAA/GML.* [Online] Available at: www.esrl.noaa.gov/gmd/ccgg/trends/[Accessed 30 04 2021].

Dossou, K. & Gléhouenou-Dossou, B., 2007. The vulnerability to climate change of Cotonou (Benin): the rise in sea level. *Environment and Urbanization,* 19(1), pp. 65-79.

Doust, M., 2018. *More than 60 cities now use "gold-standard" global protocol to report on GHG emissions.* [Online] Available at: https://www.c40.org/news/more-than-60-cities-now-use-gold-standard-global-protocol-to-report-on-ghg-emissions/ [Accessed 03 07 2022].

dr. Dobos, K. et al., 2015. *Smart City Tudásplatform Metodikai Javaslat.* Budapest: Lechner Tudásközpont.

Easy Park Inc., 2022. *The Cities of the Future Index.* [Online] Available at: https://easyparkgroup.com/studies/cities-of-the-future/en/[Accessed 15 08 2022].

EESZT, 2022. *History of EESZT.* [Online] Available at: https://e-egeszsegugy.gov.hu/web/eeszt-information-portal//history-of-eeszt [Accessed 05 07 2022].

Eger, J., 2003. Smart communities: Becoming smart is not so much about developing technology as about engaging the body politic to reinvest governance in the digital age. *Urban Land,* 60(1), pp. 50-55.

Emas, R., 2015. *The Concept of Sustainable Development: Definition and Defining Principles,* Florida: Florida International University.

Engfeldt, L., 2009. *From Stockholm to Johannesburg and beyond.* Stockholm: Swedish Ministry for Foreign Affairs.

Engineering the Future, 2011. *Infrastructure, Engineering and Climate Change Adaptation: Ensuring Services in an Uncertain Future.* London, UK: Royal Academy of Engineering.

EPA, 2020. *Greenhouse Gas Emissions.* [Online] Available at: https://www.epa.gov/ghgemissions/understanding-global-warming-potentials [Accessed 20 04 2021].

Erdelystat, 2022. *Erdély (Transilvania).* [Online] Available at: http://statisztikak.erdelystat.ro/adatlapok/erdely/3280 [Accessed 25 08 2022].

Eremia, M., Toma, L. & Sanduleac, M., 2017. The Smart City Concept in the 21st Century. *Procedia Engineering,* Issue Volume 181, pp. 12-19.

Erian, W., Katlan, B. & Babah, O., 2010. *Drought vulnerability in the Arab region. Special case study: Syria ,* Geneva: U.N. International Strategy for Disaster Reduction.

EU, 2020. *Update of the NDC of the European Union and its Member States.* [Online] Available at: https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/European%20Union%20First/EU_NDC_Submission_December%202020.pdf [Accessed 23 05 2021].

EU, 2021. *EU Emissions Trading System (EU ETS).* [Online] Available at: https://ec.europa.eu/clima/policies/ets_en [Accessed 30 05 2021].

European Commission , 2010. *EUROPE 2020 A European strategy for smart, sustainable and inclusive growth,* Brussels: European Commission .

European Commission, 2011. *White Paper on transport,* Luxembourg: European Union.

European Commission, 2012. *Energy roadmap 2050,* Luxembourg: European Union,.

European Commission, 2014. *European Energy Security Strategy ,* Brussels: European Union.

European Commission, 2018. *European Commission - Climate Action.* [Online] Available at: https://ec.europa.eu/clima/change/consequences_en [Accessed 09 December 2018].

European Commission, 2018b. *Indicators for Sustainable Cities,* s.l.: EU.

European Commission, 2019. *The European Green Deal,* Brussels: European Union.

European Commission, 2020. *EURÓPA 2020 Az intelligens, fenntartható és inkluzív növekedés stratégiája ,* Brussel: European Commission.

European Commission, 2021. *EU Adaptation Strategy.* [Online] Available at: https://ec.europa.eu/clima/policies/adaptation/what_en [Accessed 21 05 2021].

European Commission, 2021b. *Smart Cities.* [Online] Available at: https://ec.europa.eu/info/eu-regional-and-urban-development/topics/cities-and-urban-development/city-initiatives/smart-cities_en [Accessed 02 06 2021].

European Commission, 2021c. *A Europe fit for the digital age.* [Online] Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/europe-fit-digital-age_en [Accessed 03 06 2021].

European Commission, 2021d. *Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change,* Brussels: European Union.

European Commission, 2021e. *Smart Cities Marketplace.* [Online] Available at: https://smart-cities-marketplace.ec.europa.eu/ [Accessed 04 06 2021].

European Commission, 2022. *City Initiatives.* [Online] Available at: https://ec.europa.eu/info/es-regionu-ir-miestu-pletra/temos/miestai-ir-miestu-pletra/miestu-iniciatyvos_en [Accessed 10 06 2022].

European Commission, 2022b. *Smart Cities Marketplace.* [Online] Available at: https://smart-cities-marketplace.ec.europa.eu/ [Accessed 15 08 2022].

European Commission, 2022c. *Funding for cities.* [Online] Available at: https://ec.europa.eu/info/es-regionu-ir-miestu-pletra/temos/miestai-ir-miestu-pletra/miestu-finansavimas_en [Accessed 15 08 2022].

European Parliament, 2022. *Taxonomy: MEPs do not object to inclusion of gas and nuclear activities,* Strasbourg: Press Releases PLENARY SESSION .

Falconer, G. & Mitchell, S., 2012. Smart city framework. *Cisco Internet Bussiness Solutions Group,* Volume 12, pp. 2-10.

Fan, M., Sun, J., Zhou, B. & Chen, M., 2016. The Smart Health Initiative in China: The Case of Wuhan, Hubei Province. *Journal of Medical Systems,* 40(62), pp. 4-17.

Faragó, T. & Láng, I., 2012. Nemzetközi Program a Fenntartható Fejlődésért – Riótól Rióig. *Magyar Tudomány,* 173(5), pp. 590-594.

Faragó, T., 2012. A fenntartható fejlődéssel foglalkozó nemzetközi együttműködés négy évtizede. *Külügyi Szemle,* 11.(3.), pp. 189-211.

Faragó, T., 2017. Közös jövőnk: ego vagy öko?. *Zöld Ipar Magazin,* 7(3), pp. 34-35.

Farley, K. A., Tague, C. & Grant, G. E., 2011. Vulnerability of water supply from the Oregon Cascades to changing climate: linking science to users and policy. *Global Environmental Change,* 21(1), pp. 110-122.

Fehér, K. & Boros, I., 2020. Recommendations, best practices and key factors of smart city and smart citizenship. *Smart Cities and Regional Development Journal,* 4(1), pp. 37-55.

Fekete, K. & Zsóka, Á., 2021. *Resilient cities in practice.* Graz, ERSCP, pp. 169-182.

Feldman, D. & Wilt, C., 1993. Motivations and roles for sub-national governmental participation in managing climate change. *International Journal of Environment and Pollution,* Volume 9, p. 213–226.

Flamer, C. & Meager, M., 1992. Post-Earth Summit Analysis: UNCED Implementation, Follow-up Measures Proposed. *Eco Log*, 07 08, pp. 2-3.

Freeman, G., 2017. *The Origin and Implementation of the Smart-Sustainable City Concept The Case of Malmö, Sweden.* Lund: IIIEE, Lund University.

G20 Global Smart Cities Alliance, 2020. *About the Alliance.* [Online] Available at: https://globalsmartcitiesalliance.org/?page_id=107 [Accessed 10 06 2021].

Galli, A. et al., 2016. Questioning the Ecological Footprint. *Ecological Indicators,* Volume 69, p. 224–232.

Garau, C., Masala , F. & Pinna, F., 2016. Cagliari and smart urban mobility: Analysis and comparison. *Cities,* Volume 56, pp. 35-46.

Garrido-Marijuan, A., Pargova, Y. & Wilson, C., 2017. *The making of a smart city: best practices across Europe,* Belgium: GOPA Com.

GCF, 2021. *Project Portfolio.* [Online] Available at: https://www.greenclimate.fund/projects/dashboard [Accessed 30 04 2021].

George, A. L. & Bennett, A., 2004. *Case Studies and Theory Development in the Social Sciences..* London: MIT Press.

Gerring, J., 2007. *Case Study Research Principles and Practices.* Cambridge: Cambridge University Press.

Gibbs, D., Krueger, R. & MacLeod, G., 2013. Grappling with smart city politics in an era of market triumphalism. *Urban Studies,* 50(11), p. 2151–2157.

Giffinger, R. et al., 2007. *Smart cities—Ranking of European medium-sized cities,* Vienna: Vienna University of Technology (2007).

Glasmeiera, A. & Christophersonb, S., 2015. Thinking about smart cities. *Cambridge Journal of Regions, Economy and Society ,* Volume 8, pp. 3-12.

Gleick, P. H., 2014. Water, drought, climate change, and conflict in Syria. *Weather, Climate, and Society,* 6(3), p. 331–340.

Global Carbon Project, 2019. *Supplemental data of Global Carbon Budget 2019 (Version 1.0) [Data set].* [Online] Available at: https://www.icos-cp.eu/global-carbon-budget-2019 [Accessed 01 05 2021].

Global Footprint Network, 2021. *Footprint Network.* [Online] Available at: https://www.footprintnetwork.org/resources/data/ [Accessed 20 06 2022].

Global Monitoring Laboratory, 2021. *Trends in Atmospheric Carbon Dioxide.* [Online] Available at: https://www.esrl.noaa.gov/gmd/ccgg/trends/ [Accessed 20 04 2021].
Global Monitoring Laboratory, 2021b. *Trends in Atmospheric Methane.* [Online] Available at: https://www.esrl.noaa.gov/gmd/ccgg/trends_ch4/ [Accessed 20 04 2021].
Global Monitoring Laboratory, 2021c. *Trends in Atmospheric Nitrous Oxide.* [Online] Available at: esrl.noaa.gov/gmd/ccgg/trends_n2o/ [Accessed 20 04 2021].
Global Monitoring Laboratory, 2021d. *Trends in Atmospheric Sulfur Hexaflouride.* [Online]
Available at: https://www.esrl.noaa.gov/gmd/ccgg/trends_sf6/ [Accessed 20 04 2021].
GlobalData Thematic Research , 2020. *History of smart cities: Timeline.* [Online] Available at: https://www.verdict.co.uk/smart-cities-timeline/ [Accessed 01 06 2021].
Google, 2021. *Google Trends.* [Online] Available at: https://trends.google.com/trends/explore?date=all&q=smart%20city,smart%20cities [Accessed 09 06 2021].
Government of Romania, 2020. *The 2021-2030 Integrated National Energy and Climate Plan,* s.l.: Government of Romania.
Government of the Netherlands, 2019. *Climate Agreement,* The Hague: Government of the Netherlands.
Graham, S., 2002. Bridging urban digital divides: Urban polarisation and information and communication technologies. *Urban Studies,* 39(1), pp. 33-56.
Greenhouse Gas Protocol, 2021. *Global Warming Potential Values.* [Online] Available at: https://ghgprotocol.org/sites/default/files/Global-Warming-Potential-Values%20%28Feb%2016%202016%29_1.pdf [Accessed 20 04 2021].
GreenWall Solution, 2022. *Greenwall-Solution.* [Online] Available at: https://greenwall-solutions.com [Accessed 23 08 2022].
Gutro, R., 2005. *NASA - What's the Difference Between Weather ans Climate.* [Online] Available at: https://www.nasa.gov/mission_pages/noaa-n/climate/climate_weather.html [Accessed 01 05 2021].
Haaland, C. & Bosch van den , C. K., 2015. Challenges and strategies for urban green-space planning in cities undergoing densification: A review. *Urban Forestry & Urban Greening,* Volume 14(Issue 4), pp. 760-771.
Haibullin, L., 2018. Introduction of the smart cities model as one of priorities of social and economic development of territories. *Technology Audit and Production Reserves,* 4/5(42), pp. 30-35.

Hajat, S., O'Connor, M. & Kosatsky, T., 2010. Health effects of hot weather: from awareness of risk factors to effective health protection. *The Lancet,* 375(9717), pp. 856-863.

Hall, R. E. et al., 2000. The vision of a smart city. *Brookhaven National Laboratory,* pp. 1-6.

Hanák, P., 2018. Okos életvitel. In: G. Sallai, ed. *Az okos város (Smart City).* Budapest: Dialóg Campus Kiadó, pp. 153-185.

Handy, S., Boarnet, M., Ewing, R. & Killingsworth, R., 2002. How the Built Environment Affects Physical Activity: Views from Urban Planning. *American Journal of Preventive Medicine,* 23(2S), pp. 64-73.

Hardin, G., 1968. The Tragedy of the Commons. *Science,* Vol. 162(Issue 3859), pp. 1243-124.

Harrison, C. & Donnelly, I., 2011. *A Theory of Smart City.* s.l.: IBM.

Harrison, C. et al., 2010. Foundations for smarter cities. *IBM Journal of Research and Development,* 54(4), pp. 1-16.

Harvey, L. D., 1993. Tackling urban CO2 emissions in Toronto. *Environment,* 35(7), pp. 16–20, 38–44.

Haynes, K., 2012. Reflexivity in Qualitative Research. In: G. Symon & C. Cassell, eds. *Qualitative Organizational Research: Core Methods and Current Challenges.* London: Sage Publication Ltd., pp. 72-89.

Herrera, F. P. & Fajardo, C., 2016. *Fully Smart Cities: Analysis of the City to Smart City transformation process.* Trento, IEEE International Smart Cities Conference (ISC2).

Herrfahrdt-Pähle, E., 2010. South African water governance between administrative and hydrological boundaries. *Climate and Development,* 2(2), pp. 111-127.

Hogan, T., Bunnell, T. & Pow, C. P., 2012. Asian urbanisms and the privatization of cities. *Cities,* 29(1), pp. 29-63.

Höjer, M. & Wangel, J., 2014. Smart Sustainable Cities: Definition and Challenges. In: L. M. Hilty & B. Aebischer, eds. *ICT Innovations for Sustainability. Advances in Intelligent Systems and Computing 310.* s.l.:Springer International Publishing, pp. 1-16.

Hollands, R., 2008. Will the Real Smart City Please Stand up?: Intelligent, Progressive or Entrepreneurial?. *City,* 12(3), pp. 303-320.

Hoornweg, D., Sugar, L. & Gomez, C. L. T., 2020. Cities and Greenhouse Gas Emissions: Moving Forward. *Urbanisation,* 5(1), pp. 43-62.

Horowitz, J., 2009. The income-temperature relationship in a cross-section of countries and its implications for predicting the effects of global warming. *Environmental and Resource Economics,* 44(4), pp. 475-493.
Horsefield, J. K., 1969. *The International Monetary Fund 1945–1965: Twenty Years of International Monetary Cooperation.* Washington: International Monetary Fund.
Horváthné Dr. Barsi, B. & Dr. Lados, M., 2011. *"Smart cities" tanulmány,* Győr: MTA RKK NYUTI.
Humusz, 2016. *Szemeteskuka telítettségi szenzorok.* [Online] Available at: https://humusz.hu/hirek/szemeteskuka-telitettsegi-szenzorok/22666 [Accessed 05 07 2022].
Ibănescua, B.-C., Pascariuab, G. C., Bănicăc, A. & Bejenarud, I., 2022. Smart city: A critical assessment of the concept and its implementation in Romanian urban strategies. *Journal of Urban Management,* 11(2), pp. 246-255.
IESE Business School , 2020. *IESE Cities in Motion Index 2020,* Navarra: IESE.
IESE, 2017. *IESE Cities in Motion Index (ST-442-E),* Navarra: IESE Business School.
Ilcsik, C., 2022. *Smart City Solution - Interview* [Interview] 2022.
Imrei, A., 2022. *Smart City Soltions - Interview* [Interview] 2022.
INTERMAP, 2022. *Intelligent geospatial information platform.* [Online] Available at: https://www.intermap.hu/en/ [Accessed 01 08 2022].
IPCC, 2007. *Climate Change 2007 The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.
IPCC, 2007b. *Climate Change 2007: Synthesis Report . Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change.* Geneva: IPCC.
IPCC, 2014. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Genova: IPCC.
IPCC, 2014b. *Climate Change 2014 Impacts, Adaptation, and Vulnerability Part A: Global and Sectoral Aspects.* New York: Cambridge University Press.
ISO, 2018. *ISO 37120:2018 Sustainable cities and communities — Indicators for city services and quality of life.* [Online] Available at: https://www.iso.org/standard/68498.html [Accessed 01 05 2022].

ITU, Geneva. *Agreed definition of a Smart Sustainable City. Focus Group on Smart Sustainable Cities,* 2014 : UN.

Jakab, A., 2022. *Smart City Soltions - Interview* [Interview] 2022.

Jakab, L., Sallai, G. & Kovács, K., 2018. A Smart City Megoldások Technológiai Háttere és Fenntartható Komplex Modellje. *Magyar Tudomány,* 179(9), p. 1304–1314.

Jayathilake, H. M. et al., 2021. Drivers of deforestation and degradation for 28 tropical conservation landscapes. *Ambio,* Volume 50, pp. 215-228.

Johnson, M. P., 2001. Environmental impacts of urban sprawl: a survey of the literature and proposed research agenda. *Environment and Planning A,* Volume 33(Issue 4), pp. 717-735.

Johnstone, S. & Mazo, J., 2013. *Global warming and the Arab Spring. In the Arab Spring and climate change. A climate and security correlations series.* [Online] Available at: http s://climateandsecurity.files.wordpress.com/2012/04/climatechangearabspring-ccs - cap-stimson.pdf [Accessed 11 07 2019].

Jwijati, I. M., 2017. *Exploring the Influence of National Culture on Performance Management Systems.* Dubai: Heriot-Watt University School of Social Sciences.

Kaika, M., 2017. 'Don't call me resilient again!': the New Urban Agenda as immunology... or... what happens when communities refuse to be vaccinated with 'smart cities' and indicators. *Environment and Urbanization,* 29(1), pp. 89-102.

Katanich, D., 2021. Kenyan women turn plastic waste into bricks stronger than concrete. *Euronews Green*, 12 02.

Kenesei, Z. et al., 2019. *Technológia-elfogadás speciális jellemzői az idős internetezők körében.* Veszprém, Pannon Egyetem.

Kent, J., 2011. *Individual responsibility and voluntary action on climate change: activating agency.* Northampton,: Edward Elgar Publishing Ltd..

Kiehl, J. T. & Trenberth, K. E., 1997. Earth's Annual Global Mean Energy Budget. *National Center for Atmospheric Research,* Volum 78(No.2), pp. 197-208.

Kiernan, M., 1983. Ideology, politics, and planning: reflections on the theory and practice of urban planning. *Environment and Planning B: Planning and Design ,* 10(1), pp. 71-87.

Kim, J., 2022. Smart city trends: A focus on 5 countries and 15 companies. *Cities,* Volume 123.

King, G., Keohane, R. & Verba, S., 1994. *Designing Social Inquiry: Scientific Inference in Qualitative Research.* Princeton: Princeton University Press.

Kirimtat, A., Krejcar, O., Kertész, A. & Tasgetiren, M. F., 2020. Future Trends and Current State of Smart City Concepts: A Survey. *IEEE Access,* 8(Part II.), pp. 86448-86467.

Kirkpatrick, L. O. & Smith, M. P., 2011. The infrastructural limits to growth: Rethinking the urban growth machine in times of fiscal crisis. *International Journal of Urban and Regional Research,* Volume 35, p. 477–503.

KKVHáz, 2018. *Az éghajlatváltozásról röviden.* [Online] Available at: https://www.kkvhaz.hu/cikk/418-az-eghajlatvaltozasrol-roviden [Accessed 20 04 2021].

Kocsis, C., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Kocsis, J. & Gere, L., 2021. Okos város globális nézőpontból. *Századvég,* Volume 1, pp. 101-129.

Kocsis, K. et al., 2016. Geographical characteristics of contemporary international migration in and into Europe. *Hungarian Geographical Bulletin,* 65(4), pp. 369-390.

Köki, 2022. *Bringapont.* [Online] Available at: https://kokiterminal.hu/informaciok/bringapont/ [Accessed 20 08 2022].

Kourtit, K., Macharis, C. & Nijkamp, P., 2014. A multi-actor multi-criteria analysis of the performance of global cities. *Applied Geography,* Volume 49, pp. 24-36.

Kovács, Z. et al., 2017. Az urbanizáció környezeti hatásai – Az ingázás ökológiai lábnyomának változása a budapesti várostérségben. *Területi Statisztika,* 57(5), pp. 469-494.

Kramer , R. J. et al., 2021. Observational Evidence of Increasing Global Radiative Forcing. *Geophisical Research Letter,* Volume 48(Issue 7).

Kramers, A., Höjer, M., Lövehagen, N. & Wangel, J., 2014. Smart sustainable cities: Exploring ICT solutions for reduced energy use in cities. *Environmental Modelling & Software,* Volume 56, pp. 52-62.

Krishna, G., 2021. Understanding and identifying barriers to electric vehicle adoption through thematic analysis. *Transportation Research Interdisciplinary Perspectives,* 10(1), p. 100364.

Kumar, A. & Rattan, J. S., 2020. *A Journey from Conventional Cities to Smart Cities in Smart Cities and Construction Technologies.* s.l.:IntechOpen.

Kumar, S., Kumar, N. & Vivekadhish, S., 2016. Millennium Development Goals (MDGs) to Sustainable Development Goals (SDGs): Addressing Unfinished Agenda and Strengthening Sustainable Development and Partnership. *Indian Journal of Community Medicine,* 41(1), pp. 1-4.

Kummitha, R. & Crutzen, N., 2017. How Do We Understand Smart Cities? An Evolutionary Perspective. *Cities,* Volume 67, pp. 43-52.

