Article

Creating Smart, Sustainable Cities: Results from Best Practice Smart Cities and Cities in Slovakia

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Dominika Šulyová

University of Žilina, Department of Management Theories, Slovakia

Milan Kubina

University of Žilina, Department of Management Theories, Slovakia

Abstract

In light of current climate change concerns, it is not enough to create only Smart Cities but it is important to create Smart Sustainable Cities. Countries like Slovakia have not been adequately considering these issues as much as they should. Responding to the opportunity to fill a research gap, primary research has been conducted for this article that seeks i) to use results from previous research to compare currently identified elements influencing the development of a sustainable Smart City concept in Slovakia with best practice cities around the world; and ii) to identify those elements that have achieved a statistically significant correlation with the conceptualisation of Smart Cities in Slovakia. Research data were collected through sociological interrogation, processed in a statistical programme, and subsequently evaluated. The findings point to key elements in developing Smart Cities such as trust, state support and adapting to change. The main output is a general model for conceptualising a Smart City. It can be utilised by strategic city management, fellow researchers and residents of a city implementing it in their own practices. The model reflects social, environmental, technological, and managerial aspects. Further research into the model and subsequent verification are planned in future.

Keywords

Sustainable development; Smart Cities; Climate change; Urbanization; Limited resources; Slovakia; Technology

JEL Classification

R11, Q01, O13, Q56

Introduction

Population growth, migration trends and climate change have all had an adverse impact on limited resources (Macke et al., 2019; Obringer & Nateghi, 2021). The direct impact of the last is mainly reflected in energy and water consumption, weather, and soil biodiversity (Fernández & Peek, 2020). Several experts believe that sustainability of finite resources is possible and negative environmental fluctuations can be minimised through conceptualised smart, sustainable cities (Macke et al., 2019; Obringer & Nateghi, 2021; Vukovic et al., 2021; Treude, 2021; Ahvenniemi et al., 2017; Laconte, 2018). Over the past decade, demand for sustainable cities has risen as they become the driving force for 21st century development (Akande et al., 2019; D´Auria et al., 2018). It is estimated that more than 70% of the world's population will be living in urban areas by 2050 (Ismail, 2017). The Smart Cities market is forecast to grow at a CAGR (Compound annual growth rate) of 18.22% between 2021 and 2026 (Mordor Intelligence, 2022; ReportLinker, 2022).

According to the world's experts, climate change will be reflected in cities by a 1.5 °C rise in temperature (Kjaer Global, 2020; Dupont, 2020). Global temperatures have increased since the 19th century, driven by higher CO_2 levels in the atmosphere, with 60-80% of carbon dioxide generated primarily by cities (Guillén, 2020). Urban agglomerations consume 75% of resources, produce 80% of emissions and generate 85% of gross domestic product (ESPAS, 2020; Fisk, 2019). They have been a driving force for progress, providing a higher quality of life and job opportunities (Lynas, 2020; Marshall, 2018). In 2020, there were 20 megacities, and by 2025 the number will have grown to 37 (Chism, 2014).

The world's best Smart City practices can be analysed through various rankings. However, only the IMD Smart City Index approaches a comprehensive understanding of the technological core, while focusing strongly on social and environmental elements. Research articles using data from this index dealt with the issue of smart

Corresponding author:
Dominika Šulyová, Faculty of Management Science and Informatics, University of Žilina, Slovakia
Email: dominika.sulyova@fri.uniza.sk

manufacturing, the Smart City Framework for Malaysia or the assessment of urban development only on a theoretical level, for example in the Czech Republic (Suvarna et al., 2020; Lim et al., 2021; Hajek et al., 2022). However, in these articles there was a lack of connection between the ranking results and the realization of primary research. They also lack a clear connection between the technological basis, the social and environmental element, which is the focus of this article.

The topic has hardly been covered in Slovakia. Relevant articles connected with the researched issue tend to concentrate on awareness of the Smart City concept itself or innovations at specific cities in the country such as Bratislava and Poprad (Cagáňová et al., 2019; Adamuscin et al., 2016; Husar & Ondrejicka, 2016; Baculakova, 2020). The outputs themselves date from 2016-20 and the information is not up-to-date. Their specific focus creates no opportunity for general implementation of the knowledge and findings for any strategic management of cities in Slovakia. Even in Slovakia, climate change has become noticeable and there is currently not even one Smart City in the country studying it, thus creating a research gap (Bakonyi, 2020).