Kurenkov, S., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Kuube, 2022. *Smart Bench.* [Online] Available at: https://kuube.hu/en/ [Accessed 11 08 2022].

L Mobile, 2021. *Mi is az az RFID-technológia? Meghatározás, jelentés, működés.* [Online] Available at: https://www.l-mobile.com/hu/industrie-40/mi-az-rfid-technologia-meghatarozas-jelentes-mukodes/ [Accessed 10 06 2021].

Lambright, W. H., Changnon, S. A. & Harvey, L. D., 1996. rban reactions to the global warming issue: agenda setting in Toronto and Chicago. *Climatic Change,* Volume 34, p. 463–478.

Latif, M., 2011. Uncertainty in climate change projections. *Journal of Geochemical Exploration,* 07, Volume 110(Issue 1), p. 1–7.

Lechner Tudásközpont, 2021. *Okos Város.* [Online] Available at: http://okosvaros.lechnerkozpont.hu/hu [Accessed 30 05 2021].

Lechner Tudásközpont, 2021b. *Smart projects.* [Online] Available at: http://okosvaros.lechnerkozpont.hu/en/projects [Accessed 01 06 2021].

Lemonsu, A. et al., 2013. Evolution of the Parisian urban climate under a global changing climate. *Climatic Change,* 116(3-4), pp. 679-692.

Letaifa, B., 2015. How to Strategize Smart Cities: Revealing the SMART Model. *Journal of Business Research,* 68(7), pp. 1414-1419.

Leydesdorff, L. & Deakin, M., 2011. The triple-helix model of smart cities: A neoevolutionary perspective. *Journal of Urban Technology,* Volume 18, pp. 3-63.

Limb, L., 2022. *euronews.green.* [Online] Available at: https://www-euronews-com.cdn.ampproject.org/c/s/www.euronews.com/green/amp/2022/07/06/sand-batteries-could-be-key-breakthrough-in-storing-solar-and-wind-energy-year-round [Accessed 15 07 2022].

Lindqvist, A. et al., 2020. User Perception of a Smartphone App to Promote Physical Activity Through Active Transportation: Inductive Qualitative Content Analysis Within the Smart City Active Mobile Phone Intervention (SCAMPI) Study. *JMIR Mhealth Uhealth,* 8(8).

Linnér, B. & Selin, H., 2005. The road to Rio: early efforts on environment and development. In: C. A. Kallhauge, G. Sjöstedt & E. Corell, eds. *Global Challenges:*

Furthering the Multilateral Process for Sustainable Development. s.l.:Greenleaf Publishing, pp. 58- 73.

Lom, M. & Přibyl, O., 2020. Smart city model based on systems theory. *International Journal of Information Management,* 56(3), p. 102092.

Lombardi, P., Giordano, S., Farouh, H. & Yousef, W., 2012. Modelling the smart city performance. *Innovation: The European Journal of Social Science Research,* 25(2), p. 137–149.

Los Angeles Community Analysis Bureau, 1974. *The State of the City: The Cluster Analysis of Los Angeles,* Los Angeles, CA, USA: Community Analysis Bureau.

Lovász, L., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Lui, L., 2016. Using Generic Inductive Approach in Qualitative Educational Research: A Case Study Analysis. *Journal of Education and Learning,* 5(2), pp. 129-135.

Magyarország Kormánya, 2008. *National Climate Change Strategy 2008-2025, 29/2008. (III. 20.) OGY,* Budapest: s.n.

Magyarország Kormánya, 2017. *56/2017. (III. 20.) Korm. rendelet egyes kormányrendeleteknek az „okos város", „okos város módszertan" fogalom meghatározásával összefüggő módosításáról,* Budapest: s.n.

Mahler, A. G., 2017. *"Global South." Oxford Bibliographies in Literary and Critical Theory.* New York: Oxford University Press.

Mahler, A. G., 2018. *From the Tricontinental to the Global South: Race, Radicalism, and Transnational Solidarity.* Durham: Duke University Press.

Malchenko, Y. A. & Smirnova, M., 2019. What Drives Consumers Smart? The challenge of Adoption of Smart City Solutions. *Russian Management Journal,* 17(3), p. 387–410.

Malek, J. A., 2010. Informative Global Community Development Index of Intelligent City. *WSEAS TRANSACTIONS on INFORMATION SCIENCE and APPLICATIONS,* 1(7), pp. 112-121.

Manville, C. et al., 2014. *Mapping Smart Cities in the EU,* Brussels: European Union.

Maoz, Z., 2002. Case Study Methodology in International Studies: From Storytelling to Hypothesis Testing. In: P. Frank, H. Brecher & M. Brecher, eds. *Evaluating Methodology in International Studies: Millennial Reflections on International Studies.* Ann Arbor: University of Michigan Press, p. 455–475.

Marsal-Llacuna, M.-L., Colomer-Llinàs, J. & Meléndez-Frigola, J., 2015. Lessons in urban monitoring taken from sustainable and livable cities to better address the smart city initiatives. *Technological Forecasting and Social Change,* 90(B), p. 611–622.

Mátyus, L., 2022. *Smart City Soltions - Interview* [Interview] 2022.

McAdam, J., ed., 2010. *Climate Change and Displacement: Multidisciplinary Perspectives.* Oxford: Hart Publishing Ltd..

McEvoy, D., Gibbs, D. & Longhurts, J., 1999. The prospects for improved energy efficiency in the UK residential sector. *Journal of Environmental Planning and Management,* 42(3), p. 409–424.

McLean, A., Bulkeley, H. & Crang, M., 2016. Negotiating the urban smart grid: Socio-technical experimentation in the city of Austin. *Urban Studies,* 53(15), pp. 3246-3263.

Meadows, D. H., Meadows, D. L., Randers, J. & Behrens III, W. W., 1972. *The Limits to Growth,* New York: Universe Books.

Meakin, S., 1992. *The Rio Earth Summit: Summary of the United Nations Conference on Environment and Development.* [Online] Available at: http://publications.gc.ca/Collection-R/LoPBdP/BP/bp317-e.htm#(42)txt [Accessed 26 01 2021].

Mehrotra, S., Natenzon, C. E., Omojola, A. & et al., 2009. *Framework for City Climate Risk Assessment,* Buenos Aires, Delhi, Lagos, New York: World Bank.

Mester, M. A., 2015. *A globális klímaváltozás becslésére készült új RCP kibocsátási szcenáriók összehasonlítása,* Budapest: Eötvös Loránd Tudományegyetem Földrajz- és Földtudományi Intézet Meteorológiai Tanszék.

Mideksa, T. K. & Kallbekken, S., 2010. The impact of climate change on the electricity market: a review. *Energy Policy,* 38(7), pp. 3579-3585.

Mikulák, P., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Ministry of Economic Affairs and Climate Policy, 2019. *Integrated National Energy and Climate Plan 2021-2030,* s.l.: Ministry of Economic Affairs and Climate Policy.

Molnár PhD, L. et al., 2021. Miskolc as a "Smart City" – Experiences of a Questionnaire Survey. *Review of Business & Management,* 17(Special Issue Nr. 1), pp. 11-21.

MOME, 2020. *Csak egy avatár kell – Mobilapp a kommunikációs nehézségekkel élőknek.* [Online] Available at: https://mome.hu/hu/hir/280/csak-egy-avatar-kell-mobilapp-a-kommunikacios-nehezsegekkel-eloknek [Accessed 10 06 2022].

Monfreda, C., Wackernagel, M. & Deumling, D., 2004. Establishing national natural capital accounts based on detailed ecological footprint and biological capacity accounts. *Land Use Policy,* Volume 21, p. 231–246.

Mora, L. & Deakin, M., 2019. *Untangling Smart Cities From utopian dreams to innovation systems for a technology-enabled urban sustainability.* s.l.:Elsevier.

Mora, L., Bolici, R. & Deakin, M., 2017. The first two decades of smart-city research: A bibliometric analysis. *Journal of Urban Technology,* 24(1), pp. 3-27.

Moran, D. et al., 2018. Carbon footprints of 13 000 cities. *Environmental Research Letters,* 13(6), pp. 1-9.

Mosco, V., 2019. *The Smart City in a Digital World.* s.l.:Emerald Publishing.

Moser, S., 2015. New cities: Old wine in new bottles?. *Dialogue in Human Geography,* 5(1), pp. 31-35.

Mudler, I., 2014. Sociable smart cities: Rethinking our future through co-creative partnerships. In: N. Streitz & P. Markopoulos, eds. *Distributed, ambient, and pervaisive interactions.* Heidelberg: Springer, p. 566–574.

Myerson, G., 2001. *Heidegger, Habermas and the mobile phone.* Cambridge, UK: Icons Book Ltd.

Myhre, G. et al., 2013. *Anthropogenic and Natural Radiative Forcing. In: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change,* Cambridge: Cambridge University Press.

Nabhan, G., 2010. *Drought drives Middle Eastern pepper farmers out of business, threatens prized heirloom chilies.* [Online] Available at: https://grist.org/article/2010-01-15-dr ought-drives-middle-eastern-peppers/ [Accessed 11 07 2019].

Nagy, G., 2022. *Smart City Solution - Interview* [Interview] 2022.

Najam, A. & Cleveland, C. J., 2003. Energy and Sustainable Development at Global Environmental Summits: An Evolving Agenda. *Environment Development and Sustainability,* 5(1), pp. 117-138.

Najam, A., 1995. An environmental negotiation strategy for the South. *International Environmental Affairs,* 7(3), p. 249–287.

Naphade, M. et al., 2011. Smarter Cities and their Innovation Challenges. *IEEE Computer,* 44(6), pp. 32-39.

NASA, 2017. *Earth's Atmospheric Layers.* [Online] Available at: https://www.nasa.gov/mission_pages/sunearth/science/atmosphere-layers2.html [Accessed 01 05 2021].

National Geographic, 2019. *Climate Milestone: Earth's CO2 Level Passes 400 ppm.* [Online] Available at: https://www.nationalgeographic.org/article/climate-milestone-earths-co2-level-passes-400-ppm/ [Accessed 30 04 2021].

Neirotti, P. et al., 2014. Current trends in smart city initiatives: Some stylised facts. *Cities,* Volume 38, pp. 25-36.

Németh, B., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Nemzeti Fejlesztési Minisztérium, 2010. *Digitális Megújulás Cselekvési Terv 2010 - 2014,* Budapest: Nemzeti Fejlesztési Minisztérium.

Nemzeti Fejlesztési Minisztérium, 2014. *National Infocommunication Strategy 2014-2020,* Budapest: Nemzeti Fejlesztési Minisztérium.

Nicholls, R. J., 2004. Coastal flooding and wetland loss in the 21st century: changes under the SRES climate and socio-economic scenarios. *Global Environmental Change,* 14(1), pp. 69-86.

Nielsen, L., 2011. *Classifications of Countries Based on Their Level of Development: How it is Done and How it Could be Done ,* Washington: International Monetary Fund.

Nordås, R. & Gleditsch, N. P., 2007. Climate change and conflict. 08, Volume 26(Issue 6), pp. pp. 627-638.

Nordhaus, W., 2011. Estimates Of The Social Cost Of Carbon: Background And Results From The Rice-2011 Model. Cowles Foundation Discussion Paper(No. 1826).

Norman, E. S. & Carr, D., 2009. Rio Summit. In: R. Kitchin & N. Thrift, eds. *International Encyclopedia of Human Geography.* Oxford: Elsevier, p. 406–411.

Nzeadibe, T. & Mbah, P., 2015. Beyond urban vulnerability: interrogating the social sustainability of a livelihood in the informal economy of Nigerian cities. *Review of African Political Economy,* 42(144), pp. 279-298.

OECD, 2010. *Cities and Climate Change,* s.l.: OECD Publishing.

OECD, 2018. *The policy implications of digital innovation and megatrends in (smart) cities of the future: A project proposal,* Paris: OECD.

OECD, 2019. *OECD (2019), Enhancing the Contribution of Digitalisation to the Smart Cities of the Future,* s.l.: OECD.

Orlikowski, W. J., 2000. Using technology and constituting structures: A practical lens for studying technology in organisations. *Organisation Science,* 11(4), pp. 404-428.

Our World in Data, 2020. *Sector by sector: where do global greenhouse gas emissions come from?.* [Online] Available at: https://ourworldindata.org/ghg-emissions-by-sector [Accessed 21 05 2021].

Ovington, T. & Houpis, G., 2018. *How Smart Cities can help tackle climate change.* [Online] Available at: http://www.frontier-economics.com/uk/en/news-and-articles/articles/article-i4604-how-smart-cities-can-help-tackle-climate-change/#_ftn1 [Accessed 21 11 2020].

Pachauri, R. K., Meyer, L. & The Core Writing Team (ed.), 2015. *Climate Change 2014: Synthesis Report,* Genova CH: IPCC.

Palik, J., 2020. *Interstate Rivals' Intervention in Third Party Civil Wars: The Comparative Case of Saudi Arabia and Iran in Yemen (2004-2018).* Budapest: Corvinus University of Budapest.

Palmer, G., 1992. The Earth Summit: What Went Wrong at Rio?. *Washington University Law Review,* Volume 70(Issue 4), pp. 1005-1028.

Parry, M. et al., 2007. *Climate change 2007: Climate change impacts, adaptation, and vulnerability,* Cambridge, UK: Cambridge University Press.

Passell, P., Roberts, M. & Ross, L., 1972. *The New York Times.* [Online] Available at: https://www.nytimes.com/1972/04/02/archives/the-limits-to-growth-a-report-for-the-club-of-romes-project-on-the.html [Accessed 15 12 2020].

Patt, G. A. et al., 2009. Estimating least-developed countries' vulnerability to climate-related extreme events over the next 50 years. *Current Issue,* Vol. 107(No. 4), p. 1333–1337.

Pearson, L. B. & et al., 1969. *Partners in Development: Report of the Commission on International Development.* New York: Praeger Publishers.

Peck, J., 2005. Struggling with the creative class. *International Journal of Urban and Regional Research,* 29(4), p. 740–770.

Peck, J., 2012. Austerity urbanism. *City,* 16(6), p. 626–655.

Perera, C., Zaslavsky, A., Christen, P. & Georgakopoulos, D., 2013. Context aware computing for the internet of things: A survey. *IEEE - Communications Surveys Tutorials,* vol. 16(no. 1), p. 414–454.

Perry, A. L., Low, P. J., Ellis, J. L. & Reynolds, J. D., 2005. Climate change and distribution shifts in marine fishes. *Science,* 208(5730), pp. 1912-1915.

Piao, S., Ciais, P., Huang , Y. & et al., 2010. The impacts of climate change on water resources and agriculture in China. *Nature,* 09, Vol.467(https://doi.org/10.1038/nature09364), pp. 43-51.

Pires, M., Fidelis, T. & Ramos, T., 2014. Measuring and comparing local sustainable development through common indicators: Constraints and achievements in practice. *Cities,* Volume 39, pp. 1-9.

PocketGuide, 2022. *Let the city talk to you.* [Online] Available at: https://pocketguideapp.com [Accessed 29 08 2022].

Pravalie, R. et al., 2021. Arable lands under the pressure of multiple land degradation processes. A global perspective. *Environmental Research,* 194(110697).

Rab, J. & Szemerei, S., 2018. *AZ OKOS VÁROS FEJLESZTÉSI MODELL MÓDSZERTANI ALAPJAI,* Budapest: Lechner Nonprofit Kft.

Raleigh, C. & Urdal, H., 2007. Climate change, environmental degradation and armed conflict. *Political Geography,* 08, Volume 26(Issue 6), pp. 674-694.

Rapoport, E., 2014. Utopian Visions and Real Estate Dreams: The Eco-city Past, Present and Future. *Geography Compass,* Volume 8(Issue 2), pp. 137-149.

Rees, W. E., 1992. Ecological footprints and appropriated carrying capacity: what urban economics leaves out. *Environment and Urbanization,* 4(2), pp. 121-130.

Reuveny, R., 2007. Climate change-induced migration and violent conflict. *Political Geography,* 08, Volume 26(Issue 6), pp. 656-673.

Revi, A. et al., 2014. *Urban areas. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Cambridge: Cambridge University Press.

Richter, C., Kraus, S. & Syrja, P., 2015. The smart city as an opportunity for entrepreneurship. *International Journal of Entrepreneurial Venturing,* 7(3), pp. 211-226.

Ritchie, H. & Roser, M., 2017. *CO_2 and Greenhouse Gas Emissions.* [Online] Available at: https://ourworldindata.org/co2-and-other-greenhouse-gas-emissions [Accessed 30 04 2021].

Rockström, J., Steffen, W. & Noone, K., 2009. A safe operating space for humanity. *Nature,* Volume Vol. 461, pp. 472-475.

Romania Journal, 2020. *Smart Cities In Romania: 594 Projects In 87 Cities.* [Online] Available at: Smart Cities In Romania: 594 Projects In 87 Cities [Accessed 27 08 2022].

Rommes, E., Oost, E. V. & Oudshoorn, N., 1999. Gender in the design of the digital city of Amsterdam. *Information, Communication & Society,* Volume 2, p. 476–495.

Rosenzweig, C., Solecki, W. D., Hammer, S. A. & Mehrotra, S. eds., 2011. *Climate Change and Cities: First Assessment Report of the Urban Climate Change Research Network (ARC3).* Cambridge: Cambridge University Press.

Salamin, G. & Péti, M., 2019. Terület- és Településfejlesztési Tervek, Elképzelések. *Tér és Társadalom,* 33(3), pp. 7-28.

Salkind, N. J., 2010. Triangulation. In: *Encyclopedia of Research Design.* Thousand Oaks: SAGE Publications, Inc., pp. (Vols. 1-0).

Sallai, G., 2016. Smart City a célkeresztben. *Híradástechnika,* LXXI(1), pp. 1-64.

Sallai, G., 2018. Az okos város koncepciója. In: G. Sallai, ed. *Az okos város (Smart city).* Budapest: Dialóg Campus Kiadó, pp. 13-34.

Sallai, G., 2019. *Az okosváros-koncepció és az internettechnológia.* Budapest: Dialóg Campus Kiadó.

Samih, H., 2019. Smart cities and internet of things. *Journal of Information Technology Case and Application Research,* 21(1), pp. 3-12.

Sánchez-Rodríguez, R., 2011. Urban and social vulnerability to climate variability in Tijuana, Mexico. In: R. Kasperson & M. Berberian, eds. *Integrating Science and Policy Vulnerability and Resilience in Global Environmental Change.* Earthscan, Abingdon, Oxon: Routledge, pp. 187-214.

Sarkadi, P., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Satterthwaite, D., 1997. Sustainable cities or cities that contribute to sustainable development?. *Urban Studies,* 34(10), p. 1667–1691.

Satterthwaite, D., 2008. Cities' contribution to global warming: notes on the allocation of greenhouse gas emissions. *Environment & Urbanization,* Volume 20(2), pp. 539-549.

Schmidhuber, J. & Tubiello, F. N., 2007. Global food security under climate change. *PNAS,* 11 12, Vol. 104(no.50), pp. 19703-19708.

Schneider, T., 2021. *What is a sensor different types of sensors applications.* [Online] Available at: https://sverige.energy/electrician/what-is-a-sensor-different-types-of-sensors-applications [Accessed 10 06 2021].

Servon, L. J., 2002. *Bridging the digital divide: Technology, community and public Policy.* Oxford, UK: Blackwell Publishing.

Shapiro, J., 2006. Smart Cities: Quality of Life, Productivity, and the Growth Effects of Human Capital. *The Review of Economics and Statistics,* 88(2), pp. 324-335.

Shepherd, J., 2009. *Geoengineering the climate: science governance and uncertainty,* London: The Royal Society.

Shilu, T. et al., 2016. Climate change, food, water and population health in China. *Bulletin of the World Health Organization,* 10, 94(10), p. 759–765.

Sikos, T. T. & Szendi, D., 2021. Kialakulhatnak-e okos falvak az Abaúji térségben?. *Tér és Társadalom,* 35(3), pp. 154-181.

Sinden, A., 2007. Climate Change and Human Rights. *Journal of Land, Resources & Environmental Law,* Legal Studies Research Paper Series(No. 2008-49).

SmartEcoCity, 2022. *SmartEcoCity Index.* [Online] Available at: https://www.smartecocity.com/smartecocity-index/ [Accessed 10 08 2022].

Statista, 2021. *Smart city initiative investment worldwide in 2018-2023.* [Online] Available at: https://www.statista.com/statistics/884092/worldwide-spending-smart-city-initiatives/ [Accessed 01 06 2021].

Stoica, V. & Ilas, A., 2009. Romanian Urban e-Government. Digital Services and Digi-tal Democracy in 165 Cities. *Electronic Journal of e-Government,* 7(2), pp. 171 - 182.

Stübinger , J. & Schneider, L., 2020. Understanding Smart City—A Data-Driven Literature Review. *Sustainability,* 12(20), pp. 1-23.

Su, K., Li, J. & Fu , H., 2011. Smart city and the applications. *International Conference on Electronics, Communications and Control (ICECC),* pp. 1028-103.

Sugár, P., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Sydeman, W. J. & Bograd, S. J., 2009. Marine ecosystems, climate, and phenology: introduction. *Marine Ecology Progress Series,* Volume 393, pp. 185-188.

Szántó, Z. O. & Kocsis, J. B., 2019. *Smart cities and social futuring,* Budapest: Corvinus University of Budapest, Social Futuring Center.

Széles, A., 2022. *Smart City Soltions - Interview* [Interview] 2022.

Szűcs, A., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Thales, 2021. *Secure, sustainable smart cities and the IoT.* [Online] Available at: https://www.thalesgroup.com/en/markets/digital-identity-and-security/iot/inspired/smart-cities [Accessed 23 05 2021].

Toh, C. K., 2022. Smart city indexes, criteria, indicators and rankings: An in-depth investigation and analysis. *IET Smart Cities,* 4(2), pp. 1-18.

Tóth-Birtan, C., 2022. *Smart City Solutions - Interview* [Interview] 2022.

Townsend, A., 2013. *Smart cities: Big data, civic hackers, and the quest for a new utopia.* New York: W.W. Norton & Co..

Tsolakis, N. & Anthopoulos, L., 2015. (2015). Ecocities: An Integrated System Dynamics Framework and a Concise Research Taxonomy. *Sustainable Cities and Society,* Volume 17, pp. 1-14.

TU - Vienna University of Technology Department of Spatial Planning, 2014. *European Smart Cities.* [Online] Available at: http://www.smart-cities.eu/?cid=2&ver=3 [Accessed 15 02 2022].

Tubiello, F. N. et al., 2014. *Agriculture, Forestry and Other Land Use Emissions by Sources and Removals by Sinks 1990-2011 Analysis.* Rome: Climate, Energy and Tenure Division, FAO.

Turner, G. & Alexander, C., 2014. *The Guardian.* [Online] Available at: https://www.theguardian.com/commentisfree/2014/sep/02/limits-to-growth-was-right-new-research-shows-were-nearing-collapse [Accessed 15 12 2020].

Turner, G. M., 2008. A comparison of The Limits to Growth with 30 years of reality. *Global Environmental Change,* 08, Volume 18(Issue 3), pp. 397-411 .

TWI, 2021. *What is a Smart City? – Definition and Examples.* [Online] Available at: https://www.twi-global.com/technical-knowledge/faqs/what-is-a-smart-city#SmartCityTechnologies [Accessed 25 05 2021].

U.S. DOT, 2017. *Smart City Challenge.* [Online] Available at: https://www.transportation.gov/smartcity [Accessed 02 06 2021].

U4SSC, 2017. *Collection Methodology for Key Performance Indicators for Smart Sustainable Cities,* s.l.: UN.

Uddin, G. A., Salahuddin, M., Alam, K. & Gow, J., 2017. Ecological footprint and real income: panel data evidence from the 27 highest emitting countries. *Ecological Indicators,* Volume 77, p. 166–175.

UN-Habitat III, 2017. *New Urban Agenda,* Quito: United Nations.

UN-Habitat, 2011. *Cities and Climate Change Global Report on Human Settlements 2011,* London: Earthscan Ltd..

UN-HABITAT, 2020. *World Cities Report 2020 The Value of Sustainable Urbanization,* Nairobi: United Nations Human Settlements Programme.

UN-Water, 2020. *Summary Progress Update 2021 – SDG 6 – water and sanitation for all,* Geneva: UN-Water.

UN, 2012. *The Future We Want,* Rio de Janeiro: UN.

UNDP, 1990. *Human Development Report 1990: Concept and Measurement of Human Development,* New York: UNDP.

UNEP, 1972. *Declaration of the United Nations Conference on the Human Environment,* Stockholm: UNEP.

UNEP, 2021. *Mitigation.* [Online] Available at: https://www.unep.org/explore-topics/climate-change/what-we-do/mitigation [Accessed 23 05 2021].

UNEP, 2021b. *Cities and Climate Change.* [Online] Available at: https://www.unep.org/explore-topics/resource-efficiency/what-we-do/cities/cities-and-climate-change [Accessed 25 05 2021].

UNESCO, 2021. *Sustainable Development.* [Online] Available at: https://en.unesco.org/themes/education-sustainable-development/what-is-esd/sd [Accessed 24 05 2021].

UNESCO, 2021b. *ICT.* [Online] Available at: http://uis.unesco.org/en/glossary-term/information-and-communication-technologies-ict [Accessed 10 06 2021].

UNFCC, 2021. *Global warming potentials.* [Online] Available at: https://unfccc.int/process/transpa rency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-war ming-potentials

UNFCCC, 2008. *Kyoto Protocol Reference Manual on Accounting of Emissions And Assigned Amount,* s.l.: United Nations Framework Convention on Climate Change.

UNFCCC, 2016. *NDC Registry.* [Online] Available at: https://www4.unfccc.int/sites/NDCStaging/Pages/All.aspx [Accessed 01 05 2021].

UNFCCC, 2021. *NDC Spotlight.* [Online] Available at: https://unfccc.int/process/the-paris-agreement/nationally-determined-contributions/ndc-spotlight#eq-1 [Accessed 21 04 2021].

UNFCCC, 2021b. *Global Warming Potentials (IPCC Second Assessment Report).* [Online] Available at: https://unfccc.int/process/transparency-and-reporting/greenhouse-gas-data/greenhouse-gas-data-unfccc/global-warming-potentials [Accessed 20 04 2021].

UNFCCC, 2022. *Race To Zero Campaign.* [Online] Available at: https://unfccc.int/climate-action/race-to-zero-campaign#eq-4 [Accessed 01 08 2022].

UNISDR, 2009. *Global Assessment Report on Disaster Risk Reduction 2009 – Risk and Poverty in a Changing Climate: Invest Today for a Safer Tomorrow. United Nations International Strategy for Disaster Reduction (UNISDR,* Geneva, Switzerland: UNISDR Secretariat.

UNISDR, 2011. *Global Assessment Report on Disaster Risk Reduction 2011 – Revealing Risk, Redefining Development. United Nations International Strategy for Disaster Reduction (UNISDR),* Geneva, Switzerland: UNISDR Secretariat.

United Nations Human Settlements Programme, 2017. *Sustainable Urbanization in the Paris Agreement.* Nairobi: UN-Habitat.

United Nations, 1972. *Report of the United Nations Conference on the Human Environment,* Stockholm: United Nations Publication.

United Nations, 1987. *Report of the World Commission on Environment and Development: Our Common Future,* s.l.: United Nations Publications.
United Nations, 1993. *Report of the United Nations Conference on Environment and Development,* New York: United Nations.
United Nations, 1997. *Kyoto Protocol to the United Nations Framework Convention on Climate Change,* Kyoto: UN.
United Nations, 2012. *The Future We Want,* Rio de Janeiro: United Nations.
United Nations, 2015. *The Millennium Development Goals Report 2015 Summary,* New York: United Nations.
United Nations, 2015b. *The UNECE–ITU Smart Sustainable Cities Indicators,* Geneva: UN.
United Nations, 2018. *Tracking Progress Towards Inclusive, Safe, Resilient and Sustainable Cities and Human Settlements,* Nairobi: United Nations.
United Nations, 2020. *THE 17 GOALS.* [Online] Available at: https://sdgs.un.org/goals [Accessed 11 12 2020].
United Nations, 2020b. *Climate Action.* [Online] Available at: https://www.un.org/en/climatechange/climate-solutions/cities-pollution [Accessed 10 05 2021].
United Nations, 2021. *History.* [Online] Available at: https://sdgs.un.org/goals [Accessed 25 01 2021].
United Nations, 2021b. *Act Now.* [Online] Available at: https://www.un.org/en/actnow/ [Accessed 01 05 2021].
UNSTAT, 2021. *Global indicator framework for the Sustainable Development Goals and targets of the 2030 Agenda for Sustainable Development.* [Online] Available at: https://unstats.un.org/sdgs/indicators/indicators-list/
URBACT, 2021. *The chart of the smart cities in Romania still has the same leader: Alba Iulia.* [Online] Available at: https://urbact.eu/chart-smart-cities-romania-still-has-same-leader-alba-iulia [Accessed 27 08 2022].
Vairavamoorthy, K., Gorantiwar, S. D. & Pathirana, A., 2008. Managing urban water supplies in developing countries – climate change and water scarcity scenarios. *Physics and Chemistry of the Earth, Parts A/B/C,* 33(5), pp. 330-339.
Vanham, D. et al., 2019. Environmental footprint family to address local to planetary sustainability and deliver on the SDGs. *Science of The Total Environment,* Volume 693, pp. 1-12.

Vanolo, A., 2014. Smartmentality: The Smart City as Disciplinary Strategy. *Urban Studies,* 51(5), pp. 883-898.

Varga, Á., 2018. *Mérlegen az okosság - Mitől okos egy város?.* Budapest: s.n.

Varga, I. & Tettamanti, T., 2016. A jövô intelligens jármûvei és az infokommunikáció hatása. *Híradástechnika,* Volume LXXI., pp. 59-63.

Vegacomp, 2021. *Mapping of Smart Counties, Cities and Villages in Romania,* Bucharest: Vegacomp Consulting.

Vida, R., 2018. Okos energetika. In: G. Sallai, ed. *Az okos város (Smart City).* Budapest: Dialóg Campus Kiadó, pp. 141-152.

Vienna UT, 2007. *Smart cities Ranking of European medium-sized cities,* Vienna: Centre of Regional Science.

Viitanen, J. & Kingston, R., 2014. Smart cities and green growth: outsourcing democratic and environmental resilience to the global technology sector. *Environment and Planning A,* 46(4), pp. 803-819.

Vörösmarty, C. J., Green, P., Salisbury, J. & Lammers, R. B., 2000. Global Water Resources: Vulnerability from Climate Change and Population Growth. *Science,* 14 06, Vol. 289(No. 5477), pp. 284-288.

Vossen, M., 2020. Nuclear Energy in the Context of Climate Change: A Frame Analysis of the Dutch Print Media. *Journalism Studies,* Volume 21(Issue 10), pp. 1439-1458.

Waart, P., Mulder, I. & Bont, D. C., 2015. A participatory approach for envisioning a smart city. *Social Science Computer Review,* 34(6), pp. 708-723.

Wackernagel, M. et al., 2002. Tracking the ecological overshoot of the human economy. *Proc Natl Acad Sci USA,* 99(14), p. 9266–9271.

Wackernagel, M., Lewan, L. & Hansson, C. B., 1999. Evaluating the Use of Natural Capital with the Ecological Footprint: Applications in Sweden and Subregions. *Ambio,* Vol.28(No.7), pp. 604-612.

Ward, D. S. & Mahowald, N. M., 2014. Contributions of developed and developing countries to global climate forcing and surface temperature change. *Environmental Research Letters,* Volume 9, pp. 1-10.

Washburn, D. et al., 2010. *Helping CIOs understand "smart city" initiatives: Defining the smart city, its drivers, and the role of the CIO.* Cambridge: Forrester Research Inc.

WEF, 2018. *The Global Risks Report 2018,* Geneva, Switzerland: WEF.

WEF, 2020. *The Global Risks Report 2020,* Geneva, Switzerland: WEF.

WEF, 2021. *The Global Risks Report 2021,* Geneva, Switzerland: World Economic Forum.

Wei, T. et al., 2015. Developed and Developing World Contributions to Climate System Change Based on Carbon Dioxide, Methane and Nitrous Oxide Emissions. *Advances in Atmospheric Sciences,* Volume Vol.33., pp. 632-643.

WHO; WMO, 2012. *Atlas of Health and Climate. WMO No. 1098,* Geneva, Switzerland: WHO Press.

Wiedmann, T. & Minx, J., 2008. A Definition of 'Carbon Footprint'. In: C. C. Pertsova, ed. *Ecological Economics Research Trends.* Hauppauge(NY): Nova Science Publishers, pp. 1-11.

Wiig, A., 2016. The empty rhetoric of the smart city: from digital inclusion to economic promotion in Philadelphia. *Urban Geography,* 37(4), pp. 535-553.

Wilbanks, T. J. & Kates, R. W., 1999. Global change in local places: how scale matters. *Climatic Change,* Volume 43, p. 601–628.

Willems, P. et al., 2012. *Impacts of Climate Change on Rainfall Extremes and Urban Drainage Systems.* London: International Water Association (IWA) Publishing.

World Bank, 2017. *Climate Finance: Strategy.* [Online] Available at: http://www.worldbank.org/en/topic/climatefinance#2 [Accessed 05 04 2018].

World Bank, 2018. *Projects & Programs.* [Online] Available at: http://www.worldbank.org/en/topic/climatechange/projects [Accessed 05 04 2018].

World Bank, 2019. *Urban population (% of total population).* [Online] Available at: https://data.worldbank.org/indicator/SP.URB.TOTL.IN.ZS [Accessed 24 11 2020].

World Bank, 2019b. *Climate Finance.* [Online] Available at: https://www.worldbank.org/en/topic/climatefinance#3 [Accessed 10 11 2020].

World Economic Forum, 2020. *The Global Risks Report 2020,* s.l.: WEF.

World Resource Institute, 2020. *4 Charts Explain Greenhouse Gas Emissions by Countries and Sectors.* [Online] Available at: https://www.wri.org/insights/4-charts-explain-greenhouse-gas-emissions-countries-and-sectors [Accessed 01 05 2021].

World Resource Institute, 2020. *World Greenhouse Gas Emissions: 2016.* [Online] Available at: wri.org/data/world-greenhouse-gas-emissions-2016 [Accessed 01 05 2021].

Worth, R. F., 2010. *Earth is parched where Syrian farms thrived.* [Online] Available at: https://www.n
ytimes.com/2010/10/14/world/middleeast/14syria.html?_r=2&adxnnl=1&adxnnl
x=1330449407-yAiPXrD1kQsKbG2Bb5A61A&pagewanted=1 [Accessed 11 07 2019].

Xiaomi, 2022. *Smart home.* [Online] Available at: https://xiaomiofficial.hu/okosotthon-iot/ [Accessed 01 08 2022].
XIII. kerületi Önkormányzat, 2022. *Közösségi költségvetés 2022.* [Online] Available at: https://www.budapest13.hu/kozossegi-koltsegvetes-2022/ [Accessed 10 08 2022].

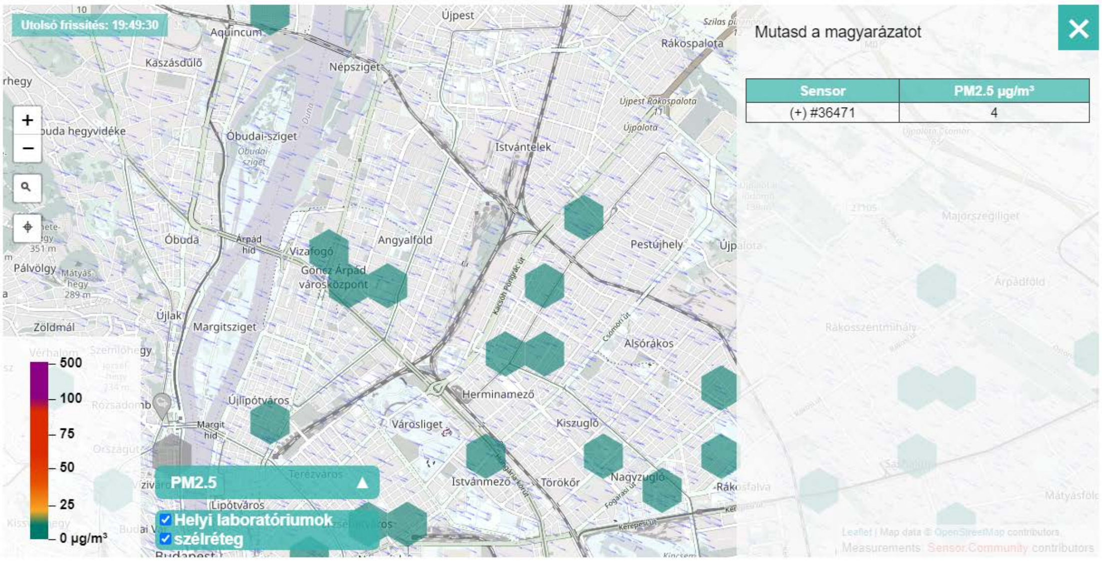
Sensors

Source: (Kocsis, 2022)

- Air quality sensor in the education (board model, prototype sensor outside-inside, dashboard, educational usage)


Nemzeti
Együttműködési
Alap
Miniszterelnökség
Bethlen Gábor
Alapkezelő Zrt.


Nemzeti
Együttműködési
Alap
Miniszterelnökség
Bethlen Gábor
Alapkezelő Zrt.



- Groundwater metering (board model, actual sensor operates in Hortobágy National Park)


M4
M9


EVE
EVE

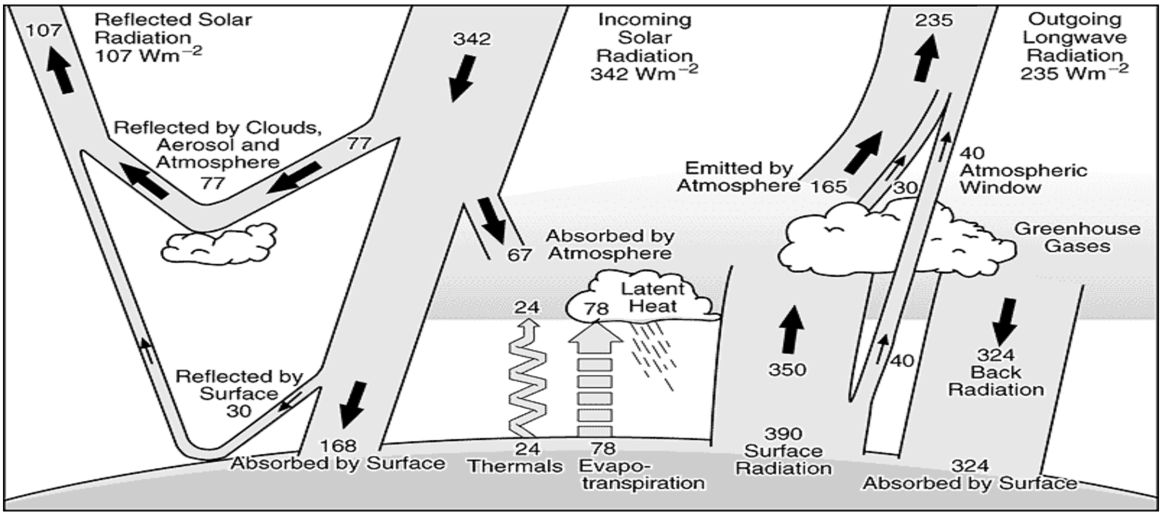
APPENDIX

Appendix 1: Climate Change extended introduction

A) Climate, Earth's Energy Budget, Greenhouse effect

The Earth solar powered climate system works as it presented in Figure 19. The mainly short-wave ultraviolet radiation from the sun heats the Earth, and this radiation is absorbed at three levels, the first is the atmosphere (~19,5 % of the radiation), the second is the clouds – aerosol level (~3%) and the third level is the surfaces level where around 49 % of the incoming radiation is absorbed. These three levels in the meantime reflects back directly around 30% of the incoming solar energy, the Earth's surface (for example by the ice) reflects back around 10%, which ratio is shrinking year by year (Kiehl & Trenberth, 1997).

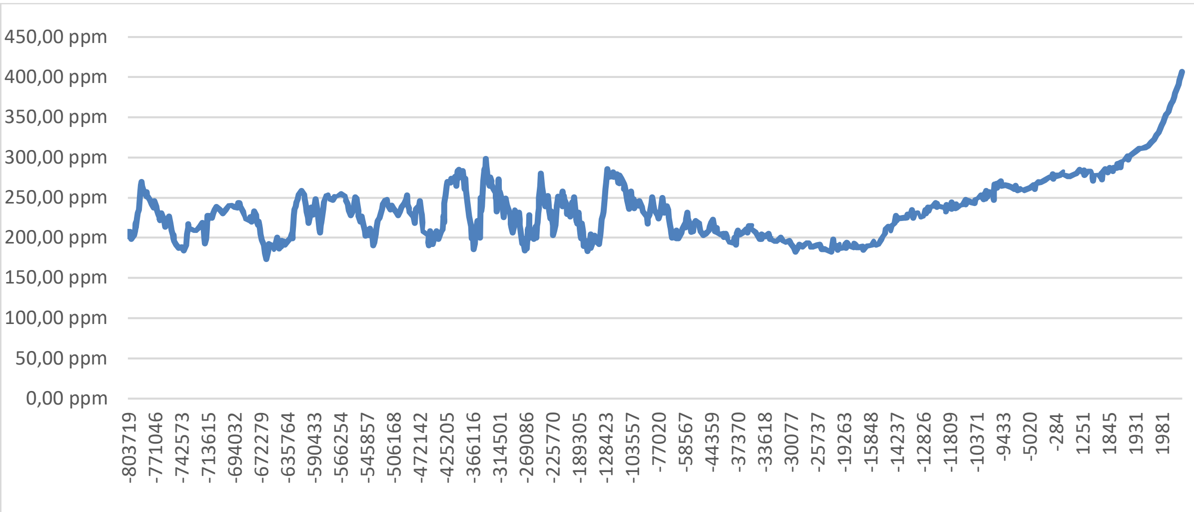
23. Figure: Schematic showing of the Earth's annual and global mean energy balance



Source: (Kiehl & Trenberth, 1997, p. 206)

The Greenhouse effect responsible for trap the heat in the atmosphere from the incoming and from the re-radiated solar energy by using a certain combination or concentration of greenhouse gases (GHGs). In case of high IRF and a strong Global Temperature change Potentials (GTP), the concentration change of CO_2 is crucial, while it has strong warming effect within a 200-year long timeframe. In Figure 20. the concentration of CO_2 is presented in yearly average, and it is estimated back to BCE period. The first half of the graph shows cyclical fluctuation[61] in the concentration but never overtake the 300 ppm, which represent and proof that there are natural climate change periods within the Earth lifetime (ice ages - low CO2 and interglacials - high CO2) (Bereiter, et al., 2015). Since the Industrial Revolution the CO_2 concentration is rapidly increasing (Ritchie & Roser, 2017), and on May 9, 2013, on Mauna Loa the day average and in April 2014, the month average, the 400 ppm has been reached (National Geographic, 2019). In February 2021, this number was 415.88 ppm (Dlugokencky & Tans, 2021). That notable change generally occurs hundreds or thousands of years, but for mankind it took for decades. This is the proof of the contributions of the main human activities in the global warming process.