Up to 40% of the country's area is devoted to agriculture and 60% of its forest ecosystems have been significantly damaged (Slovak Environmental Agency, 2015; Yar et al., 2018). Experts predict that, by 2075, temperatures in Slovakia will have risen by 2-4 °C, generating periods of drought, loss of freshwater streams and melting of snow cover (Ministry of Investments, Regional Development and Informatization of the Slovak Republic 2020; Digital transformation strategy of Slovakia 2030, 2020). By 2030, population and migration is forecast to increase in Námestovo, Tvrdošín and Bytča, three communities located in north Central Slovakia, at Kežmarok and Stará Ľubovňa in the westernmost regions of Eastern Slovakia at, and in Slovakia's second-largest city, Košice, as well as migration to communities surrounding Bratislava, the Slovakian capital (Szalai, 2019; SHMÚ, 2021).

The main problems consist of the increasing number of inhabitants in cities, the limited state of limited resources and the insufficient solution to this problem, the absence of current data in the subject area within Slovak cities.

To explore this phenomenon, the main question addressed by the research is: What factors do help to transform the cities into sustainable and smart ones?

The purpose of this article is to answer this question through research data which were collected through sociological interrogation, processed in a statistical programme and subsequently evaluated. Subjects of research were representatives of the world's best practice cities in the IMD 2020 rankings, resident from the eight region cities in Slovakia and 71 district cities in Slovakia (SmartCity, 2020; IMD, 2020). For these reasons the main goal of this article is the creation of recommendations and model which are essential in order to start addressing the issue, researching it and taking corrective and preventive action.

The ambition behind this article is to draw upon the knowledge obtained from previous research, which has long focused on the conceptualisation of sustainable Smart Cities (Šulyová & Vodák, 2020; Šulyová et al., 2021; Šulyová & Vodák, 2021). A number of elements have been identified both from our own outputs and published papers outlining how state support, competitive advantage, the level of trust in government institutions and the degree of adaptation have all played roles in conceptualising smart, sustainable cities (Šulyová & Kubina, 2022).

The novelty is represented by the results of our research activity because intensive research needed to be carried out because Smart Cities are a topic that has not been sufficiently covered in Slovakia and no research with this type of focus had been previously done in Slovakia. The main value and novelty is covered by factors which help to transform cities into Smart Sustainable Cities, as well as model of this transformation. The originality and relevance of this topic is related to the regional and national economy because cities are a driving force for progress, providing a higher quality of life and job opportunities. They are important for regional and national development and reputation (Lynas, 2020; Marshall, 2018). According to Safiullin et al. technologies from Industry 4.0 used in Smart City concept (for example Internet of Things) "create new infrastructure for the concept of Smart Cities", (Safiullin et al., 2019). The added value of this manuscript is filling a research gap with the proposed model based on data derived from the results of our own research. Once the model will be implemented in practice, the model will convey practical benefits through specified outputs such as sustainable development, engagement, efficiency and effectiveness. Fellow researchers and urban strategic management can utilise the findings in this article as a model for conceptualising and developing sustainable Smart Cities whose results will be perceivable by residents. The expected results of the research include:

- Identified factors that help transform cities into sustainable and smart ones.
- A model of such transformation, i. e. general model for creating a smart, sustainable city.
- Confirmation or eventual rejection of established hypotheses.

From review of our past works follows that cultural aspects have an impact on the sustainable development of cities in the form of elements of education on the given issue, which have a positive effect on awareness and values. At the same time, it mediates positive adaptation to change through the theory of change that supports sustainable development and overall smart city concepts. A city that uses smart technologies with the primary goal of improving the quality of life should be built on the principle of the expectations and needs of all stakeholders. The development and sustainability of Smart Cities depends on the value aspect of trust. Building trust-based Smart City concepts can make it easier to embrace and adapt to change. Confidence in strategic management should be embodied by a trusted manager who is characterized by integrity, achieving results based on his competencies and fulfilling the set tasks (Šulyová & Vodák, 2021). Advanced technologies have great importance for the future for the management of Smart City processes, resources, and stakeholders. Cities should see advanced technologies as a future trend in a holistic way of solving social and environmental problems. Smart Cities are significantly influenced by advanced technologies, including Internet of Things (IoT) for data collection, machine learning (used for prediction), databases (data management), dashboards (important for presentation of data) (Vodák et al., 2021). Responding to the opportunity to fill a research gap, primary research was conducted on a larger scale than what had previously been done. It sought i) to use results from previous research to compare currently identified elements influencing the development of a sustainable Smart City concept in Slovakia with best practice cities around the world; and ii) to identify those elements that have achieved a statistically significant correlation with the conceptualisation of Smart Cities in Slovakia. Research contributes to section of Literature Review on smart and sustainable cities and management of limited resources in the urban environment.

Literature Review

Currently, there are several approaches to understanding the term Smart City. Giffinger et al. (2007) are of the opinion that a prosperous city that achieves a high level in the field of energy, mobility or health based on strategic decision-making processes, independence, innovation, and awareness of citizens can be called a Smart City. Lombardi et al. (2011) they claim that Smart City includes not only the holistic aspect of technology, but the key element is mainly the knowledge level of citizens and their attitude towards change. The term points to the dependence between the city management and its inhabitants. Manville et al. (2014) they primarily appeal to the interactive implementation of urban processes, activities, and services by individual actors. Patrão et al. (2020) argue the importance of an integrated approach in the form of an "umbrella" that covers the technological core, the cooperation of interested parties and a high quality of life. Latest definitions from Singh et al. (2022) and Schiavo & de Magalhães (2022) define Smart City as an effective integration of solutions for citizens and an approach that uses technology as a tool to improve the quality of life.

Managing Smart City concepts with a focus on limited resources is related to the concept of sustainable development. Beaumont (2013) understands sustainable development as an effort to protect limited resources to preserve the planet for future generations by supporting the elements of sustainable development. Wahl (2020) states that it is the process of maintaining an element at a certain level to protect limited resources for future generations and increase the quality of life of citizens. Attenborough (2020) defines sustainable development in the urban concept as the stabilization of biodiversity that can be achieved by managing limited resources. The world does not have the natural sustainability of nature. Maxton (2020) reflects the importance of living like ancient civilizations, i.e. to maintain a constant consumption of limited resources. Mao & Deng (2022) they perceive sustainable development as strengthening the complex coordination of urban systems that have an impact on society and the environment because of climate change and its negative impact on the state of limited natural resources.

Traditional Smart Cities give priority to the structural elements of government, health, security, culture, and education, and prefer economic aspects related to profit generation (Ahvenniemi et al., 2017; Treude, 2021; Elgazzar & El-Gazzar, 2017). The superior term to Smart City is Smart Sustainable City, which complies with all the basic elements of the concept of Smart City with the extension of indicators related to the management of limited resources (environment, waste and water management, eco-friendly energy, etc.) (Ahvenniemi et al., 2017; Treude, 2021). A common feature between Smart City and Smart Sustainable City is the effort to increase the quality of life, the reputation of the city and the satisfaction of citizens (Ahvenniemi et al., 2017; Treude, 2021). The hallmarks of a Smart Sustainable City are sustainable principles of community-based strategic government and the conservation of resources for future generations (Elgazzar & El-Gazzar, 2017). This definition can be adopted not only for large and medium cities but also to the smaller scale cities. Lopes and Oliveira claims “small scale cities have huge potential to make their mark in Smart Cities concept, we can also state beyond doubt that small and medium sized cities do not lag behind the large ones when it comes to Smart Cities,” (Lopes & Oliveira, 2017). On a bottom-up basis, smart, sustainable cities are able to meet the social and environmental needs of all stakeholders (Macke et al., 2019). A new trend in 2022 is to build Smart Cities based on vertically oriented relationships in the proposed models (Khalid, 2022). Smart sustainable cities represent an innovative solution to optimize resources, build new and develop existing world cities (do Livramento et al., 2021; Bibri, 2018). Smart Sustainable Cities they have social, economic and ecological aspects. The social aspect includes the ability to meet the needs of citizens from the point of view of education, health, safety, housing, culture, or social inclusion (Schiavo & de Magalhães, 2022). The economic aspect reflects the possibility of getting a job, creating innovations and using the city's infrastructure (Schiavo & de Magalhães, 2022).

The ecological aspect of Sustainable Smart Cities rebuilds the ability of resources for future generations in terms of their quantity and quality. Limited resources include air, soil, water, and energy (Schiavo & de Magalhães, 2022). The same opinion have Ofoezie et al. (2022), according to which one of the important components of the Smart Sustainable City is the protection of limited natural resources. The environmental aspect of the lack of limited resources manifests itself in the social environment of cities primarily through threats to health, the ecosystem, biodiversity, and climate (Schellens & Gisladottir, 2018). The criticality of the state of limited resources is in the opinion Schellens, Gisladottir (2018) also caused by low state support and the wrong way of managing them. The trend of population growth in cities increases the consumption of limited resources, which negatively affects the management concept. However, one of the solutions is according to Currin et al. (2022) to create Smart Sustainable Cities. Building new and developing current Smart Cities based on sustainability helps the strategic management of the city to use resources effectively and efficiently.

The ecological and social aspect of Smart Cities is coming to the fore especially in the 21st century. Albino at al. (2015) they claim that earlier definitions of Smart City preferred the technological aspect, but the current ones are social (people, communities) and ecological (protection of the environment and limited resources for future generations). The same opinion have Al-qudah et al. (2022), who claim that the element of sustainability represents a city's competitive advantage and is based on understanding and meeting the needs of residents in terms of social, cultural, political and ecological aspects.