24. Figure: Atmospheric CO_2 concentration (annual) from 803,719 BCE to 2018

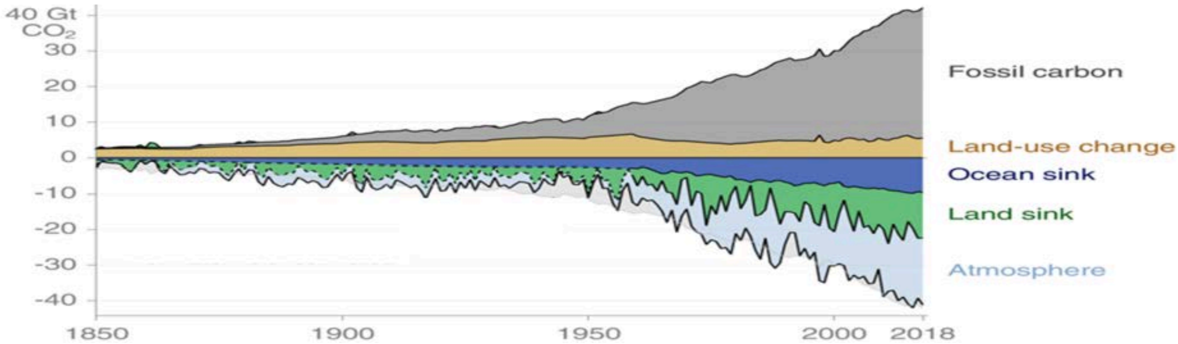


Source: Own edition based on NOAA (Dlugokencky & Tans, 2021)

These human activities and approaches, put the general natural Carbon Cycle into deficit (Figure 21.), where the emitted CO_2 (from Fossil carbon, Land-use change) cannot be sink naturally (by oceans, land and the atmosphere). This tendency urges the development of new technological solutions, such as carbon capturing systems.

[61] Caused by Milankovitch cycles.

25. Figure: CO_2 source and sinks from 1850 to 2018

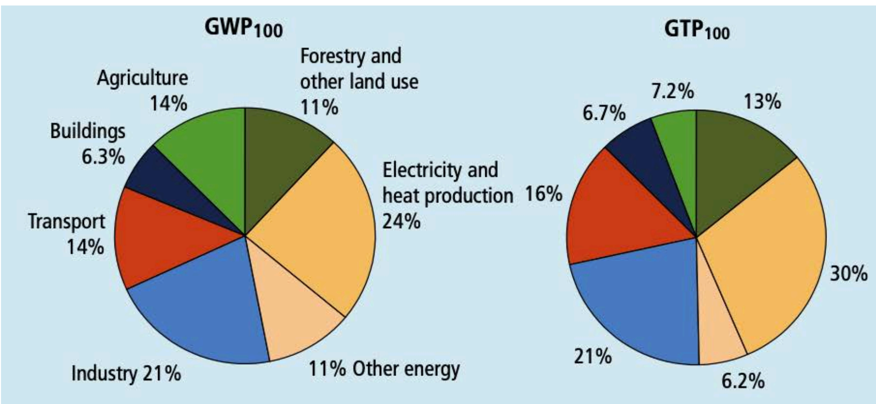


Source: CDIAC/GCP/NOAA-ESRL/UNFCCC/BP/USGS (Global Carbon Project, 2019)

B) Sectors' contribution to GHG emission in case of GWP, GTP

In Figure 22. the GWP (global warming potential) and the GTP (global temperature change potential) indices in 2010 are presented to show the ratio of the sectors and their warming effects. The dominant warming potential of the Energy sector is similar like the emission share for the total GHGs emission in case of CO_2e. However, the warming potential of the land use change and the agricultural production overweight the climatic change compared to the share of the emitted GHGs (IPCC, 2014, p. 88).

26. Figure: Contribution by sectors to total GHG emissions (GWP_{100}, GTP_{100})



Source: (IPCC, 2014, p. 88)

This graph shows that the main sectors, where significantly high global warming potential GHGs emission saving could be achieved. They are Energy and Transport, Industrial activities and Agriculture and Land use change. Potential Smart solutions are existing for all these areas (such as sensors, electric vehicles, smart agriculture, etc.) In the case of city management, the efficient and monetarised energy use, and a well-constructed transportation system are the key areas to tackle climate change.

C) Available Financial Support

The focus of the framework is the global joint action through the appropriate locally specified mitigation and adaptation processes (local actions) and the necessary and sufficient joint finance. One of the most important financial supports for mitigation and adaptation is the Green Climate Fund (GCF). It operates with more than 30 billion US$ and promoting mitigation and adaptation projects. It has already supported 173 projects, which helped to increase resilience for 498 million people and avoid 1,8 billion CO_2 equivalent GHGs emission. It supports mainly small and medium projects (33% - 41%) and it offers grants and loans (44%-43%) beside equities, results-based payments, guarantees. The main field in case of number of projects is Livelihoods of people and communities, which has been supported with 109 projects around 1 billion US$. In case of financial support, the main field is Energy generation and access, with 49 projects and 2,5 billion US$ (GCF, 2021). As this Fund shows as well, international cooperation is constrained by climate change more vigorously and it links several fields together (economy, law, social and natural science, technology etc.) and does not focus on them separately, it formed a more complex approach.

Appendix 2: Greenhouse gases and Sectors/source categories

Carbon dioxide	CO2
Methane	CH4
Nitrous oxide	N2O
Hydrofluorocarbons	HFCs
Perfluorocarbons	PFCs
Sulphur hexafluoride	SF6

Energy	Fuel combustion • Energy industries • Manufacturing industries and construction • Transport • Other sectors • Other
	Fugitive emissions from fuels • Solid fuels • Oil and natural gas • Other
Industrial processes	Mineral products Chemical industry Metal production Other production Production of halocarbons and sulphur hexafluoride Consumption of halocarbons and sulphur hexafluoride Other
Solvent and other product use	
Agriculture	Enteric fermentation Manure management Rice cultivation Agricultural soils Prescribed burning of savannas Field burning of agricultural residues Other
Waste	Solid waste disposal on land Wastewater handling Waste incineration Other

Source: own edition based (UNFCCC, 2008, p. 106)

Appendix 3: EU-28 Total GHGs emission in MtCO2e between 1990-2018

Country/ Region	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Austria	**MtCO 2e**	62,79	66,99	61,2	61,12	61,22	63,69	67,41	66,4	66,38	64,56	64,76	76,39	77,69	82,77
Belgium	**MtCO 2e**	126,81	131,76	129,84	127,66	133,02	133,19	138,55	135,36	138,13	134,27	134,3	135,68	128,4	131,8
Bulgaria	**MtCO 2e**	76,59	59,37	53,5	52,02	48,13	49,35	49,88	47,36	43,51	36,58	35,97	36,61	33,96	38,75
Croatia	**MtCO 2e**	27,85	21,34	22,36	23,25	23,33	24,61	23,96	25,44	25,8	25,41	24,49	25,3	26,3	27,4
Cyprus	**MtCO 2e**	5,35	5,87	6,29	6,56	6,81	6,7	7,08	7,17	7,49	7,77	8,03	7,76	7,99	8,65
Czech Republic	**MtCO 2e**	172,9	156,17	151,72	147	139,71	139,69	141,3	138,79	132,16	124,05	134,68	136,91	131,29	135,6
Denmark	**MtCO 2e**	68,51	79,13	72,94	75,5	79,2	76,11	89,58	79,91	75,85	73,01	68,8	69,7	69,44	74,87
Estonia	**MtCO 2e**	37,37	33,58	25,79	19,99	19,11	17,42	18,3	17,88	17,37	16,43	16,08	16,56	16,15	18,1
Finland	**MtCO 2e**	38,27	38,18	35,07	36,31	42,92	38,94	45,39	43,45	39,81	39,13	37,79	58,93	61,32	69,47
France	**MtCO 2e**	477,92	502,72	487,97	469,18	463,44	472,18	490,93	480,98	497,02	486,59	483,67	447,09	439,49	444,4
Germany	**MtCO 2e**	1109,28	1079,69	1032	1024,31	1011,41	1004,79	1032,92	994,92	968,6	934,16	924,72	973,21	954,76	953,7
Greece	**MtCO 2e**	94,44	94,55	96,63	97	99,62	104,03	105,1	106,21	110,45	111,37	117,05	117,43	117,81	121,1
Hungary	**MtCO 2e**	90,74	85,72	75,77	76,32	75,97	74,3	76,57	74,9	74,76	75,48	72,67	75,63	73,79	76,67
Ireland	**MtCO 2e**	54,11	54,68	54,89	55,54	57,02	57,85	59,34	60,84	64,24	65,8	68,77	71,35	70,62	70,9
Italy	**MtCO 2e**	456,75	454,34	451,12	444,81	439,52	464,51	460,76	464,54	475,84	483,07	488	485,95	494,23	512,8
Latvia	**MtCO 2e**	12,38	10,66	7,97	4,78	1,8	0,13	0,12	-0,44	-0,87	-1,52	-2,21	-2,87	-2,83	-2,69
Lithuania	**MtCO 2e**	45,88	47,61	32,84	26,92	24,9	23,29	24,04	23,81	24,69	21,94	20,23	20,16	20,52	20,69
Luxembourg	**MtCO 2e**	11,56	12,04	11,72	11,93	11,09	8,94	9,02	8,52	7,84	8,23	8,85	9,44	10,23	10,63
Malta	**MtCO 2e**	2,52	2,43	2,41	3,05	2,76	2,62	2,57	2,73	2,63	2,67	2,41	2,78	2,62	2,92
Netherlands	**MtCO 2e**	205,44	210,79	210,18	215,69	215,43	220,82	231,75	222,95	223,08	210,62	208,55	209,35	208,85	208,8
Poland	**MtCO 2e**	429,16	424,94	414,15	413,64	408,95	408,44	423,05	412,81	382,95	372,24	358,79	300,69	292,88	304,8
Portugal	**MtCO 2e**	57,84	59,56	63,58	62,5	64,41	68,18	66,63	68,93	74,08	80,82	80,33	78,72	83,6	78,71
Romania	**MtCO 2e**	245,92	203,46	182,02	170,57	167,11	172,66	175,94	163,31	145,8	130,19	134,81	138,07	134,98	140,8
Slovakia	**MtCO 2e**	57,56	49,51	46,97	44,27	41,56	42,15	42,19	42	40,81	39,35	36,76	38,43	37,87	38,16
Slovenia	**MtCO 2e**	8,35	7,32	7,06	7,77	7,85	8,72	9,54	10,02	9,75	9,06	8,76	7,5	7,57	7,54
Spain	**MtCO 2e**	232,63	238,82	248,65	233,85	246,79	260,7	254,16	275,71	285,23	309,99	327,4	348,65	365,39	374,5
Sweden	**MtCO 2e**	70,26	70,91	73,46	73,42	75,23	74,78	80,33	74,08	74,87	73,6	69,41	54,79	56,12	57,11
United Kingdom	**MtCO 2e**	746,4	761,64	739,51	722,61	711,75	702,55	722,68	701,07	697,42	671,25	673,87	684,64	666,82	674,5
EU-28	**MtCO 2e**	5025,58	4963,78	4797,6	4707,57	4680,06	4721,34	4849,09	4749,7	4705,7	4606,12	4607,7	4624,85	4587,9	4683
EU-27	**MtCO 2e**	4279,18	4202,14	4058,1	3984,96	3968,31	4018,79	4126,41	4048,6	4008,3	3934,87	3933,9	3940,21	3921	4009

Data source CAIT

Countries/ Regions: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom

Sectors/Subsectors: Total including LUCF,

Gases: All GHG, Calculation: Total, Show data by Countries

Country /Region	unit	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Austria	MtCO2e	83,59	83,63	81,31	78,22	77,79	70,83	76,55	73,72	70,5	71,05	67,28	68,41	68,53	70,71	67,85
Belgium	MtCO2e	130,4	126,49	123,51	118,84	121,18	114,12	121,44	109,82	109,23	110,5	104,09	109,16	110,52	108,41	108,91
Bulgaria	MtCO2e	37,44	37,41	37,48	41,68	39,21	31,8	33,49	50,74	45,04	39,96	42,55	45,2	20,47	22,65	19,52
Croatia	MtCO2e	27,17	27,06	27,79	29,3	28,47	25,91	25,35	24,41	22,45	21,33	20,6	21,19	18,39	19,06	18,21
Cyprus	MtCO2e	8,6	8,74	8,85	9,17	9,36	9,18	8,87	8,56	8,05	7,38	7,77	7,83	8,29	8,43	8,35
Czech Republic	MtCO2e	136,2	133,11	134,09	137,06	132	124,37	127,45	128,14	124,74	119,45	116,73	118,65	118,28	118,3	117,03
Denmark	MtCO2e	68,54	64,69	72,46	67,65	64,17	61,36	61,79	54,51	49,44	50,98	46,73	44,65	49,19	47,02	46,73
Estonia	MtCO2e	18,26	18,41	17,18	21,2	19,66	16,26	20,26	14,54	13,31	15,72	14,39	11,95	20,21	20,86	20,56
Finland	MtCO2e	65,56	53,39	64,75	62,92	54,8	51,19	59,29	11,43	5,73	6,47	2,38	-1,07	62,88	60,02	61,43
France	MtCO2e	442	442,64	432,32	425,14	418,88	400,59	404,32	392,42	395,28	396,16	363,05	369,04	368,04	370,47	361,37
Germany	MtCO2e	933,8	909,39	915,88	886,8	889,47	832,31	862,97	823,34	837,46	854,7	814,43	818,22	820,7	803,18	776,61
Greece	MtCO2e	120,7	122,83	121,21	124,62	120,71	113,81	107,1	107,17	102,01	94,37	91,31	89,58	88,31	87,92	86,14
Hungary	MtCO2e	75,48	74,57	73,8	71,63	70,22	64,37	64,35	62,68	58,81	56,47	56,74	59,67	60,86	62,78	62,81
Ireland	MtCO2e	70,13	71,35	72,32	70,69	69,64	64,27	62,91	58,41	60,06	59,14	59,3	61,1	63,08	62,45	62,29
Italy	MtCO2e	523,9	525,16	512,76	506,06	491,14	442,26	450,75	439,93	422,08	390,27	370,58	381,49	398,64	393,01	386,78
Latvia	MtCO2e	-2,6	-2,44	-1,91	-1,48	-1,8	-2,59	-1,41	9,1	8,89	8,84	8,76	8,83	8,56	8,47	8,89
Lithuania	MtCO2e	21,64	22,78	22,9	23,9	23,33	19,74	20,55	13,92	13,83	12,94	12,46	12,71	18,21	18,11	18,21
Luxembourg	MtCO2e	12,07	12,3	12,11	11,52	11,44	10,86	11,46	11,59	11,34	10,81	10,32	9,81	9,5	9,64	9,94
Malta	MtCO2e	2,92	2,97	3,05	3,14	3,08	2,89	2,99	2,98	3,16	2,83	2,84	2,16	1,86	2,01	2,03
Netherlands	MtCO2e	210,3	204,7	200,03	199,91	197,69	192,44	203,24	190,26	188,48	188,06	180,75	189,7	189,52	185,91	179,99
Poland	MtCO2e	309	310,64	324,47	324,46	318,18	302,33	320,3	360,67	353,7	348,35	335,26	339,15	344,31	357,17	356,74
Portugal	MtCO2e	80,6	83,7	78,41	76,99	74,74	73,87	68,6	66,31	64,62	62,92	62,51	66,64	66,81	71,77	67,15
Romania	MtCO2e	137,9	136,3	137,74	133,95	131,91	115,28	112,18	-165,52	-168,24	-177,81	-178,7	-177,03	82,96	85,69	86,13
Slovakia	MtCO2e	37,5	38,39	37,92	36,94	36,81	33,17	34,76	34,06	31,75	32,39	29,74	30,16	37,52	39,42	38,86
Slovenia	MtCO2e	7,76	7,96	8,33	8,26	9,25	7,26	7,56	16,4	15,79	15,15	13,6	13,68	17,48	17,65	17,51
Spain	MtCO2e	390,7	405,41	399,28	415,54	382,32	345,5	330,31	340,98	334,71	308,62	307,09	317,67	301,97	318,35	313,06
Sweden	MtCO2e	55,69	52,14	50,61	48,52	47,38	43,5	49,08	33,83	30,98	29,28	27,95	27,85	32,87	32,5	30,05
United Kingdom	MtCO2e	669,8	663,91	661,01	645,52	625,56	570,73	583,6	540,98	562,45	543,71	502,84	486,78	464,28	450,24	441,13
EU-28	MtCO2e	4675	4637,63	4629,66	4578,15	4466,59	4137,61	4230,11	3815,38	3775,65	3680,04	3493,3	3533,18	3852,24	3852,2	3774,3
EU-27	MtCO2e	4005	3973,72	3968,65	3932,63	3841,03	3566,88	3646,51	3274,4	3213,2	3136,33	2990,5	3046,4	3387,96	3402	3333,2

Source: own edition based (Climate Watch Data, 2021)

Appendix 4: UNECE-ITU Smart Sustainable Cities Indicators

Area	Topic	Indicator	Typology
ECONOMY	T1.1 ICT infrastructure	C1.1.1 Internet access in households	core
		A1.1.1 Electronic devices penetration	core
		A1.1.2 Wireless broadband subscriptions	additional
		A1.1.3 Fixed broadband subscriptions	additional
	T1.2 Innovation	C1.2.1 R&D expenditure	core
		C1.2.2 Patents	core
	T1.3 Employment	C1.3.1 Employment trends	core
		A1.3.1 Creative industry employment	additional
		A1.3.2 Tourism industry employment	additional
	T1.4 Trade – eCommerce	C1.4.1 e-Commerce transactions	core
		A1.4.1 Electronic and mobile payment	additional
		T1.4 Trade – export/import	additional
		A1.4.2 Knowledge-intensive export/import	additional
	T1.5 Productivity	A1.5.1 Companies providing eservices	additional
		A1.5.2 Computing platforms	additional
		A1.5.3 SMEs trends	additional
	T1.6 Physical infrastructure – piped water	16 C1.6.1 Smart water meters	core
		A1.6.1 Water system leakages	additional
	T1.6 Physical infrastructure – electricity	C1.6.2 Smart electricity meters	core
		C1.6.3 Reliability of electricity system	core
	T1.6 Physical infrastructure – health	A1.6.2 Sporting infrastructure	additional
	T1.6 Physical infrastructure – transport	C1.6.4 Public transport system	core
		C1.6.5 Road traffic efficiency	core
		C1.6.6 Real-time public transport information	core
		C1.6.7 Share of EVs	core
		A1.6.3 Traffic monitoring	additional
	T1.6 Physical infrastructure – buildings	A1.6.4 Integrated management in public buildings	additional
Environment	T2.1 Air quality	C2.1.1 Air pollution	core
		A2.1.1 Air pollution monitoring system	addition
		C2.1.2 GHG emissions	core
	T2.2 Water	C2.2.1 Quality of water resources	core
		2.2.1 Water saving in households	additional
		C2.2.2 Waste water treatment	core
		C2.2.3 Household sanitation	core
		A2.2.2 Drainage system management	additional
	T2.3 Noise	C2.3.1 Exposure to noise	core
		A2.3.1 Noise monitoring	additional

	T2.4 Environmental quality	C2.4.1 EMF consideration	core
		C2.4.2 Solid waste treatment	core
		C2.4.3 Perception on environmental quality	core
	T2.5 Biodiversity	C2.5.1 Green areas and public spaces	core
		C2.5.2 Native species monitoring	core
		A2.5.1 Protected natural areas	additional
	T2.6 Energy	C2.6.1 Renewable energy	core
		A2.6.1 Renewable energy generation	additional
		A2.6.2 Energy saving in households	additional
Society and Culture	T3.1 Education	C3.1.1 Students' ICT capability	core
		C3.1.2 Adult literacy trends	core
		C3.1.3 Higher education ratio	core
		A3.1.1 e-learning systems	additional
	T3.2 Health	C3.2.1 Electronic records	core
		C3.2.2 Sharing of medical resources	core
		A3.2.1 Adoption of telemedicine	additional
		C3.2.3 Life expectancy core	core
		C3.2.4 Maternal mortality trends	core
		A3.2.2 In-patient hospital beds	additional
		A3.2.3 Health insurance	additional
	T3.3 Safety – disaster relief	C3.3.1 Vulnerability assessment	core
		C3.3.2 Disaster mitigation plans	core
	T3.3 Safety – emergency	C3.3.3 Emergency response	core
		A3.3.1 Disaster and emergency alert	additional
	T3.3 Safety – ICT	C3.3.4 Information security and privacy protection	core
		A3.3.2 Child Online Protection (COP)	additional
	T3.4 Housing	C3.4.1 Housing expenditure	core
		C3.4.2 Slums reduction	core
	T3.5 Culture	C3.5.1 Smart libraries	core
		C3.5.2 Culture infrastructure	core
		C3.5.1 Protected cultural heritage sites	additional
	T3.6 Social inclusion	C3.6.1 Public participation	core
		C3.6.2 Gender income equity	core
		C3.6.3 Opportunities for people with special needs	core
		C3.6.4 Attractiveness for skilled people	core
		A3.6.1 Gini coefficient	additional

Source: own edition based (United Nations, 2015b)