Summary of section Literature Review is findings that Smart Sustainable Cities represent a higher level of Smart City and their creation and development contribute to the protection of limited resources for future generations. With the growth of the population in cities and the decrease of limited resources, it is important to develop solutions that will include not only the ecological but also the social aspect of adaptation to changes in connection with the technological core of the concept Smart Sustainable Cities. It follows from the above findings that the main objective which is to develop a general model for conceptualising a Smart City based on results from our own research. The groundwork for our research is the questions set out in the materials and methods section of this article and hypotheses that serve to validate, describe, and design the model, and to obtain a better understanding of the issues in Slovakia. Hypotheses 1 and 1a focus on conceptualisation elements; in other words, a city's readiness to adopt a Smart City concept in Slovakia. The point behind Hypothesis 2 is to link the social element of change adoption to the foundation of each Smart City, i. e. the technological core. The hypotheses are in the following formulations:

Hypothesis 1: *If a city's readiness to successfully create a Smart City depends on the elements of (1) trust, (2) state support, (3) city size and (4) competitive advantage, then cities in Slovakia whose population is greater than 100,000 inhabitants have the greatest potential to become Smart Cities based on sustainable development.*

Hypothesis 1a: *If readiness and successful implementation of the Smart City concept depend primarily on the element of trust, then there is a positive correlation between state support and trust.*

Hypothesis 2: *If residents are more positive about change adoption in their lives, then they will have more confidence in cutting edge technologies and applications.*

Methods

Study area – research focused on the world's best practice Smart Cities according to a selected ranking and cities inside Slovakia. Among member states of the European Union, Slovakia ranks 31st by population. Its area is 49,035 square kilometres and, according to figures, the population is 5,449,270. Slovakia has no Smart Cities itself at this time although initial conceptualisation initiatives started in 2017 (Bakonyi, 2020). They remain only theoretical, and the concepts have yet to be put into practice. None of the plans presented to date have been implemented. However, climate change, migration, and population growth, evident in the scarcity of resources, are creating the conditions for conceptualising Smart Cities and pressure is being put on Slovakia to follow through on the first Smart Cities. Research involved the contact of 71 sufficiently populated district cities, covering an adequate area to be feasible, out of the 141 cities registered in Slovakia's eight regions (Slovakia – regional geography, 2022; Slovakia, 2022; Slovak Republic – summary statistics, 2022; List of cities in Slovakia, 2022; Ministry of Economy of the Slovak Republic, 2017).

Objectives: (i) to use results from previous research to compare currently identified elements/factors influencing the development of a sustainable Smart City concept in Slovakia with best practice cities around the world; and (ii) to identify those elements that have achieved a statistically significant correlation with the conceptualisation of Smart Cities in Slovakia.

Intensive research needed to be carried out because Smart Cities are a topic that has not been sufficiently covered in Slovakia and no research with this type of focus had been previously done.

Subjects of research – Smart City respondents consisting of the following:

- Representatives of the world's best practice cities in the IMD 2020 rankings (SmartCity, 2020; IMD, 2020).
- Residents from the eight region cities in Slovakia (sampled from a population of 1,121,256 people, 95%

confidence interval, 5% sampling error, so a minimum 385 residents of Slovakia).

- 71 district cities in Slovakia.

The IMD ranking was selected to meet criteria for comprehensiveness and centrism toward the cities' residents. Their selection was conditioned to concentrate on economic, technological and social aspects such as quality of life and the urban environment from the perspective of a city's residents (SmartCity, 2020).

The research spanned the thirteen-month period from June 2021 to July 2022. Because the IMD 2021 rankings were not available when research began (they were only published in November 2021), the IMD 2020 rankings were used for selection.

Twenty-two mayors were contacted from among the sample of Smart Cities and, during the selection process, a questionnaire was sent to the top three ranked cities by best practice and to eight other respondents who had been contacted in previous research:

- Auckland;
- Copenhagen;
- Amsterdam;
- Prague;
- Budapest;
- Berlin;
- Athens;
- Rio de Janeiro.

When selecting additional cities, two criteria had to be simultaneously satisfied:

- They were European Smart Cities (cities in England were not considered part of the European Union); and
- They had risen in the rankings between the base year 2019 and 2020.

Eleven cities met the conditions above. Overall, the sample consisted of 22 Smart Cities globally. Cities in Slovakia were categorised by their size into five groups:

1. Less than 6,000 (two cities)
2. 6,000 – 10,999 (five cities)
3. 11,000 – 19,999 (22 cities)
4. 20,000 – 99,999 (40 cities)
5. 100,000 or more (two cities)

Methods – primary research was comprised of sociological interrogation with an online questionnaire created in Google Forms, which contained the research questions below. They were developed from previous research (Šulyová & Kubina, 2022) and the results therefrom, with the aim of follow-up research and to prepare this article:

- To what extent are stakeholders satisfied with current state support for urban modernisation?
- What is the region's competitive advantage?
- What is the degree of trust in government institutions?
- What is the level of the city's strategic management's readiness to put the Smart City concept into practice?
- How adaptable are residents to change?
- How much do residents trust modern applications?
- How is the city currently managing finite resources?
- How many projects involving the management of limited resources have taken place in the last three years?