Appendix 5: Benchmarks models

Smart/Sustainable City Model	Characteristics (sectors)	Factors (domains)	Indicators (Components)
European Smart Cities 3.0	Smart Economy	Innovative spirit	3
European Smart Cities 3.0	Smart Economy	Entrepreneurship	3
European Smart Cities 3.0	Smart Economy	Economic image & trademarks	1
European Smart Cities 3.0	Smart Economy	Productivity	3
European Smart Cities 3.0	Smart Economy	Flexibility of labour market	3
European Smart Cities 3.0	Smart Economy	International embeddedness	2
European Smart Cities 3.0	Smart Mobility	Local accessibility	3
European Smart Cities 3.0	Smart Mobility	(Inter-)national accessibility	1
European Smart Cities 3.0	Smart Mobility	Availability of IT-Infrastructure	3
European Smart Cities 3.0	Smart Mobility	Sustainability of the transport system	4
European Smart Cities 3.0	Smart Environment	Environmental conditions	2
European Smart Cities 3.0	Smart Environment	Air quality (no pollution)	3
European Smart Cities 3.0	Smart Environment	Ecological awareness	3
European Smart Cities 3.0	Smart Environment	Sustainable resource management	2
European Smart Cities 3.0	Smart People	Level of qualification	2
European Smart Cities 3.0	Smart People	Lifelong learning	3
European Smart Cities 3.0	Smart People	Ethnic plurality	2
European Smart Cities 3.0	Smart People	Open-mindedness	4
European Smart Cities 3.0	Smart Living	Cultural facilities	3
European Smart Cities 3.0	Smart Living	Health conditions	6
European Smart Cities 3.0	Smart Living	Individual security	2
European Smart Cities 3.0	Smart Living	Housing quality	3

European Smart Cities 3.0	Smart Living	Education facilities	5
European Smart Cities 3.0	Smart Living	Touristic attractiveness	1
European Smart Cities 3.0	Smart Living	Economic welfare	5
European Smart Cities 3.0	Smart Governance	Participation public life	4
European Smart Cities 3.0	Smart Governance	Public and social services	2
European Smart Cities 3.0	Smart Governance	Transparent governance	3
Smart City Wheel	Smart Economy	Entrepreneurship & Innovation	Number of new opportunity-based startup/year
Smart City Wheel	Smart Economy	Entrepreneurship & Innovation	% GDP invested in R&D in private sector
Smart City Wheel	Smart Economy	Entrepreneurship & Innovation	% of people in full-time employment
Smart City Wheel	Smart Economy	Entrepreneurship & Innovation	Innovation cities index
Smart City Wheel	Smart Economy	Productivity	Gross Regional Product per capita
Smart City Wheel	Smart Economy	Local and Global Connection	% of GRP based on technology exports
Smart City Wheel	Smart Economy	Local and Global Connection	Number of international congresses and fairs attendees
Smart City Wheel	Smart Mobility	Efficient Transport	km of bicycle paths and lanes per 100.000
Smart City Wheel	Smart Mobility	Efficient Transport	# of shared bicycles per capita
Smart City Wheel	Smart Mobility	Efficient Transport	# of shared vehicles per capita
Smart City Wheel	Smart Mobility	Efficient Transport	# of EV charging stations within the city
Smart City Wheel	Smart Mobility	Multi-modal Access	Annual # of public transport trips per capita
Smart City Wheel	Smart Mobility	Multi-modal Access	% non-motorized transport trips of total transport
Smart City Wheel	Smart Mobility	Multi-modal Access	Integrated fare system for public transport
Smart City Wheel	Smart Mobility	Technology Infrastructure	Presence of demand-based pricing
Smart City Wheel	Smart Mobility	Technology Infrastructure	% of traffic lights connected to real-time traffic management system
Smart City Wheel	Smart Mobility	Technology Infrastructure	# of public transit services that offer real time information to the public
Smart City Wheel	Smart Mobility	Technology Infrastructure	Availability of multi-modal transit app with at least 3 services integrated
Smart City Wheel	Smart Environment	Smart Buildings	Number of LEED or BREAM sustainability certified buildings in the city
Smart City Wheel	Smart Environment	Smart Buildings	% of commercial and industrial buildings with smart meters
Smart City Wheel	Smart Environment	Smart Buildings	% of commercial buildings with a building automation system
Smart City Wheel	Smart Environment	Smart Buildings	% of homes with smart meters
Smart City Wheel	Smart Environment	Resource Management	%of total energy derived from renewable sources
Smart City Wheel	Smart Environment	Resource Management	Total residential energy use per capita

Smart City Wheel	Smart Environment	Resource Management	% of municipal grid meeting all of following requirements for smart grid
Smart City Wheel	Smart Environment	Resource Management	Supports for addressing system outages
Smart City Wheel	Smart Environment	Resource Management	GHG emissioned measured in tonnes per capita
Smart City Wheel	Smart Environment	Resource Management	Fine particular matter 2.5 concentration
Smart City Wheel	Smart Environment	Resource Management	% of city's solid waste that is recycled
Smart City Wheel	Smart Environment	Resource Management	Total collected municipal solid waste city per capita (in kg)
Smart City Wheel	Smart Environment	Resource Management	% of commercial buildings with smart water meters
Smart City Wheel	Smart Environment	Resource Management	Total water consumption per capita
Smart City Wheel	Smart Environment	Sustainable Urban Planning	Does your city have a public climate resilience strategy/plan in place?
Smart City Wheel	Smart Environment	Sustainable Urban Planning	Population weighted density
Smart City Wheel	Smart Environment	Sustainable Urban Planning	Green areas per 100.000 (in m2)
Smart City Wheel	Smart People	Inclusion	% of Internet-connected households
Smart City Wheel	Smart People	Inclusion	% of residents with smartphone access
Smart City Wheel	Smart People	Inclusion	# of civic engagement activities offered by the municipality last year
Smart City Wheel	Smart People	Inclusion	Voter participation in last municipal election
Smart City Wheel	Smart People	Education facilities	% of students completing secondary education
Smart City Wheel	Smart People	Education facilities	Number of higher education degrees per 100.000 inhabitants
Smart City Wheel	Smart People	Creativity	% of population born in a foreign country
Smart City Wheel	Smart People	Creativity	# of officially registered ENOLL living labs
Smart City Wheel	Smart People	Creativity	% of labor force engaged in creative industries
Smart City Wheel	Smart Living	Culture and Well-being	% of inhabitants with housing deficiency in any of 5 area
Smart City Wheel	Smart Living	Culture and Well-being	Gini coefficient of inequality
Smart City Wheel	Smart Living	Culture and Well-being	Mercer ranking in most recent quality of life survey
Smart City Wheel	Smart Living	Culture and Well-being	% of municipal budget allocated to culture
Smart City Wheel	Smart Living	Safety	Violent crime rate per 100.000 population
Smart City Wheel	Smart Living	Safety	# technologies in use to assist with crime prevention
Smart City Wheel	Smart Living	Health	% of residents with single, unified health histories facilitating patient and health provider access to complete medical records
Smart City Wheel	Smart Living	Health	Average life expectancy
Smart City Wheel	Smart Governance	Online Services	% of government services that can be accessed by citizen via web or mobile phone
Smart City Wheel	Smart Governance	Online Services	Existence of electronic benefit payments
Smart City Wheel	Smart Governance	Infrastructure	Number of WIFI hotspots per km2
Smart City Wheel	Smart Governance	Infrastructure	% of commercial and residential users with internet download speed of at least 2 Mbit/s

Smart City Wheel	Smart Governance	Infrastructure	% of commercial and residential users with internet download speed of at least 1 gigabit/s
Smart City Wheel	Smart Governance	Infrastructure	# of infrastructure components with installed sensors
Smart City Wheel	Smart Governance	Infrastructure	# of services integrated in a singular operations center leveraing real-time data
Smart City Wheel	Smart Governance	Open Government	Open data use
Smart City Wheel	Smart Governance	Open Government	# of mobile apps available (iPhone) based on open data
Smart City Wheel	Smart Governance	Open Government	Existance of official citywide privacy policy to protect confidential citizen data
ISO 37120:2018	ND	Economy	Assessed value of commercial and industrial properties as a percentage of total assessed value
ISO 37120:2018	ND	Economy	% of persons in full-time employment
ISO 37120:2018	ND	Economy	Youth unemployment rate
ISO 37120:2018	ND	Economy	# of businesses per 100 000 population
ISO 37120:2018	ND	Economy	# of new patents per 100 000 population per year
ISO 37120:2018	ND	Economy	Annual number of visitor stays (overnight) per 100 000 population
ISO 37120:2018	ND	Economy	Commercial air connectivity (number of non-stop commercial air destinations)
ISO 37120:2018	ND	Economy	City's unemployment rate
ISO 37120:2018	ND	Education	% of female school-aged population enrolled in school
ISO 37120:2018	ND	Education	% of students completing primary education: survival rate
ISO 37120:2018	ND	Education	% of students completing secondary education: survival rate
ISO 37120:2018	ND	Education	Primary education student-teacher ratio
ISO 37120:2018	ND	Education	% of school-aged population enrolled in school
ISO 37120:2018	ND	Education	# of higher education degrees per 100 000 population
ISO 37120:2018	ND	Energy	Total end-use energy consumption per capital (GJ/year)
ISO 37120:2018	ND	Energy	% of total end-use derived from renewable sources
ISO 37120:2018	ND	Energy	% of city population with authorized electrical service (residential)
ISO 37120:2018	ND	Energy	Number of gas distribution service connections per 100 000 population (residential)
ISO 37120:2018	ND	Energy	Final energy consumption of public buildings per year (GJ/m^2)
ISO 37120:2018	ND	Energy	Electricity consumption of public street lighting per kilometre of lighted street (kWh/year)
ISO 37120:2018	ND	Energy	Average annual hours of electrical service interruptions per household
ISO 37120:2018	ND	Environment and Climate Change	Fine Particulate Matter (PM2.5) concentration

ISO 37120:2018	ND	Environment and Climate Change	Particulate Matter (PM10) concentration
ISO 37120:2018	ND	Environment and Climate Change	Greenhouse gas emissions measured in tonnes per capita
ISO 37120:2018	ND	Environment and Climate Change	% of areas designated for natural protection
ISO 37120:2018	ND	Environment and Climate Change	NO2 (nitrogen dioxide) concentration
ISO 37120:2018	ND	Environment and Climate Change	SO2 (sulphur dioxide) concentration
ISO 37120:2018	ND	Environment and Climate Change	O3 (ozone) concentration
ISO 37120:2018	ND	Environment and Climate Change	Noise pollution
ISO 37120:2018	ND	Environment and Climate Change	% change in number of native species
ISO 37120:2018	ND	Finance	Debt service ratio (debt service expenditure as a percentage of a city's own-source revenue)
ISO 37120:2018	ND	Finance	Capital spending as a percentage of total expenditures
ISO 37120:2018	ND	Finance	Own-source revenue as a percentage of total revenues
ISO 37120:2018	ND	Finance	Tax collected as percentage of tax billed
ISO 37120:2018	ND	Governance	Women as a percentage of total elected to city-level office
ISO 37120:2018	ND	Governance	# of convictions for corruption and/ or bribery by city officials per 100 000 population
ISO 37120:2018	ND	Governance	# of registered voters as a percentage of the voting age population
ISO 37120:2018	ND	Governance	Voter participation in last municipal election (as a percentage of registered voters)
ISO 37120:2018	ND	Health	Average life expectancy
ISO 37120:2018	ND	Health	# of in-patient hospital beds per 100 000 population
ISO 37120:2018	ND	Health	# of physicians per 100 000 population
ISO 37120:2018	ND	Health	Under age five mortality per 1 000 live births
ISO 37120:2018	ND	Health	# of nursing and midwifery personnel per 100 000 population
ISO 37120:2018	ND	Health	Suicide rate per 100 000 population
ISO 37120:2018	ND	Housing	% of city population living in inadequate housing
ISO 37120:2018	ND	Housing	% of population living in affordable housing
ISO 37120:2018	ND	Housing	# of homeless per 100 000 population
ISO 37120:2018	ND	Housing	% of households that exist without registered legal title
ISO 37120:2018	ND	Population and social conditions	% of city population living below the international poverty line
ISO 37120:2018	ND	Population and social conditions	% of city population living below the national poverty line

ISO 37120:2018	ND	Population and social conditions	Gini coefficient of inequality
ISO 37120:2018	ND	Recreation	m2 of public indoor recreation space per capita
ISO 37120:2018	ND	Recreation	m2 of public outdoor recreation space per capita
ISO 37120:2018	ND	Safety	# of firefighters per 100 000 population
ISO 37120:2018	ND	Safety	# of fire-related deaths per 100 000 population
ISO 37120:2018	ND	Safety	# of natural-hazard-related deaths per 100 000 population
ISO 37120:2018	ND	Safety	# of police officers per 100 000 population
ISO 37120:2018	ND	Safety	# of homicides per 100 000 population
ISO 37120:2018	ND	Safety	# of volunteer and part-time firefighters per 100 000 population
ISO 37120:2018	ND	Safety	Response time for emergency response services from initial call
ISO 37120:2018	ND	Safety	Crimes against property per 100 000 population
ISO 37120:2018	ND	Safety	# of deaths caused by industrial accidents per 100 000 population
ISO 37120:2018	ND	Safety	# of violent crimes against women per 100 000 population
ISO 37120:2018	ND	Solid waste	% of city population with regular solid waste collection (residential)
ISO 37120:2018	ND	Solid waste	Total collected municipal solid waste per capita
ISO 37120:2018	ND	Solid waste	% of the city’s solid waste that is recycled
ISO 37120:2018	ND	Solid waste	% of the city’s solid waste that is disposed of in a sanitary landfill
ISO 37120:2018	ND	Solid waste	% of the city’s solid waste that is treated in energy-fromwaste plants
ISO 37120:2018	ND	Solid waste	% of city’s solid waste that is biologically treated and used as compost or biogas
ISO 37120:2018	ND	Solid waste	% of the city’s solid waste that is disposed of in an open dump
ISO 37120:2018	ND	Solid waste	% of the city’s solid waste that is disposed of by other means
ISO 37120:2018	ND	Solid waste	Hazardous waste generation per capita
ISO 37120:2018	ND	Solid waste	% of city’s hazardous waste that is recycled
ISO 37120:2018	ND	Sport and culture	# of cultural institutions and sporting facilities per 100 000 population
ISO 37120:2018	ND	Sport and culture	% of municipal budget allocated to cultural and sporting facilities
ISO 37120:2018	ND	Sport and culture	Annual number of cultural events per 100 000 population (e.g. exhibitions, festivals, concerts)
ISO 37120:2018	ND	Telecommunication	# of internet connections per 100 000 population
ISO 37120:2018	ND	Telecommunication	# of mobile phone connections per 100 000 population
ISO 37120:2018	ND	Transportation	Kilometres of public transport system per 100 000 population
ISO 37120:2018	ND	Transportation	Annual number of public transport trips per capita

ISO 37120:2018	ND	Transportation	% of commuters using a travel mode other than a personal vehicle
ISO 37120:2018	ND	Transportation	Kilometres of bicycle paths and lanes per 100 000 population
ISO 37120:2018	ND	Transportation	Transportation deaths per 100 000 population
ISO 37120:2018	ND	Transportation	% of population living within 0,5 km of public transit running at least every 20 min during peak periods
ISO 37120:2018	ND	Transportation	Average commute time
ISO 37120:2018	ND	Urban/local agriculture and food security	Total urban agricultural area per 100 000 population
ISO 37120:2018	ND	Urban/local agriculture and food security	Amount of food produced locally as a percentage of total food supplied to the city
ISO 37120:2018	ND	Urban/local agriculture and food security	% of city population undernourished
ISO 37120:2018	ND	Urban/local agriculture and food security	% of city population that is overweight or obese – Body Mass Index (BMI)
ISO 37120:2018	ND	Urban planning	Green area (hectares) per 100 000 population
ISO 37120:2018	ND	Urban planning	Areal size of informal settlements as a percentage of city area
ISO 37120:2018	ND	Urban planning	Jobs-housing ratio
ISO 37120:2018	ND	Urban planning	Basic service proximity
ISO 37120:2018	ND	Wastewater	% of city population served by wastewater collection
ISO 37120:2018	ND	Wastewater	% of city's wastewater receiving centralized treatment
ISO 37120:2018	ND	Wastewater	% of population with access to improved sanitation
ISO 37120:2018	ND	Wastewater	Compliance rate of wastewater treatment
ISO 37120:2018	ND	Water	% of city population with potable water supply service
ISO 37120:2018	ND	Water	% of city population with sustainable access to an improved water source
ISO 37120:2018	ND	Water	Total domestic water consumption per capita (litres/day)
ISO 37120:2018	ND	Water	Compliance rate of drinking water quality
ISO 37120:2018	ND	Water	Total water consumption per capita (litres/day)
ISO 37120:2018	ND	Water	Average annual hours of water service interruptions per household
ISO 37120:2018	ND	Water	% of water loss (unaccounted for water)
U4SSC	Economy	ICT infrastructure	Internet access in households
U4SSC	Economy	ICT infrastructure	Wireless broadband coverage
U4SSC	Economy	ICT infrastructure	Wireless broadband subscriptions
U4SSC	Economy	ICT infrastructure	Fixed broadband subscriptions
U4SSC	Economy	ICT infrastructure	Availability of WIFI in Public Areas
U4SSC	Economy	Innovation	R&D expenditure
U4SSC	Economy	Innovation	Patents

U4SSC	Economy	Innovation	Small and Medium- sized Enterprises
U4SSC	Economy	Employment	Unemployment rate
U4SSC	Economy	Employment	Youth unemployment rate
U4SSC	Economy	Employment	Tourism sector employment
U4SSC	Economy	Employment	ICT sector employment
U4SSC	Economy	Drainage	Drainage / Storm Water System ICT Monitoring
U4SSC	Economy	Waste	Solid waste collection
U4SSC	Economy	Water and Sanitation	Smart water meters
U4SSC	Economy	Water and Sanitation	Water Supply ICT monitoring
U4SSC	Economy	Water and Sanitation	Basic water supply
U4SSC	Economy	Water and Sanitation	Portable water supply
U4SSC	Economy	Water and Sanitation	water supply loss
U4SSC	Economy	Water and Sanitation	Wastewater collection
U4SSC	Economy	Water and Sanitation	Household sanitation
U4SSC	Economy	Electricity supply	Smart electricity meters
U4SSC	Economy	Electricity supply	Electricity supply ICT monitoring
U4SSC	Economy	Electricity supply	Demand Response Penetration
U4SSC	Economy	Electricity supply	Electricity System Outage Frequency
U4SSC	Economy	Electricity supply	Electricity System Outage Time
U4SSC	Economy	Electricity supply	Access to Electricity
U4SSC	Economy	Transport	Dynamic Public Transport Information
U4SSC	Economy	Transport	Traffic Monitoring
U4SSC	Economy	Transport	Intersection Control
U4SSC	Economy	Transport	Public Transport Network
U4SSC	Economy	Transport	Public Transport Network Convenience
U4SSC	Economy	Transport	Bicycle network
U4SSC	Economy	Transport	Transporttation mode share
U4SSC	Economy	Transport	Travel time index
U4SSC	Economy	Transport	Shared bicycle
U4SSC	Economy	Transport	Shared Vehicles
U4SSC	Economy	Transport	Low-Carbon Emission Passenger Vehicles
U4SSC	Economy	Public sector	Open data
U4SSC	Economy	Public sector	e-Government
U4SSC	Economy	Public sector	Public Sector e-procurement
U4SSC	Economy	Buildings	Public Building Sustainability
U4SSC	Economy	Buildings	Integrated Building Management Systems in Public Buildings

U4SSC	Economy	Urban Planing	Pedestrian infrastructure
U4SSC	Economy	Urban Planing	Urban Development and Spatial Planning
U4SSC	Environment	Air quality	Air pollution
U4SSC	Environment	Air quality	GHG emissions
U4SSC	Environment	Water and Sanitation	Quality of drinking water
U4SSC	Environment	Water and Sanitation	Water consumption
U4SSC	Environment	Water and Sanitation	Fress water consumption
U4SSC	Environment	Water and Sanitation	Wastewater treatment
U4SSC	Environment	Waste	Solid waste treatment
U4SSC	Environment	Environmental quality	EMF Exposure
U4SSC	Environment	Environmental quality	Noise Exposure
U4SSC	Environment	Public Space and Nature	Green areas
U4SSC	Environment	Public Space and Nature	Green Area Accessibility
U4SSC	Environment	Public Space and Nature	Protected natural areas
U4SSC	Environment	Public Space and Nature	Recreational Facilities
U4SSC	Environment	Energy	Renewable energy consumption
U4SSC	Environment	Energy	Electricity Consumption
U4SSC	Environment	Energy	Residential Thermal Energy Consumption
U4SSC	Environment	Energy	Public Building Energy Consumption
U4SSC	Society and Culture	Education	Students' ICT access
U4SSC	Society and Culture	Education	School enrollment
U4SSC	Society and Culture	Education	Higher education degrees
U4SSC	Society and Culture	Education	Adult literacy
U4SSC	Society and Culture	Health	Electronic health records
U4SSC	Society and Culture	Health	Physicians
U4SSC	Society and Culture	Health	In-Patient Hospital Beds
U4SSC	Society and Culture	Health	Life expectancy
U4SSC	Society and Culture	Health	Maternal mortality rate
U4SSC	Society and Culture	Health	Health Insurance / Public Health Coverage
U4SSC	Society and Culture	Safety	Population Living in Disaster Prone Areas
U4SSC	Society and Culture	Safety	Natural Disaster Related Deaths
U4SSC	Society and Culture	Safety	Resilience Plans
U4SSC	Society and Culture	Safety	Disaster Related Economic Losses
U4SSC	Society and Culture	Safety	Emergency Service Response Time
U4SSC	Society and Culture	Safety	Police Service
U4SSC	Society and Culture	Safety	Fire Service