The data obtained from the questionnaires were then statistically processed in IBM SPSS Statistics 26 software, where the variables were correlated according to their type, with Pearson's Chi-squared, Cramer's V and a contingency coefficient used for nominal data and, for ordinal numbers, Spearman's rank correlation coefficient (rho) to compare two variables and the Kruskal-Wallis one-way analysis of variance (H) to compare more than two variables. If the Chi-squared test's predictive power was very low and the expected multiplicity was lower than the set materiality level of 5%, then the likelihood-ratio and Fisher-Freeman-Halton tests were utilised for contingency tables larger than 2 x 2. In addition to the statistical tests, a hypothesis verification method and a Pareto distribution diagram were also used.

Comparative methods were applied to study the relationship between Smart Cities outside of Slovakia and cities in Slovakia, while problem-solving methods such as modelling, creativity, logic, synthesis, induction and deduction contributed toward the development of a general model for conceptualising a smart sustainable city).

Results

Profile of respondents: Sampled cities

After writing mayors in selected cities several times, and in Slovakia telephoning them, responses were obtained from 16 Smart Cities around the world (73% success rate) and all 71 district cities in Slovakia (100% success rate). The Smart Cities that were researched are marked in bold on Table 1.

Table 1. Selected Smart Cities addressed in the research phase.

Position in ranking	Smart Cities	Ranking	Reason for selection
Top	Singapore	1.	Best practice
	Helsinki	2.	
	Zürich	3.	
	Auckland	4.	Contact
	Copenhagen	6.	
	Amsterdam	9.	
	Munich	11.	The new Smart City in Europe
	Stockholm	16.	European Smart City + growth in the rankings
	Sydney	18.	Contact
	Hamburg	22.	The new Smart City in Europe
Middle	Vienna	25.	Contact
	The Hague	28.	European Smart City + growth in the rankings
	Rotterdam	29.	
	Berlin	38.	Contact
	Prague	44.	
	Krakow	58.	European Smart City + growth in the rankings
	Tallinn	59.	
	Brussel	60.	
End	Lisbon	75.	
	Budapest	77.	Contact
	Athens	99.	
	Rio de Janeiro	102.	

Source: processed according to IMD (2020)

Profile of respondents: Sampled populations

The characteristics of the population of Slovakia are important for providing an idea of the structure of the sample that is relevant to the research (see Figure 1). At a 95% confidence level and 5% sampling error, 385 residents participated in the Smart City survey and 444 residents completed the questionnaire.

From the data collected, the sample comprised mainly respondents aged 31 to 45 (50%) and 19 to 30 years (28%). In terms of their education, the highest percentage of the population sampled had a university degree (50%), followed by residents with only a secondary school education (48%). Women expressed more interest in the issue with a participation rate of 64%. The administrative region variable appears to be the most important characteristic. The largest number of respondents came from Trenčín Region (32%), followed by Žilina Region (18%) and Bratislava Region (16%).

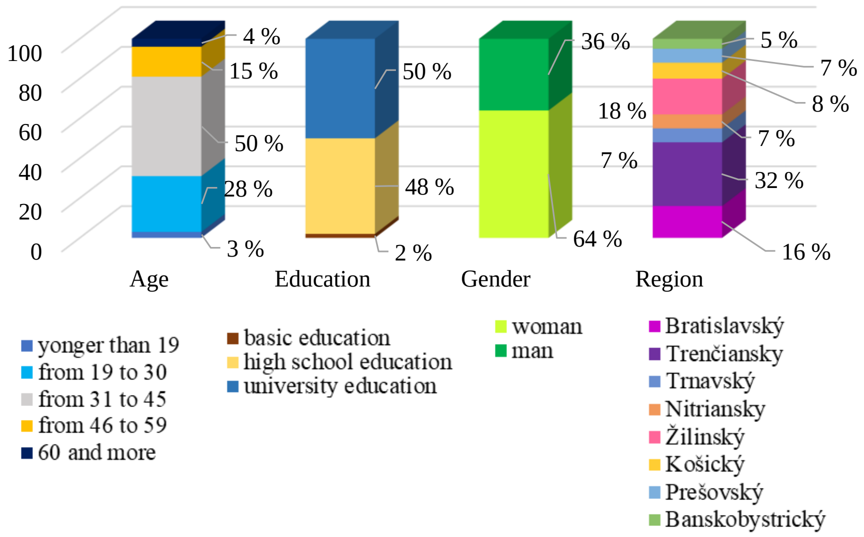

Fig. 1. Sample from the population of Slovakia.
Source: own processing

In our opinion, the level of respondents' involvement depended on where the researchers live permanently, the university from where the research was conducted and, in the case of Bratislava Region, the level of concern that residents had expressed about the issue and the capital city's prestige.

Factors influencing the conceptualisation of Smart Cities

An essential element of the research questions was the ability from them to derive information about the level of support, competitive advantage, level of trust and the readiness of the cities to embark upon becoming a Smart City. Size was made an indicator after the cities were categorised into five groups according to population (see Methodology).

To what extent are stakeholders satisfied with current state support for urban modernisation?

Figure 2 shows cities outside Slovakia scoring significantly higher in terms of satisfaction with current government support for urban modernisation, at 8 on a scale of 1 (minimum) to 10 (maximum).

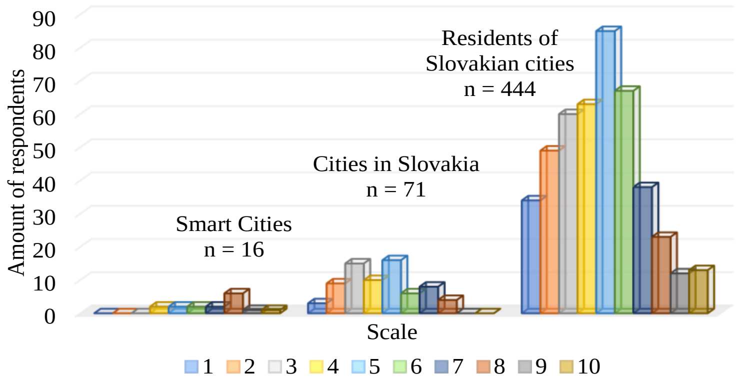

Fig. 2. Evaluation of respondents' satisfaction with state support for modernisation.
Source: own processing

Mayors of cities in Slovakia expressed a level of satisfaction between 3 and 5 on the same scale, while residents in Slovakia overwhelmingly preferred to score the indicator at 5, at the middle of the scale.

What is the region's competitive advantage?

Ten of the 16 rest-of-world cities have a combined advantage (both natural and acquired), while six of them had an acquired advantage, second in the ranking.

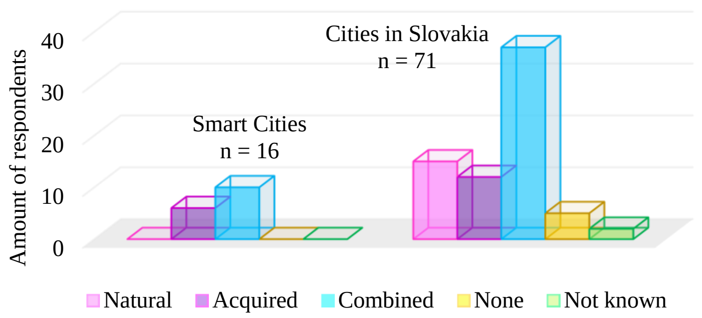

Fig. 3. Evaluation of regional competitive advantages.
Source: own processing

In Slovakia, 37 cities (see Figure 3) enjoyed a combined advantage, 15 a natural advantage (forests, meadows, pastures and the like) and 12 an acquired advantage (expertise and technology). Compared to the cities beyond its borders, however, Slovakia's district cities felt either that they had no advantage or did not know if they had any.

What is the degree of trust in government institutions?

World cities trust government institutions, with five of them placing their level of confidence at 8 on the scale, and another seven at 9. In Slovakia, the degree of trust is much lower, as shown by Figure 4. The highest values were 5, expressed by sixteen cities and 3 by fifteen cities.

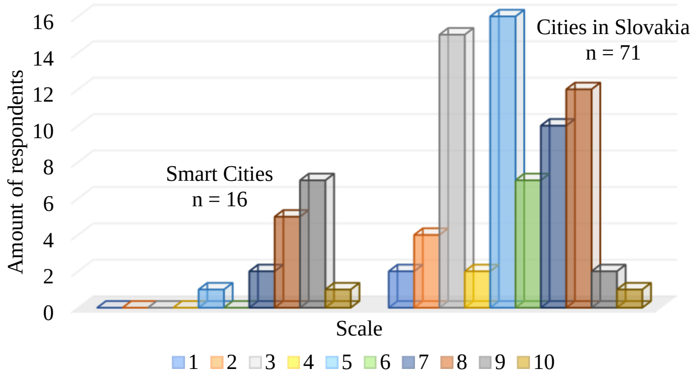

Fig. 4. Evaluation of the level of trust in government institutions.
Source: own processing

What is the level of the city's strategic management's readiness to put the Smart City concept into practice?