U4SSC	Society and Culture	Safety	Violent Crime Rate
U4SSC	Society and Culture	Safety	Traffic Fatalities
U4SSC	Society and Culture	Housing	Housing expenditure
U4SSC	Society and Culture	Housing	Informal housing
U4SSC	Society and Culture	Culture	Cultural expenditure
U4SSC	Society and Culture	Culture	Culture infrastructure
U4SSC	Society and Culture	Social inclusion	Voter participation
U4SSC	Society and Culture	Social inclusion	Gender income equity
U4SSC	Society and Culture	Social inclusion	Child Care Availability
U4SSC	Society and Culture	Social inclusion	Poverty
U4SSC	Society and Culture	Social inclusion	Gini coefficient
U4SSC	Society and Culture	Food Security	Local Food Production
EU - RFSC	Economy	Unemployment rates/ Jobs	Underemployment rates
EU - RFSC	Economy	Unemployment rates/ Jobs	Employment rates
EU - RFSC	Economy	Unemployment rates/ Jobs	Unemployment rates
EU - RFSC	Economy	Unemployment rates/ Jobs	% of green jobs in the local economy
EU - RFSC	Economy	Unemployment rates/ Jobs	Average professional education years of labour force
EU - RFSC	Economy	Economic growth	Annual GDP growth rate
EU - RFSC	Economy	Economic growth	Annual GNP growth rate
EU - RFSC	Economy	Economic growth	Net Export Growth rates (% increase of country's total exports minus the value of its total imports per annum; Foreign Direct Investments (Capital/Earnings accrued from listed FDI's per annum)
EU - RFSC	Environment	Green spaces	% of preserved areas in relation to the total land
EU - RFSC	Environment	Green spaces	% of reservoirs in relation to total land area
EU - RFSC	Environment	Green spaces	% of waterways in relation to total land area
EU - RFSC	Environment	Green spaces	% of waterways in relation to total land area
EU - RFSC	Environment	Green spaces	% of trees in the city in relation to city area and/or population size
EU - RFSC	Environment	Reduce greenhouse gases/ Energy efficiency	Total amount of GHG emissions per city
EU - RFSC	Environment	Reduce greenhouse gases/ Energy efficiency	Total amount of GHG emissions per capita
EU - RFSC	Environment	Reduce greenhouse gases/ Energy efficiency	% of total energy consumed in the city that comes from renewable sources
EU - RFSC	Environment	Mobility	% of private to transportation
EU - RFSC	Environment	Mobility	% of public to transportation
EU - RFSC	Environment	Mobility	% of bicycle to transportation
EU - RFSC	Environment	Mobility	% of pedestrians to transportation

EU - RFSC	Environment	Mobility	Average commute time
EU - RFSC	Environment	Mobility	Averag commute cost
EU - RFSC	Environment	Water quality/ Availability	Total amount of water availability
EU - RFSC	Environment	Water quality/ Availability	Water quality index
EU - RFSC	Environment	Water quality/ Availability	Water quality score
EU - RFSC	Environment	Water quality/ Availability	Proportion of population with access to adequate and safe drinking water
EU - RFSC	Environment	Air quality	Levels of Particulate Matter (PM10 – mg/m3)
EU - RFSC	Environment	Air quality	Levels of Particulate Matter (PM2.5 – mg/m3)
EU - RFSC	Environment	Waste/ Reuse/ Recycle	Recycling rate (Percentage diverted from waste stream)
EU - RFSC	Environment	Waste/ Reuse/ Recycle	Volume of solid waste generated
EU - RFSC	Social	Complete neighbourhood/ Compact city	Access to local services within a short distance
EU - RFSC	Social	Complete neighbourhood/ Compact city	Access to neighbourhood services within a short distance
EU - RFSC	Social	Complete neighbourhood/ Compact city	Crime rates
EU - RFSC	Social	Complete neighbourhood/ Compact city	Measures of income distribution
EU - RFSC	Social	Complete neighbourhood/ Compact city	Measures of income inequality
EU - RFSC	Social	Housing	% of social housing
EU - RFSC	Social	Housing	% of affordable housing
EU - RFSC	Social	Housing	% of priority housing
EU - RFSC	Social	Housing	Breakdown of housing sector by property type (owner occupied/ rental, single occupant/couples/family/multifamily etc.)
EU - RFSC	Social	Quality public space	% of roadways in good condition
EU - RFSC	Social	Quality public space	% of green space (public parks) coverage in relation to city area and/or population size
EU - RFSC	Social	Education	# of schools with environmental education programs
EU - RFSC	Social	Education	Adult literacy rate
EU - RFSC	Social	Sanitation	% of population with access to waterborne or alternative (and effective) sanitary sewage infrastructure
EU - RFSC	Social	Health	Mortality rate
EU - RFSC	Social	Health	Life expectancy
EU - RFSC	Social	Health	% of population with access to health care services
GCI	Business activity	ND	Fortune 500

GCI	Business activity	ND	Top global service firm
GCI	Business activity	ND	Capital markets
GCI	Business activity	ND	Air freight
GCI	Business activity	ND	Sea freight
GCI	Business activity	ND	ICCA conferences
GCI	Business activity	ND	Unicorn companies
GCI	Human Capital	ND	Foreign born population
GCI	Human Capital	ND	Top universities
GCI	Human Capital	ND	Population with tertiary degree
GCI	Human Capital	ND	International student population
GCI	Human Capital	ND	# of international schools
GCI	Human Capital	ND	Medical universities
GCI	Information exchange	ND	Access to TV news
GCI	Information exchange	ND	New agency bureau
GCI	Information exchange	ND	Broadband subscribers
GCI	Information exchange	ND	Freedom of expression
GCI	Information exchange	ND	Online Presence
GCI	Cultural experience	ND	Museums
GCI	Cultural experience	ND	Visual and performing arts
GCI	Cultural experience	ND	Sport events
GCI	Cultural experience	ND	International travellers
GCI	Cultural experience	ND	Culinary offerings
GCI	Cultural experience	ND	Sister cities
GCI	Political engagement	ND	Embassies and consulates
GCI	Political engagement	ND	Think tanks
GCI	Political engagement	ND	International organisations
GCI	Political engagement	ND	Political conferences
GCI	Political engagement	ND	Local institutions with global reach
CIMI	Human Capital	Secondary or higher education	Secondary or higher education Proportion of population with secondary and higher education
CIMI	Human Capital	Schools	Number of public or private schools per city
CIMI	Human Capital	Business schools	Number of business schools in the city that are included in the Top 100 of the Financial Times
CIMI	Human Capital	Expenditure on education	Per capita expenditure on education
CIMI	Human Capital	Per capita expenditure on leisure and recreation	Annual per capita expenditure on leisure and recreation

CIMI	Human Capital	Expenditure on leisure and recreation	Expenditure on leisure and recreation as a percentage of GDP
CIMI	Human Capital	Movement of students	International movement of higher-level students (number of students)
CIMI	Human Capital	Museums and art galleries	# of museums and art galleries per city
CIMI	Human Capital	Number of universities	# of universities in the top 500
CIMI	Human Capital	Theaters	# of theaters per city
CIMI	Social Cohesion Indicators	Female-friendly	This variable shows whether a city provides a friendly environment for women scale 1-5
CIMI	Social Cohesion Indicators	Hospitals	# of public or private hospitals by city. Includes health centers.
CIMI	Social Cohesion Indicators	Crime rate	Estimate of the general level of crime in a given city
CIMI	Social Cohesion Indicators	Slavery index	This variable represents the response of the national government to situations of slavery in the country
CIMI	Social Cohesion Indicators	Happiness index	The countries with the highest value in this index are those with the highest degree of overall happiness
CIMI	Social Cohesion Indicators	Gini index	Gini coefficient
CIMI	Social Cohesion Indicators	Peace index	Global Peace index
CIMI	Social Cohesion Indicators	Health index	Estimate of the overall quality of the healthcare system, health professionals, equipment, personnel, doctors, costs, etc.
CIMI	Social Cohesion Indicators	Price of property	Price of property as percentage of income
CIMI	Social Cohesion Indicators	Homicide rate	Homicide rate per 100,000 inhabitants
CIMI	Social Cohesion Indicators	Death rate	Death rate per 100,000 inhabitants
CIMI	Social Cohesion Indicators	Female employment ratio	Ratio of female workers in the public administration. Between 0 and 1
CIMI	Social Cohesion Indicators	Suicide rate	Suicide rate per 100,000 inhabitants
CIMI	Social Cohesion Indicators	Unemployment rate	The unemployment rate is calculated as (number of unemployed/total workforce) x 100
CIMI	Social Cohesion Indicators	Terrorism	# of terrorist incidents by city in the last three years
CIMI	Economy	Collaborative economy	Whether the city has Uber and/or Glovo services
CIMI	Economy	Ease of starting a business	The top positions in the ranking indicate a more favorable regulatory environment for creating and operating a local company
CIMI	Economy	Mortgage	Mortgage as a percentage of income is the ratio of the real monthly mortgage cost to the family income (the lower, the better)

CIMI	Economy	Motivation that people have to undertake early-stage entrepreneurial activity	% of new entrepreneurs who are motivated by an opportunity for improvement divided by the percentage of new entrepreneurs who are motivated by need.
CIMI	Economy	Number of headquarters	# of headquarters of publicly traded companies
CIMI	Economy	Purchasing power	Purchasing power (determined by the average salary) for the purchase of goods and services in the city, compared with that of New York City
CIMI	Economy	Productivity	Labor productivity calculated as GDP per working population (in thousands)
CIMI	Economy	Hourly wage in US dollars	Hourly wage in the city in US dollars
CIMI	Economy	Time required to start a business	# of calendar days needed for a business to be able to operate legally
CIMI	Economy	GDP	Gross domestic product in millions of US dollar
CIMI	Economy	GDP per capita	Gross domestic product per capita
CIMI	Economy	Estimated GDP	Forecast annual GDP growth for the next year
CIMI	Governance	Government buildings	# of government buildings and premises in the city
CIMI	Governance	E Government Development Index (EGDI)	The Electronic Government Development Index (EGDI)
CIMI	Governance	Embassie	# of embassies per city
CIMI	Governance	Employment in the public administration	% of the population employed in public administration and defense, education, healthcare, community, social and personal service activities, and other.
CIMI	Governance	Strength of legal rights index	Legal rights index
CIMI	Governance	Corruption perceptions index	Corruption perceptions index
CIMI	Governance	ISO 37120 certification	Yes or No
CIMI	Governance	Research centers	# of research and technology centers per city
CIMI	Governance	Open data platform	This describes whether the city has an open data system.
CIMI	Governance	Democracy ranking	Democracy ranking
CIMI	Governance	Reserves	Total reserves in millions of current US dollars
CIMI	Governance	Reserves per capita	Reserves per capita in millions of current US dollars
CIMI	Environment	Solid waste	Average amount of municipal solid waste generated annually per person (kg/year)
CIMI	Environment	Future climate	% of summer temperature increase in the city forecast for 2100 if carbon pollution continues to increase
CIMI	Environment	CO_2 emissions	Carbon dioxide emissions that come from the burning of fossil fuels and the manufacture of cement. Measured in kilotons (kt).
CIMI	Environment	Methane emissions	Methane emissions that arise from human activities such as agriculture and the industrial production of methane. Measured in kt of CO_2 equivalent.
CIMI	Environment	Environmental performance index	Environmental Performance Index (from 1 [poor] to 100 [good])

CIMI	Environment	CO2 emission index	CO2 emission index
CIMI	Environment	Pollution index	Pollution index
CIMI	Environment	PM10	# of particles in the air with a diameter of less than 10 µm. Annual average
CIMI	Environment	PM2.5	# of particles in the air with a diameter of less than 2.5 µm. Annual average
CIMI	Environment	Percentage of the population with access to the water supply	% of the population with reasonable access to an appropriate quantity of water resulting from an improvement in the water supply
CIMI	Environment	Renewable water resources	Total renewable water sources per capita
CIMI	Mobility and Transportation	Bicycle rental	Whether the city has a bicycle rental service
CIMI	Mobility and Transportation	Moped rental	Whether the city has a moped rental service
CIMI	Mobility and Transportation	Scooter rental	Whether the city has a scooter rental service
CIMI	Mobility and Transportation	Bicycles per household	Bicycles owned per household
CIMI	Mobility and Transportation	Bike sharing	This system shows the automated services for the public use of shared bicycles that provide transportation from one location to another within a city 0-8
CIMI	Mobility and Transportation	Traffic inefficiency index	This index is an estimate of the inefficiencies in traffic
CIMI	Mobility and Transportation	Exponential traffic index	This index is estimated by considering the time spent in traffic.
CIMI	Mobility and Transportation	Traffic index	Index of time based on how many minutes it takes to get to work
CIMI	Mobility and Transportation	Length of the metro system	Length of the city's metro system
CIMI	Mobility and Transportation	Metro stations	# of metro stations per city
CIMI	Mobility and Transportation	High-speed train	Binary variable that shows whether the city has a high-speed train or not
CIMI	Mobility and Transportation	Commercial vehicles in the city	# of commercial vehicles in the city
CIMI	Mobility and Transportation	Flights	# of incoming flights (air routes) in a city.
CIMI	Urban Planning	Bicycles for rent	# of bike-rental or bike-sharing points, based on docking stations where bikes can be picked up or dropped off
CIMI	Urban Planning	Buildings	This variable is the number of completed buildings in the city
CIMI	Urban Planning	Number of people per household	Average number of people per household
CIMI	Urban Planning	Percentage of the urban population with adequate sanitation services	% of the urban population that uses at least basic sanitation services—that is, improved sanitation facilities that are not shared with other households
CIMI	Urban Planning	Buildings over 35 meters high	# of buildings at least 12 stories or 35 meters high (high-rise)

CIMI	International Projection	Number of passengers per airport	# of passengers per airport in thousands
CIMI	International Projection	Hotels	# of hotels per capita
CIMI	International Projection	Restaurant index	This index is a comparison of the prices of food and beverages in restaurants and bars in comparison with New York City
CIMI	International Projection	McDonald's	# of McDonald's restaurants per city
CIMI	International Projection	Number of conferences and meetings	# of international conferences and meetings that are held in a city.
CIMI	International Projection	Number of photos of the city uploaded online	Ranking of cities according to the number of photos taken in the city and uploaded online. The top positions correspond to the cities with the most photographs
CIMI	Technology	3G coverage	% of the population that has at least 3G coverage
CIMI	Technology	Innovation index	The Culture of Innovation Index (ICI) is a ranking of the leading cities in innovation
CIMI	Technology	Internet	% of households with access to the internet
CIMI	Technology	Online banking	% of the population that uses the internet for banking services
CIMI	Technology	Online video calls	% of the population using the internet for video calls
CIMI	Technology	LTE/WiMAX	% of the population covered by at least one LTE/WiMAX mobile network
CIMI	Technology	Mobile phone penetration ratio	# of landline subscriptions per 100 inhabitants
CIMI	Technology	Personal computers	% of households in the city with a personal computer
CIMI	Technology	Social networks	Registered Twitter users by city, in thousands of people + number of registered LinkedIn members
CIMI	Technology	Landline subscriptions	# of landline subscriptions per 100 inhabitants. IP per capita
CIMI	Technology	Broadband subscriptions	Broadband subscriptions per 100 inhabitants
CIMI	Technology	Telephony	% of households with some kind of telephone service
CIMI	Technology	Mobile telephony	% of households in the city with mobile phones
CIMI	Technology	Internet usage away from home and/or office	% of the population that uses the internet away from their home or workplace
CIMI	Technology	Internet speed	Average internet speed in the city in Mbps
CIMI	Technology	Web Index	The Web Index seeks to measure the economic, social and political benefit that countries obtain from the internet
CIMI	Technology	Wi-Fi hotspots	# of wireless access points globally
CFI	Digital Life	Citizen Adoption	# of startups in the healthcare,lifestyle and Internet service sectors in each city, both in absolute terms and on a per population basis
CFI	Digital Life	Citizen Adoption	# of app downloads and ranking in food, navigation, travel, education and financial services categories, excluding reference and utility apps.
CFI	Digital Life	Government Adoption	National Digital Infrastructure Indices.
CFI	Digital Life	Government Adoption	Digital Economy Score.

CFI	Digital Life	Government Adoption	Development of eGovernment services.
CFI	Digital Life	Healthcare Innovation	Healthcare Quality and Access Index.
CFI	Digital Life	Healthcare Innovation	# of startups in the healthcare sector in each city, both in absolute terms and on a per population basis.
CFI	Digital Life	Healthcare Innovation	# of app downloads and ranking in the healthcare and medical categories, excluding reference and utility apps.
CFI	Digital Life	Tech Education	Highly ranked universities for computer science degrees.
CFI	Digital Life	Tech Education	Highly ranked universities for engineering degrees.
CFI	Mobility Innovation	Parking Innovation	The overall number of parking spaces per capita.
CFI	Mobility Innovation	Parking Innovation	The number of parking spaces capable of accepting digital payments.
CFI	Mobility Innovation	Parking Innovation	The number of parking technology providers operating in the city.
CFI	Mobility Innovation	Parking Innovation	Civilian adoption of parking technology.
CFI	Mobility Innovation	Parking Innovation	The level of parking technology implementation.
CFI	Mobility Innovation	Traffic Management	Congestion levels.
CFI	Mobility Innovation	Traffic Management	Time spent in traffic during a commute.
CFI	Mobility Innovation	Traffic Management	Dissatisfaction due to long commute times.
CFI	Mobility Innovation	Clean Transport	Electric cars per capita and new electric car sales.
CFI	Mobility Innovation	Clean Transport	Electric car charging stations per capita.
CFI	Mobility Innovation	Clean Transport	CO_2 emissions.
CFI	Business Tech Infrastructure	Business Innovation	Healthcare.
CFI	Business Tech Infrastructure	Business Innovation	Internet Services.
CFI	Business Tech Infrastructure	Business Innovation	Financial Services.
CFI	Business Tech Infrastructure	Business Innovation	Lifestyle Services.
CFI	Business Tech Infrastructure	Business Innovation	Media.
CFI	Business Tech Infrastructure	ePayments	% of the population that is in favour of a cashless society.
CFI	Business Tech Infrastructure	ePayments	% of the population that has been cashless since the beginning of the pandemic.
CFI	Business Tech Infrastructure	ePayments	# of cashless retail transactions per 1,000 adults.
CFI	Business Tech Infrastructure	ePayments	Credit card ownership.
CFI	Business Tech Infrastructure	ePayments	Debit card ownership.
CFI	Business Tech Infrastructure	ePayments	% of the population that paid bills or bought something online in the past year.