Both the processing of the results and interpretation of them (see Figure 5 and Table 2) show cities in Bratislava Region to be the most prepared for adopting the Smart City concept.

Table 2. Average value of city readiness for the Smart City concept by region.

Region	Readiness (average value)
Bratislava	6.4
Banská Bystrica	2.1
Košice	2.9
Nitra	2.4
Prešov	2.5
Trenčín	2.8
Trnava	2.8
Žilina	3.4

Cities in Žilina and Košice Regions were the second and third most prepared, respectively. But compared to Bratislava Region, they were on average about two times less prepared.

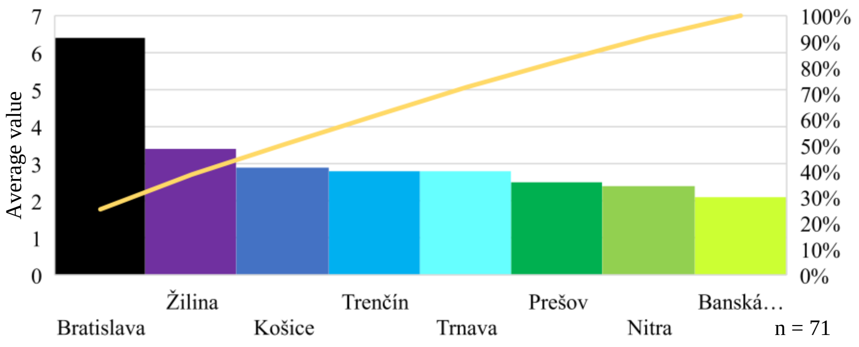

Fig. 5. Readiness by region of cities in Slovakia to embrace the Smart Cities concept.
Source: own processing

How adaptable are residents to change?

Figure 6 indicates that an absolute majority of respondents valued their level of change adaptation at 3, on a sale of 1 (low) to 10 (high).

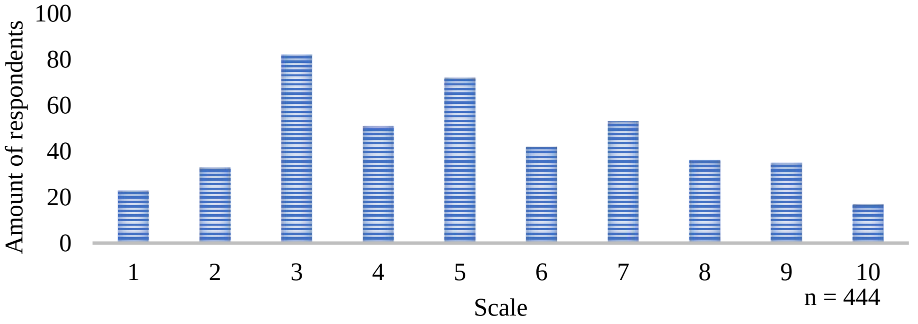

Fig. 6. Evaluated degree of residents' adaptation to change.
Source: own processing

The chart implies no positive perception of change among people in Slovakia. They can neither acclimatise themselves easily to a changing environment, nor flexibly adjust to it.

How much do residents trust modern applications?

On a scale of 1 (minimum) to 10 (maximum), the trust expressed by residents of Slovakia (444 respondents) in modern applications spiked at 1, 3 and 8 (see Figure 7).

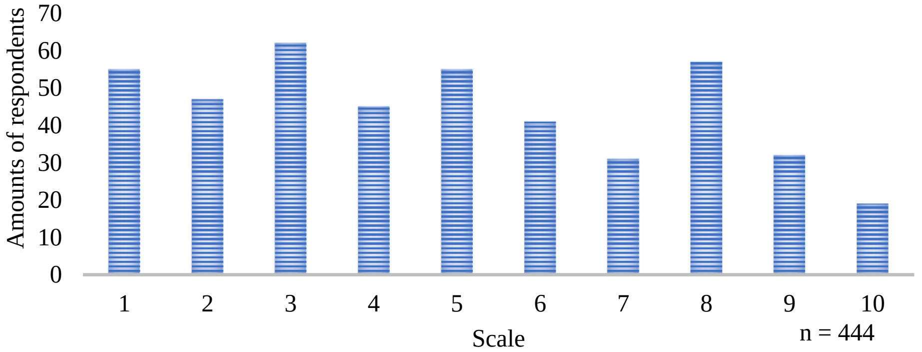

Fig. 7. Evaluated level of local trust in modern applications.
Source: own processing

Management of limited resources in the urban concept

How is the city currently managing finite resources?