CFI	Business Tech Infrastructure	Internet Connectivity	Median download and upload speeds.
CFI	Business Tech Infrastructure	Internet Connectivity	5G deployment and government efforts to promote 5G.
CFI	Business Tech Infrastructure	Internet Connectivity	5G availability in major cities.
CFI	Business Tech Infrastructure	Internet Connectivity	# of 5G providers per city
CFI	Sustainability	Green Energy	Share of nationwide energy consumed from renewable sources.
CFI	Sustainability	Green Energy	Share of electricity consumption from renewable sources
CFI	Sustainability	Green Buildings	# of certified green buildings.
CFI	Sustainability	Green Buildings	Building activities.
CFI	Sustainability	Green Buildings	Activities per square foot.
CFI	Sustainability	Green Buildings	% of total buildings certified as green
CFI	Sustainability	Waste Management	Waste generated per capita.
CFI	Sustainability	Waste Management	Waste collection coverage.
CFI	Sustainability	Waste Management	The recycling rate in each country
CFI	Sustainability	Climate Response	Estimated percentage increase in greenhouse gas emissions.
CFI	Sustainability	Climate Response	Total CO_2 emissions from fuel combustion.
CFI	Sustainability	Climate Response	Expenditure on environment protection.
CFI	Sustainability	Climate Response	Change in CO_2 emissions per capita over time.
CFI	Sustainability	Climate Response	# of climate laws, policies and targets in place
IGC	Humanware	ND	Ability to use computer
IGC	Humanware	ND	Ability to use software
IGC	Humanware	ND	Ability to create Web page
IGC	Humanware	ND	Computer innovative capability
IGC	Humanware	ND	Computer maintaining and servicing capability
IGC	Humanware	ND	Computer virus detection capability
IGC	Humanware	ND	Ability to notice cyber criminal
IGC	Humanware	ND	Computer skills and software course attendance
IGC	Humanware	ND	Information Management course attendance
IGC	Technoware	ND	Computer quantity per household
IGC	Technoware	ND	Computer capacity per household
IGC	Technoware	ND	Modem capacity per household
IGC	Technoware	ND	Internet facility connection
IGC	Technoware	ND	Alternative internet facility
IGC	Technoware	ND	Telephones quantity per household
IGC	Technoware	ND	Handphones quantity per household

IGC	Technoware	ND	TV property per household
IGC	Technoware	ND	Radio property per household
IGC	Technoware	ND	Fax machine property per household
IGC	Inforware	ND	Newspapers purchase per household
IGC	Inforware	ND	Educational reads purchase per household
IGC	Inforware	ND	Magazines purchase per household
IGC	Inforware	ND	Frequency referring to info in Internet
IGC	Inforware	ND	Frequency of communication via email
IGC	Inforware	ND	Frequency observing market and share commodity in ICTs
IGC	Inforware	ND	Quantity channel types of TV satellite
IGC	Inforware	ND	Frequency of communication with international friends
IGC	Inforware	ND	Activeness in dissemination and sharing info
IGC	Valueware	ND	Sensitive and careful with global changes
IGC	Valueware	ND	Having netropolitan thought namely informative need from ICTs
IGC	Valueware	ND	Technopreneur, innovative and creative Behavior
IGC	Valueware	ND	Activeness and readiness in sharing information
IGC	Valueware	ND	Cooperate in reducing cyber and computer crimes

Appendix 6: Benchmarks models – Factors simplification

Benchmarks	pc / Factors (Components)
CFI	**50**
Apps	2
Building	4
Business Innovation	2
Climate Response	2
Cultural	1
Economy	1
Education	2
Electric car	2
Energy supply	2
ePayments	6
GHG emission	4
Governance	3
Health	2
ICT infrastructure	4
Internet	1
Mobility	3
Parking Innovation	5
Services	1
Waste	3
CIMI	**101**
ISO 37120 certification	1
(Inter-)national accessibility	6
(Un)employment	3
Air quality	2
Bicycle	4
Building	2
Business Innovation	2
Climate Response	1
Crime - Corruption	2
Cultural	2
Economy	9
Education	8
Environmental	1
Gadget	3
GHG emission	3
Governance	3
Happiness index	1
Health	5
ICT infrastructure	6

Inequality	3
Internet	6
Life	12
Mobility	9
Political	1
Services	2
Waste	1
Water and Sanitation	3
EU - RFSC	**47**
(Un)employment	5
Air quality	2
Crime - Corruption	1
Economy	3
Education	2
Energy supply	1
GHG emission	2
Green spaces	6
Health	3
Housing	4
Inequality	1
Life	2
Mobility	6
Services	2
Waste	2
Water and Sanitation	5
European Smart Cities 3.0	**28**
(Inter-)national accessibility	3
(Un)employment	1
Air quality	1
Business Innovation	2
Cultural	1
Economy	4
Education	3
Environmental	2
Governance	2
Health	1
Housing	1
ICT infrastructure	1
Inclusion	2
Life	1
Mobility	1
Safety	1
Services	1

GCI	**29**
(Inter-)national accessibility	7
Business Innovation	2
Cultural	4
Economy	7
Education	4
Gadget	1
ICT infrastructure	1
Inclusion	2
Political	1
IGC	**33**
(Inter-)national accessibility	1
Business Innovation	1
Crime - Corruption	1
Cultural	4
Education	9
Gadget	5
ICT infrastructure	5
Inclusion	2
Internet	4
Political	1
ISO 37120:2018	**104**
(Inter-)national accessibility	1
(Un)employment	3
Air quality	2
Crime - Corruption	2
Cultural	2
Economy	8
Education	6
Energy supply	7
Environmental	6
Food Security	4
Gadget	1
GHG emission	1
Governance	5
Green spaces	1
Health	6
Housing	4
Inequality	3
Internet	1
Life	6
Mobility	7
Safety	7

Waste	10
Water and Sanitation	11
Smart City Wheel	**62**
(Inter-)national accessibility	2
(Un)employment	1
Air quality	1
Apps	2
Bicycle	2
Building	4
Business Innovation	3
Climate Response	1
Crime - Corruption	2
Cultural	2
Economy	6
Education	2
Electric car	1
Energy supply	4
Gadget	1
GHG emission	1
Governance	2
Green spaces	1
Health	2
ICT infrastructure	6
Inclusion	1
Inequality	2
Internet	1
Life	1
Mobility	6
Political	1
Waste	2
Water and Sanitation	2
U4SSC	**91**
(Un)employment	4
Air quality	1
Building	2
Climate Response	1
Crime - Corruption	1
Cultural	2
Economy	3
Education	4
Energy supply	10
Environmental	3
Food Security	1

GHG emission	1
Governance	3
Green spaces	2
Health	6
Housing	2
ICT infrastructure	7
Inequality	3
Internet	1
Life	2
Mobility	12
Political	1
Safety	8
Waste	2
Water and Sanitation	9
Sum	**545**

Appendix 7: Benchmarks models – Distribution of the Indicators

Indicators	pc / Smart/Sustainable City Model
ISO 37120 certification	**1**
Yes or No	1
(Inter-)national accessibility	**20**
(Inter-)national accessibility	1
# of embassies per city	1
# of headquarters of publicly traded companies	1
# of hotels per capita	1
# of incoming flights (air routes) in a city.	1
# of international conferences and meetings that are held in a city.	1
# of international schools	1
# of passengers per airport in thousands	1
% of population born in a foreign country	2
Annual number of visitor stays (overnight) per 100 000 population	1
Embassies and consulates	1
Frequency of communication with international friends	1
International embeddedness	1
International organisations	1
International travellers	1
Local institutions with global reach	1
Number of international congresses and fairs attendees	1
Sister cities	1
Touristic attractiveness	1
(Un)employment	**17**
% of green jobs in the local economy	1
% of people in full-time employment	2
% of the population employed in public administration and defense, education, healthcare, community, social and personal service activities, and other.	1
Average professional education years of labour force	1
Employment rates	1
Flexibility of labour market	1
ICT sector employment	1
Ratio of female workers in the public administration. Between 0 and 1	1
Tourism sector employment	1
Underemployment rates	1
Unemployment rate	4

Youth unemployment rate	2
Air quality	**9**
Air pollution	1
Air quality (no pollution)	1
Levels of Particulate Matter (PM10 – mg/m3)	3
Levels of Particulate Matter (PM2.5 – mg/m3)	4
Apps	**4**
# of app downloads and ranking in food, navigation, travel, education and financial services categories, excluding reference and utility apps.	1
# of app downloads and ranking in the healthcare and medical categories, excluding reference and utility apps.	1
# of mobile apps available (iPhone) based on open data	1
Availability of multi-modal transit app with at least 3 services integrated	1
Bicycle	**6**
# of bike-rental or bike-sharing points, based on docking stations where bikes can be picked up or dropped off	1
# of shared bicycles per capita	1
Bicycles owned per household	1
km of bicycle paths and lanes per 100.000	1
This system shows the automated services for the public use of shared bicycles that provide transportation from one location to another within a city 0-8	1
Whether the city has a bicycle rental service	1
Building	**12**
# of buildings at least 12 stories or 35 meters high (high-rise)	1
# of certified green buildings.	1
% of commercial and industrial buildings with smart meters	1
% of commercial buildings with a building automation system	1
% of homes with smart meters	1
% of total buildings certified as green	1
Activities per square foot.	1
Building activities.	1
Integrated Building Management Systems in Public Buildings	1
Number of LEED or BREAM sustainability certified buildings in the city	1
Public Building Sustainability	1
This variable is the number of completed buildings in the city	1
Business Innovation	**12**
# of officially registered ENOLL living labs	1
# of startups in the healthcare sector in each city, both in absolute terms and on a per population basis.	1
# of startups in the healthcare,lifestyle and Internet service sectors in each city, both in absolute terms and on a per population basis	1

% of labor force engaged in creative industries	1
% of new entrepreneurs who are motivated by an opportunity for improvement divided by the percentage of new entrepreneurs who are motivated by need.	1
Innovation cities index	1
Innovative spirit	1
New agency bureau	1
Open-mindedness	1
Technopreneur, innovative and creative Behavior	1
The Culture of Innovation Index (ICI) is a ranking of the leading cities in innovation	1
Think tanks	1
Climate Response	**5**
# of climate laws, policies and targets in place	1
% of summer temperature increase in the city forecast for 2100 if carbon pollution continues to increase	1
Does your city have a public climate resilience strategy/plan in place?	1
Drainage / Storm Water System ICT Monitoring	1
Expenditure on environment protection.	1
Crime - Corruption	**9**
# of violent crimes against women per 100 000 population	1
# technologies in use to assist with crime prevention	1
Cooperate in reducing cyber and computer crimes	1
Corruption perceptions index	1
Crime rates	1
Crimes against property per 100 000 population	1
Estimate of the general level of crime in a given city	1
Violent Crime Rate	2
Cultural	**18**
# of cultural institutions and sporting facilities per 100 000 population	1
# of museums and art galleries per city	2
# of theaters per city	1
% of municipal budget allocated to culture	1
Annual number of cultural events per 100 000 population (e.g. exhibitions, festivals, concerts)	1
Culinary offerings	1
Cultural	1
Cultural expenditure	1
Culture infrastructure	1
Educational reads purchase per household	1
Magazines purchase per household	1
Media.	1
Mercer ranking in most recent quality of life survey	1
Newspapers purchase per household	1

Quantity channel types of TV satellite	1
Sport events	1
Visual and performing arts	1
Economy	**41**
Gross domestic product per capita	1
# of businesses per 100 000 population	1
# of calendar days needed for a business to be able to operate legally	1
# of new patents per 100 000 population per year	1
% GDP invested in R&D in private sector	1
% of GRP based on technology exports	1
Air freight	1
Annual GDP growth rate	1
Annual GNP growth rate	1
Assessed value of commercial and industrial properties as a percentage of total assessed value	1
Capital markets	1
Capital spending as a percentage of total expenditures	1
Commercial air connectivity (number of non-stop commercial air destinations)	1
Debt service ratio (debt service expenditure as a percentage of a city’s own-source revenue)	1
Economic image & trademarks	1
Economic welfare	1
Economy	1
Existence of electronic benefit payments	1
Financial Services.	1
Forecast annual GDP growth for the next year	1
Fortune 500	1
Gross domestic product in millions of US dollar	1
Gross Regional Product per capita	1
ICCA conferences	1
Labor productivity calculated as GDP per working population (in thousands)	1
Net Export Growth rates (% increase of country’s total exports minus the value of its total imports per annum; Foreign Direct Investments (Capital/Earnings accrued from listed FDI’s per annum)	1
Number of new opportunity-based startup/year	1
Own-source revenue as a percentage of total revenues	1
Patents	1
Presence of demand-based pricing	1
Productivity	1
Purchasing power (determined by the average salary) for the purchase of goods and services in the city, compared with that of New York City	1
R&D expenditure	1
Reserves per capita in millions of current US dollars	1

Sea freight	1
Small and Medium- sized Enterprises	1
Tax collected as percentage of tax billed	1
The top positions in the ranking indicate a more favorable regulatory environment for creating and operating a local company	1
Top global service firm	1
Total reserves in millions of current US dollars	1
Unicorn companies	1
Education	**40**
# of higher education degrees per 100 000 population	3
# of research and technology centers per city	1
# of schools with environmental education programs	1
# of universities in the top 500	1
% of female school-aged population enrolled in school	1
% of school-aged population enrolled in school	1
% of students completing primary education: survival rate	1
% of students completing secondary education	2
Ability to create Web page	1
Ability to notice cyber criminal	1
Ability to use computer	1
Ability to use software	1
Adult literacy rate	2
Computer innovative capability	1
Computer maintaining and servicing capability	1
Computer skills and software course attendance	1
Computer virus detection capability	1
Education facilities	1
Expenditure on leisure and recreation as a percentage of GDP	1
Highly ranked universities for computer science degrees.	1
Highly ranked universities for engineering degrees.	1
Information Management course attendance	1
International movement of higher-level students (number of students)	1
International student population	1
Level of qualification	1
Lifelong learning	1
Medical universities	1
Number of business schools in the city that are included in the Top 100 of the Financial Times	1
Number of public or private schools per city	1
Per capita expenditure on education	1
Population with tertiary degree	1
Primary education student-teacher ratio	1

School enrollment	1
Secondary or higher education Proportion of population with secondary and higher education	1
Students’ ICT access	1
Top universities	1
Electric car	**3**
# of EV charging stations per capita	1
# of EV charging stations within the city	1
Electric cars per capita and new electric car sales.	1
Energy supply	**24**
% of city population with authorized electrical service (residential)	1
% of municipal grid meeting all of following requirements for smart grid	1
% of total end-use derived from renewable sources	1
%of total energy derived from renewable sources	1
Access to Electricity	1
Average annual hours of electrical service interruptions per household	1
Demand Response Penetration	1
Electricity Consumption	1
Electricity consumption of public street lighting per kilometre of lighted street (kWh/year)	1
Electricity supply ICT monitoring	1
Electricity System Outage Frequency	1
Electricity System Outage Time	1
Final energy consumption of public buildings per year (GJ/m²)	1
Number of gas distribution service connections per 100 000 population (residential)	1
Public Building Energy Consumption	1
Residential Thermal Energy Consumption	1
Share of electricity consumption from renewable sources	3
Share of nationwide energy consumed from renewable sources.	1
Smart electricity meters	1
Supports for addressing system outages	1
Total end-use energy consumption per capital (GJ/year)	1
Total residential energy use per capita	1
Environmental	**12**
% change in number of native species	1
% of areas designated for natural protection	1
Ecological awareness	1
EMF Exposure	1
Environmental conditions	1
Environmental Performance Index (from 1 [poor] to 100 [good])	1
NO2 (nitrogen dioxide) concentration	1
Noise pollution	2
O3 (ozone) concentration	1

Protected natural areas	1
SO2 (sulphur dioxide) concentration	1
ePayments	**6**
# of cashless retail transactions per 1,000 adults.	1
% of the population that has been cashless since the beginning of the pandemic.	1
% of the population that is in favour of a cashless society.	1
% of the population that paid bills or bought something online in the past year.	1
Credit card ownership.	1
Debit card ownership.	1
Food Security	**5**
% of city population that is overweight or obese – Body Mass Index (BMI)	1
% of city population undernourished	1
Amount of food produced locally as a percentage of total food supplied to the city	1
Local Food Production	1
Total urban agricultural area per 100 000 population	1
Gadget	**11**
# of landline subscriptions per 100 inhabitants	1
# of mobile phone connections per 100 000 population	1
% of households in the city with mobile phones	1
% of households with some kind of telephone service	2
% of residents with smartphone access	1
Fax machine property per household	1
Handphones quantity per household	1
Radio property per household	1
TV property per household	2
GHG emission	**12**
Change in CO2 emissions per capita over time.	1
CO2 emission index	1
CO2 emissions.	1
Estimated percentage increase in greenhouse gas emissions.	1
GHG emissioned measured in tonnes per capita	3
GHG emissions	1
Methane emissions that arise from human activities such as agriculture and the industrial production of methane. Measured in kt of CO2 equivalent.	1
Total amount of GHG emissions per city	1
Total CO2 emissions from fuel combustion	2
Governance	**18**
# of convictions for corruption and/ or bribery by city officials per 100 000 population	1
# of government buildings and premises in the city	1
# of registered voters as a percentage of the voting age population	1
% of municipal budget allocated to cultural and sporting facilities	1

Development of eGovernment services.	4
Digital Economy Score.	1
Existance of official citywide privacy policy to protect confidential citizen data	1
Legal rights index	1
National Digital Infrastructure Indices.	1
Sustainable resource management	1
The Electronic Government Development Index (EGDI)	1
Transparent governance	1
Urban Development and Spatial Planning	1
Voter participation in last municipal election (as a percentage of registered voters)	1
Women as a percentage of total elected to city-level office	1
Green spaces	**10**
% of reservoirs in relation to total land area	1
% of green space (public parks) coverage in relation to city area and/or population size	1
% of preserved areas in relation to the total land	1
% of trees in the city in relation to city area and/or population size	1
% of waterways in relation to total land area	2
Green area (hectares) per 100 000 population	1
Green Area Accessibility	1
Green areas	1
Green areas per 100.000 (in m2)	1
Happiness index	**1**
The countries with the highest value in this index are those with the highest degree of overall happiness	1
Health	**25**
# of in-patient hospital beds per 100 000 population	1
# of nursing and midwifery personnel per 100 000 population	1
# of physicians per 100 000 population	1
# of public or private hospitals by city. Includes health centers.	1
% of population with access to health care services	1
% of residents with single, unified health histories facilitating patient and health provider access to complete medical records	1
Average life expectancy	2
Death rate per 100,000 inhabitants	1
Electronic health records	1
Health	3
Health Insurance / Public Health Coverage	1
Healthcare Quality and Access Index.	1
Homicide rate per 100,000 inhabitants	1
In-Patient Hospital Beds	1
Life expectancy	2

Maternal mortality rate	1
Mortality rate	1
Physicians	1
Suicide rate per 100 000 population	1
Suicide rate per 100,000 inhabitants	1
Under age five mortality per 1 000 live births	1
Housing	**11**
# of homeless per 100 000 population	1
% of priority housing	1
% of affordable housing	1
% of city population living in inadequate housing	1
% of households that exist without registered legal title	1
% of population living in affordable housing	1
% of social housing	1
Breakdown of housing sector by property type (owner occupied/ rental, single occupant/couples/family/multifamily etc.)	1
Housing expenditure	1
Housing quality	1
Informal housing	1
ICT infrastructure	**30**
# of 5G providers per city	1
# of infrastructure components with installed sensors	1
# of services integrated in a singular operations center leveraing real-time data	1
# of wireless access points globally	1
% of commercial and residential users with internet download speed of at least 1 gigabit/s	1
% of commercial and residential users with internet download speed of at least 2 Mbit/s	1
% of households in the city with a personal computer	1
% of the population covered by at least one LTE/WiMAX mobile network	1
% of the population that has at least 3G coverage	1
5G availability in major cities.	1
5G deployment and government efforts to promote 5G.	1
Availability of IT-Infrastructure	1
Availability of WIFI in Public Areas	1
Broadband subscribers	1
Broadband subscriptions per 100 inhabitants	1
Computer capacity per household	1
Computer quantity per household	1
Fixed broadband subscriptions	1
Frequency observing market and share commodity in ICTs	1
Having netropolitan thought namely informative need from ICTs	1
Median download and upload speeds.	1

Modem capacity per household	1
Number of WIFI hotspots per km2	1
Open data use	3
Smart water meters	1
Water Supply ICT monitoring	1
Wireless broadband coverage	1
Wireless broadband subscriptions	1
Inclusion	**7**
# of civic engagement activities offered by the municipality last year	1
Activeness and readiness in sharing information	1
Activeness in dissemination and sharing info	1
Ethnic plurality	1
Freedom of expression	1
Online Presence	1
Participation public life	1
Inequality	**12**
% of city population living below the international poverty line	1
% of city population living below the national poverty line	1
% of inhabitants with housing deficiency in any of 5 area	1
Gender income equity	1
Gini coefficient	4
Measures of income inequality	1
Mortgage as a percentage of income is the ratio of the real monthly mortgage cost to the family income (the lower, the better)	1
Poverty	1
This variable represents the response of the national government to situations of slavery in the country	1
Internet	**14**
% of households with access to the internet	2
# of internet connections per 100 000 population	1
# of landline subscriptions per 100 inhabitants. IP per capita	1
% of Internet-connected households	1
% of the population that uses the internet away from their home or workplace	1
% of the population using the internet for video calls	1
Alternative internet facility	1
Average internet speed in the city in Mbps	1
Frequency of communication via email	1
Frequency referring to info in Internet	1
Internet facility connection	1
Internet Services.	1

The Web Index seeks to measure the economic, social and political benefit that countries obtain from the internet	1
Life	**24**
# of deaths caused by industrial accidents per 100 000 population	1
# of McDonald's restaurants per city	1
# of terrorist incidents by city in the last three years	1
% of roadways in good condition	1
Annual per capita expenditure on leisure and recreation	1
Areal size of informal settlements as a percentage of city area	1
Average number of people per household	1
Basic service proximity	1
Child Care Availability	1
Global Peace index	1
Hourly wage in the city in US dollars	1
Jobs-housing ratio	1
Local accessibility	1
m2 of public indoor recreation space per capita	1
m2 of public outdoor recreation space per capita	1
Measures of income distribution	1
Pollution index	1
Population weighted density	1
Price of property as percentage of income	1
Ranking of cities according to the number of photos taken in the city and uploaded online. The top positions correspond to the cities with the most photographs	1
Recreational Facilities	1
Registered Twitter users by city, in thousands of people + number of registered LinkedIn members	1
Restaurant index	1
This variable shows whether a city provides a friendly environment for women scale 1-5	1
Mobility	**44**
# of commercial vehicles in the city	1
# of metro stations per city	1
# of public transit services that offer real time information to the public	1
# of shared vehicles per capita	1
% non-motorized transport trips of total transport	1
% of bicycle to transportation	1
% of commuters using a travel mode other than a personal vehicle	1
% of pedestrians to transportation	1
% of population living within 0,5 km of public transit running at least every 20 min during peak periods	1

% of private to transportation	1
% of public to transportation	1
% of traffic lights connected to real-time traffic management system	1
Annual # of public transport trips per capita	2
Averag commute cost	1
Average commute time	2
Bicycle network	1
Binary variable that shows whether the city has a high-speed train or not	1
Congestion levels	1
Dissatisfaction due to long commute times.	1
Dynamic Public Transport Information	1
Index of time based on how many minutes it takes to get to work	1
Integrated fare system for public transport	1
Intersection Control	1
Kilometres of bicycle paths and lanes per 100 000 population	1
Kilometres of public transport system per 100 000 population	1
Length of the city's metro system	1
Low-Carbon Emission Passenger Vehicles	1
Pedestrian infrastructure	1
Public Transport Network	1
Public Transport Network Convenience	1
Shared bicycle	1
Shared Vehicles	1
Sustainability of the transport system	1
This index is an estimate of the inefficiencies in traffic	1
This index is estimated by considering the time spent in traffic.	1
Time spent in traffic during a commute.	1
Traffic Monitoring	1
Transportation deaths per 100 000 population	1
Transporttation mode share	1
Travel time index	1
Whether the city has a moped rental service	1
Whether the city has a scooter rental service	1
Parking Innovation	**5**
Civilian adoption of parking technology.	1
The level of parking technology implementation.	1
The number of parking spaces capable of accepting digital payments.	1
The number of parking technology providers operating in the city.	1
The overall number of parking spaces per capita.	1
Political	**5**
Democracy ranking	1

Political conferences	1
Sensitive and careful with global changes	1
Voter participation	1
Voter participation in last municipal election	1
Safety	**16**
# of fire-related deaths per 100 000 population	1
# of firefighters per 100 000 population	1
# of homicides per 100 000 population	1
# of natural-hazard-related deaths per 100 000 population	1
# of police officers per 100 000 population	1
# of volunteer and part-time firefighters per 100 000 population	1
Disaster Related Economic Losses	1
Emergency Service Response Time	1
Fire Service	1
Individual security	1
Natural Disaster Related Deaths	1
Police Service	1
Population Living in Disaster Prone Areas	1
Resilience Plans	1
Response time for emergency response services from initial call	1
Traffic Fatalities	1
Services	**6**
% of the population that uses the internet for banking services	1
Access to local services within a short distance	1
Access to neighbourhood services within a short distance	1
Lifestyle Services.	1
Public and social services	1
Whether the city has Uber and/or Glovo services	1
Waste	**20**
% of city's hazardous waste that is recycled	1
% of city population with regular solid waste collection (residential)	1
% of city's solid waste that is recycled	3
% of city's solid waste that is biologically treated and used as compost or biogas	1
% of the city's solid waste that is disposed of by other means	1
% of the city's solid waste that is disposed of in a sanitary landfill	1
% of the city's solid waste that is disposed of in an open dump	1
% of the city's solid waste that is treated in energy-fromwaste plants	1
Average amount of municipal solid waste generated annually per person (kg/year)	1
Hazardous waste generation per capita	1
Solid waste collection	1
Solid waste treatment	1

The recycling rate in each country	1
Total collected municipal solid waste per capita	2
Volume of solid waste generated	1
Waste collection coverage.	1
Waste generated per capita.	1
Water and Sanitation	**30**
% of city population served by wastewater collection	1
% of city population with potable water supply service	1
% of city population with sustainable access to an improved water source	1
% of city's wastewater receiving centralized treatment	1
% of commercial buildings with smart water meters	1
% of population with access to improved sanitation	1
% of population with access to waterborne or alternative (and effective) sanitary sewage infrastructure	1
% of the population with reasonable access to an appropriate quantity of water resulting from an improvement in the water supply	1
% of the urban population that uses at least basic sanitation services—that is, improved sanitation facilities that are not shared with other households	1
% of water loss (unaccounted for water)	1
Average annual hours of water service interruptions per household	1
Basic water supply	1
Compliance rate of drinking water quality	1
Compliance rate of wastewater treatment	1
Fress water consumption	1
Household sanitation	1
Portable water supply	1
Proportion of population with access to adequate and safe drinking water	1
Quality of drinking water	1
Total amount of water availability	1
Total domestic water consumption per capita (litres/day)	1
Total renewable water sources per capita	1
Total water consumption per capita	2
Wastewater collection	1
Wastewater treatment	1
Water consumption	1
Water quality index	1
Water quality score	1
water supply loss	1
Sum	**545**

Appendix 8: Semi-structured interview draft (HUN)

Interjú - Városvezetők

Interjúalany: ....
Pozíció: ....

1. Város
   1.1. Kérem, mutatkozzon be és mutassa be röviden a városát?
   1.2. A város rendelkezik Klíma és / vagy Okos város stratégiával?
2. Klímaváltozás
   2.1. Mekkora a város hozzájárulása a klímaváltozáshoz?
   2.2. Városvezetőként, hogy tudja támogatni a város klímaváltozáshoz való hozzájárulásának csökkentését?
3. Smart City
   3.1. Hogyan definiálná azt, hogy 'Smart city'?
   3.2. Az eddigi tapasztalatai alapján, Ön szerint, mi tesz egy fejlesztést „okossá"?
   3.3. Ön szerint mi a célja, milyen területeket érint egy Smart city fejlesztés?
   3.4. Miben tér el egy hagyományos városfejlesztési projekt egy smart fejlesztéstől?
   3.5. Kérem, rangsorolja a lenti városi problémákat az Ön városára legjellemzőbbtől (1) a legkevésbé jellemzőig (11), minden szám csak egyszer szerepelhet.

   1- az Ön városára legjellemzőbbtől - 11. az ön városára legkevésbé jellemzőig.

Probléma / kihívás	Fontosság 1.-11.
A város egyre élhetetlenebbé válik (Urbanizáció)	
Egyre kevesebb a szabad (zöld)terület	
Nagy a város függősége (energia, élelmiszer)	
Jelentős a zaj/légszennyezés	
Néha / egyre többször, elviselhetetlen a forróság (városi hősziget hatás)	
Kritikus az energiaellátottság	
Nehéz megfizethető lakhatást találni	
A városi infrastruktúra (közutak, padok, stb) nem megfelelő minőségű	
Nem megfelelő a hulladékgazdálkodás	
Nagy az ökológiai lábnyoma	
Jelentős a város hozzájárulás a klímaváltozáshoz	

   3.6. Hogy ítéli meg a saját városa helyzetét? Mik az erősségei és mik a gyengeségei?
   3.7. Ön szerint, a korábbi problémák közül, melyekre tud hatékony megoldást nyújtani egy Smart city fejlesztés? Minden szám csak egyszer szerepelhet.

1.-leghatékonyabb megoldás kínálja – 11.-amire a legkisebb relevanciája van

Probléma / kihívás	Fontosság 1.-11.
A város egyre élhetetlenebbé válik (Urbanizáció)	
Egyre kevesebb a szabad (zöld)terület	
Nagy a város függősége (energia, élelmiszer)	
Jelentős a zaj/légszennyezés	
Néha / egyre többször, elviselhetetlen a forróság (városi hősziget hatás)	
Kritikus az energiaellátottság	
Nehéz megfizethető lakhatást találni	
A városi infrastruktúra (közutak, padok, stb) nem megfelelő minőségű	
Nem megfelelő a hulladékgazdálkodás	
Nagy az ökológiai lábnyoma	
Jelentős a város hozzájárulás a klímaváltozáshoz	

4. Smart fejlesztések
    4.1. Fel tudná sorolni a legfontosabb smart fejlesztéseket a városában?
    4.2. Mekkora üvegházhatásúgáz-kibocsátás csökkenést értek el ezekkel a projektekkel?
    4.3. Milyen kiemelt szempontok voltak a fejlesztésekhez kapcsolódó döntés során?
        4.3.1. Mérlegeltek a döntés során környezettudatossági, fenntarthatósági szempontokat? Ha igen, akkor mit?
    4.4. Mi akadályozza meg Önt és városát abban, hogy (további) smart fejlesztéseket hajtson végre?
    4.5. Mennyire felelnek meg a piac által nyújtott Smart megoldások az Ön és városa igényeinek? Mennyire nehéz megfelelő megoldást találni a kihívásokra?

Interjú - Cégek

Interjúalany: ....
Pozíció/ szakterület: ....

1. Cég
    1.1. Kérem, mutatkozzon be és mutassa be röviden a céget?
2. Klímaváltozás
    2.1. Hogy tudja Ön termékein/szolgáltatásain keresztül támogatni a klímaváltozáshoz való hozzájárulás csökkentését?
3. Smart City
    3.1. Hogyan definiálná azt, hogy ’Smart city’?
    3.2. Az eddigi tapasztalatai alapján, Ön szerint, mi tesz egy fejlesztést „okossá”?

3.3. Ön szerint mi a célja, milyen területeket érint egy Smart city fejlesztés?

3.4. Miben tér el egy hagyományos városfejlesztési projekt egy smart fejlesztéstől?

3.5. Kérem, rangsorolja a lenti városi problémákat az Ön szerint legjellemzőbbtől (1) a legkevésbé jellemzőig (11), minden szám csak egyszer szerepelhet.

1- a legjellemzőbbtől - 11. a legkevésbé jellemzőig.

Probléma / kihívás	Fontosság 1.-11.
A város egyre élhetetlenebbé válik (Urbanizáció)	
Egyre kevesebb a szabad (zöld)terület	
Nagy a város függősége (energia, élelmiszer)	
Jelentős a zaj/légszennyezés	
Néha / egyre többször, elviselhetetlen a forróság (városi hősziget hatás)	
Kritikus az energiaellátottság	
Nehéz megfizethető lakhatást találni	
A városi infrastruktúra (közutak, padok, stb) nem megfelelő minőségű	
Nem megfelelő a hulladékgazdálkodás	
Nagy az ökológiai lábnyoma	
Jelentős a város hozzájárulás a klímaváltozáshoz	

3.6. Ön szerint a korábbi problémák közül melyekre tud hatékony megoldást nyújtani egy Smart city fejlesztés?

1. leghatékonyabb megoldás kínálja – 11.- legkisebb relevanciája van

Probléma / kihívás	Fontosság 1.-11.
A város egyre élhetetlenebbé válik (Urbanizáció)	
Egyre kevesebb a szabad (zöld)terület	
Nagy a város függősége (energia, élelmiszer)	
Jelentős a zaj/légszennyezés	
Néha / egyre többször, elviselhetetlen a forróság (városi hősziget hatás)	
Kritikus az energiaellátottság	
Nehéz megfizethető lakhatást találni	
A városi infrastruktúra (közutak, padok, stb) nem megfelelő minőségű	
Nem megfelelő a hulladékgazdálkodás	
Nagy az ökológiai lábnyoma	
Jelentős a város hozzájárulás a klímaváltozáshoz	

4. Smart fejlesztések

4.1. Fel tudná sorolni a legfontosabb smart fejlesztéseket, amin dolgoztak?

4.2. Mekkora üvegházhatásúgáz-kibocsátás csökkenést értek el ezekkel a projektekkel?

4.3. Milyen kiemelt szempontok voltak a fejlesztésekhez kapcsolódó döntés során?

4.3.1. Mérlegeltek a döntés során környezettudatossági, fenntarthatósági szempontokat? Ha igen, akkor mit?

4.4. Mi akadályozza meg cégét abban, hogy (további) smart fejlesztéseket hajtson végre?

4.5. Kérem emlékezzen vissza egy Ön által választott smart fejlesztésre, hogyan találták meg az Önök által nyújtott megoldáshoz tartozó problémát/keresletet?

4.6. Mennyire nehéz megfelelő megoldást nyújtani a kihívásokra?

Interjú - Szakértők

Interjúalany: ....
Pozíció/ szakterület: ....

1. Szakterület
   1.1. Kérem, mutatkozzon be és mutassa be röviden a szakterületét?
2. Klímaváltozás
   2.1. Ismeretei alapján hogyan ítéli meg az okos fejlesztések hozzájárulását a klímaváltozáshoz való hozzájárulás csökkentésé vagy az adaptáció növelése terén?
3. Smart City
   3.1. Hogyan definiálná azt, hogy 'Smart city'?
   3.2. Az eddigi tapasztalatai alapján, Ön szerint, mi tesz egy fejlesztést „okossá"?
   3.3. Ön szerint, miben tér el egy hagyományos városfejlesztési projekt egy smart fejlesztéstől?
   3.4. Ön szerint mi a célja, milyen területeket érint egy Smart city fejlesztés?
   3.5. Kérem, rangsorolja a lenti városi problémákat az Ön szerint legjellemzőbbtől (1) a legkevésbé jellemzőig (11), minden szám csak egyszer szerepelhet.

   1- a legjellemzőbbtől - 11. a legkevésbé jellemzőig.

Probléma / kihívás	Fontosság 1.-11.
A város egyre élhetetlenebbé válik (Urbanizáció)	
Egyre kevesebb a szabad (zöld)terület	
Nagy a város függősége (energia, élelmiszer)	
Jelentős a zaj/légszennyezés	
Néha / egyre többször, elviselhetetlen a forróság (városi hősziget hatás)	
Kritikus az energiaellátottság	
Nehéz megfizethető lakhatást találni	
A városi infrastruktúra (közutak, padok, stb) nem megfelelő minőségű	
Nem megfelelő a hulladékgazdálkodás	
Nagy az ökológiai lábnyoma	
Jelentős a város hozzájárulás a klímaváltozáshoz	

3.6. Ön szerint a korábbi problémák közül melyekre tud hatékony megoldást nyújtani egy Smart city fejlesztés?

1. leghatékonyabb megoldás kínálja – 11.- legkisebb relevanciája van

Probléma / kihívás	Fontosság 1.-11.
A város egyre élhetetlenebbé válik (Urbanizáció)	
Egyre kevesebb a szabad (zöld)terület	
Nagy a város függősége (energia, élelmiszer)	
Jelentős a zaj/légszennyezés	
Néha / egyre többször, elviselhetetlen a forróság (városi hősziget hatás)	
Kritikus az energiaellátottság	
Nehéz megfizethető lakhatást találni	
A városi infrastruktúra (közutak, padok, stb) nem megfelelő minőségű	
Nem megfelelő a hulladékgazdálkodás	
Nagy az ökológiai lábnyoma	
Jelentős a város hozzájárulás a klímaváltozáshoz	

4. Smart fejlesztések

4.1. Fel tudna sorolni olyan smart fejlesztést, amin dolgozott? A

4.1.1. Mekkora üvegházhatásúgáz-kibocsátás csökkenést értek el ezzel a projekttel?

4.1.2. Milyen kiemelt szempontok voltak a fejlesztésekhez kapcsolódó döntés során?

4.1.2.1. Mérlegeltek a döntés során környezettudatossági, fenntarthatósági szempontokat? Ha igen, akkor mit?

4.1.3. Mi akadályozza meg cégét abban, hogy (további) smart fejlesztéseket hajtson végre?

4.1.4. Kérem emlékezzen vissza egy Ön által választott smart fejlesztésre, hogyan találták meg a problémára a megoldást?

4.1.5. Mennyire nehéz megfelelő megoldást találni a szakterületét érintő kihívásokra?

4.2. Milyen Smart megoldást ismer a szakterületéhez kapcsolódóan? B

4.3. Ha nincs információja arról, hogy a szakterületén alkalmaztak okos megoldásokat, akkor annak Ön szerint mi lehet az oka? C

Appendix 9: Online bilingual (HU-ENG) questionnaire - ENG

2. Gender: Female / Male / Other
3. Age: 0-25 / 26-35/ 36-45 / 46-55 / 56-
4. Do you live in a city? YES / NO
5. In which city do you live? ---------------------
6. Please mark all the problems you have experienced in your city.
   - ☐ Powerful urbanisation
   - ☐ Intensive land consumption, lack of green spaces
   - ☐ Intensive dependence on Hinterland (agriculture, forestry, mining)
   - ☐ Notable pollution (air, water, waste, noise, thermal)
   - ☐ More frequent heat waves (Heat Island effect)
   - ☐ Security of energy supply
   - ☐ Lack of affordable housing
   - ☐ No improvement and/ or maintenance of the urban infrastructure
   - ☐ Inadequate waste management
   - ☐ The ecological footprint of commute
   - ☐ Significant greenhouse gases emission (electricity, transportation, heating, buildings etc.)
   - ☐ There is no problem in my city
   - ☐ Other: --------------------------
7. What type of development would be essential in your city? ------------------
8. Which statement is true for you?
   D. I have a great knowledge in the context of "smart city"
   E. I am familiar with the term "smart city", but I am not an expert
   F. I am not familiar with this term
9. Do you know any example for a smart solution / innovation in YOUR city? YES /NO
10. Please shortly explain this/these smart solution(s) / innovation(s).
11. Do you know any example for a smart solution / innovation in OTHER city(cities)? YES/NO
12. Please shortly explain this/these smart solution(s) / innovation(s).

Appendix 10: Questionnaire - Result

	Both	Env	Ind	None	Other	Sum
City dweller	**75**	**11**	**47**	**343**	**5**	**481**
Expert	**24**	**1**	**10**	**12**	**3**	**50**
0-25	**3**			**2**		**5**
Male	**3**			**2**		**5**
Yes	3					3
No				2		2
26-35	**6**		**4**	**5**	**1**	**16**
Male	**5**		**3**	**3**	**1**	**12**
Yes	5		3		1	9
No				3		3
Female	**1**		**1**	**1**		**3**
Yes	1		1			2
No				1		1
Other				**1**		**1**
No				1		1
36-45	**6**	**1**	**1**	**2**	**1**	**11**
Male	**2**	**1**		**2**	**1**	**6**
Yes	2	1			1	4
No				2		2
Female	**4**		**1**			**5**
Yes	4		1			5
46-55	**7**		**4**	**1**	**1**	**13**
Male	**6**		**2**	**1**		**9**
Yes	6		2			8
No				1		1
Female	**1**		**2**		**1**	**4**
Yes	1		2		1	4
56-	**2**		**1**	**2**		**5**
Male				**1**		**1**
No				1		1
Female	**2**		**1**	**1**		**4**
Yes	2		1			3
No				1		1
Familiar	**2**		**9**	**150**		**161**
0-25				**7**		**7**
Male				**1**		**1**
No				1		1
Female				**6**		**6**
No				6		6
26-35	**2**		**5**	**34**		**41**

Male	**2**		**1**	**9**		**12**
Yes	2		1			3
No				9		9
Female			**4**	**25**		**29**
Yes			4			4
No				25		25
36-45				**46**		**46**
Male				**7**		**7**
No				7		7
Female				**39**		**39**
No				39		39
46-55			**3**	**32**		**35**
Male			**2**	**11**		**13**
Yes			2			2
No				11		11
Female			**1**	**21**		**22**
Yes			1			1
No				21		21
56-			**1**	**31**		**32**
Male				**10**		**10**
No				10		10
Female			**1**	**21**		**22**
Yes			1			1
No				21		21
Not familiar	**49**	**10**	**27**	**181**	**1**	**268**
0-25	**2**	**1**	**1**	**18**		**22**
Male	**1**			**11**		**12**
Yes	1					1
No				11		11
Female	**1**	**1**	**1**	**7**		**10**
Yes	1	1	1			3
No				7		7
26-35	**14**	**1**	**8**	**52**	**1**	**76**
Male	**8**		**2**	**17**	**1**	**28**
Yes	8		2		1	11
No				17		17
Female	**5**	**1**	**6**	**35**		**47**
Yes	5	1	6	2		14
No				33		33
Other	**1**					**1**
Yes	1					1
36-45	**13**	**3**	**7**	**42**		**65**
Male	**7**		**3**	**22**		**32**

Yes	7		3	1		11
No				21		21
Female	**6**	**3**	**4**	**19**		**32**
Yes	6	3	4			13
No				19		19
Other				**1**		**1**
No				1		1
46-55	**12**	**1**	**8**	**37**		**58**
Male	**7**		**3**	**18**		**28**
Yes	7		3			10
No				18		18
Female	**5**	**1**	**5**	**19**		**30**
Yes	5	1	5			11
No				19		19
56-	**8**	**4**	**3**	**32**		**47**
Male	**1**			**9**		**10**
Yes	1					1
No				9		9
Female	**7**	**4**	**3**	**23**		**37**
Yes	7	4	3			14
No				23		23
Other			**1**		**1**	**2**
26-35			**1**		**1**	**2**
Male			**1**			**1**
Yes			1			1
Other					**1**	**1**
Yes					1	1
Non-city dweller	**3**	**2**	**6**	**57**	**1**	**69**
Expert	**1**			**4**		**5**
0-25				**1**		**1**
Female				**1**		**1**
No				1		1
36-45	**1**					**1**
Male	**1**					**1**
Yes	1					1
46-55				**2**		**2**
Male				**2**		**2**
No				2		2
56-				**1**		**1**
Female				**1**		**1**
No				1		1
Familiar				**22**		**22**
0-25				**2**		**2**

Female				**2**		**2**
No				2		2
26-35				**9**		**9**
Male				**4**		**4**
No				4		4
Female				**5**		**5**
No				5		5
36-45				**5**		**5**
Female				**5**		**5**
No				5		5
46-55				**3**		**3**
Male				**2**		**2**
No				2		2
Female				**1**		**1**
No				1		1
56-				**3**		**3**
Male				**2**		**2**
No				2		2
Female				**1**		**1**
No				1		1
Not familiar	**2**	**2**	**6**	**31**	**1**	**42**
0-25				**2**		**2**
Male				**1**		**1**
No				1		1
Female				**1**		**1**
No				1		1
26-35	**1**	**1**	**3**	**4**		**9**
Male	**1**		**1**	**2**		**4**
Yes	1		1			2
No				2		2
Female		**1**	**2**	**2**		**5**
Yes		1	2			3
No				2		2
36-45			**2**	**8**		**10**
Male				**5**		**5**
No				5		5
Female			**2**	**3**		**5**
Yes			2			2
No				3		3
46-55	**1**		**1**	**11**		**13**
Male	**1**		**1**	**4**		**6**
Yes	1		1			2
No				4		4

Female				**7**		**7**
No				7		7
56-		**1**		**6**	**1**	**8**
Male				**5**	**1**	**6**
Yes					1	1
No				5		5
Female		**1**		**1**		**2**
Yes		1				1
No				1		1
Sum	**78**	**13**	**53**	**400**	**6**	**550**

Bibliography

Fekete, K.A. & Nemes, L. (2021): Fenntarthatóság és Smart City. In Szabadegyetem 2020.

Fekete, K.A. & Zsóka, Á. (2021): Resilient cities in practice. In Proceedings of the 20th European Roundtable on Sustainable Consumption and Production. pp. 169–182.

Fekete, K.A. (2021): Contribution and mitigation, the double role of cities in tackling climate change. In XXIV. Tavaszi Szél Konferencia 2021: Absztrakt kötet. pp. 346–346.

Fekete, K.A. & Zsóka, Á. (2021): International Security Challenges of Climate Change: Lessons from the Syrian Case for a Multi-stakeholder Approach to Resilient Adaptation. In International Security Management. pp. 155–170.

Fekete, K.A. (2019): Is This The Trend to a Better Future? In 1st International PhD Conference of the International Relations Multidisciplinary Doctoral School of CUB. pp. 46–50.

Nagy, S.G., Endrődi-Kovács, V. & Fekete, K.A. (2017): Anomalies of the internal market in the insurance and banking sector from the perspective of Visegrad countries. FOREIGN POLICY REVIEW, 2017(1), pp.145–163.