The world's Smart Cities follow a set strategy to manage limited resources and to plan and implement their projects. Over time, they monitor the data, analyse it and take corrective action, for which they raise financial resources (Figure 8). Not even one of the surveyed cities outside Slovakia indicated in their questionnaires any inability to manage finite resources.

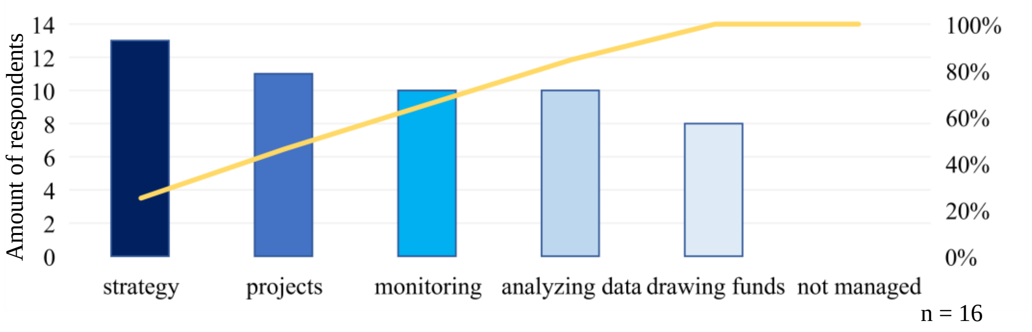

Fig. 8. Limited resources management in Smart Cities.
Source: own processing

Cities in Slovakia prefer developing projects and drawing funds. Strategy, which is supposed to be the primary step, was underestimated, and overlooked by Slovakian cities. Research showed five cities not managing their resources at all (Figure 9).

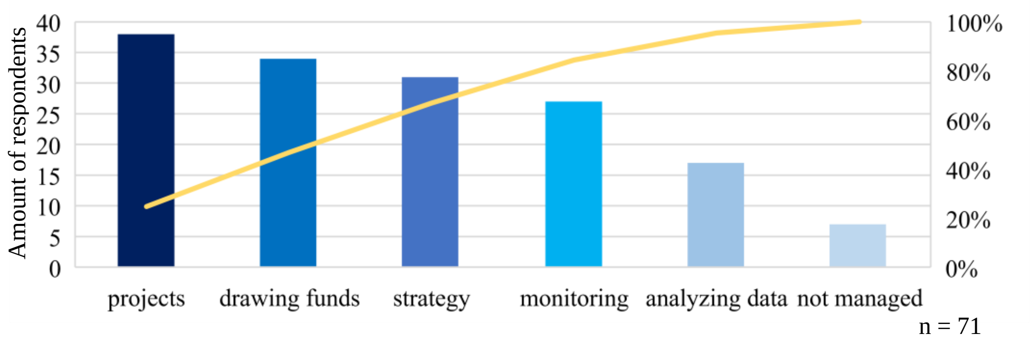

Fig. 9. Limited resources management at cities in Slovakia.
Source: own processing

How many projects involving the management of limited resources have taken place in the last three years?

Figure 10 shows seven of the Smart Cities around the world, out of the 16 that responded in the survey, to have implemented 11 or more projects in the last three years. Fifty-one cities in Slovakia, representing all of the categories (Category 1-5 by population), responded to this question about the projects they had completed.

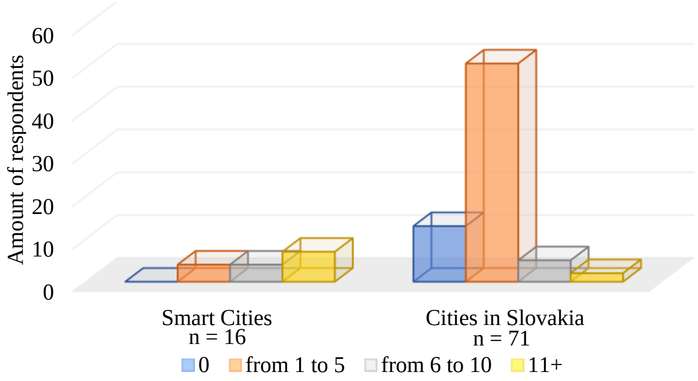

Fig. 10. Amount of limited resources management projects implemented in the last three years.
Source: own processing

The results indicated that, in the past three years, they had not been able to implement enough projects even though the previous research question had ranked them at the top in how they managed limited water resources.

Verification of hypotheses

Based on the null hypothesis of no association and dependence between the variables, the working hypotheses proposed earlier were assessed. The indicators used to verify Hypothesis 1 were the levels of government support and trust, competitive advantage, a city's readiness to adopt the Smart City concept, and its size. For Hypothesis 1a, they were the levels of government support, trust, and readiness. The degree of adaptation to change and the level of trust were the indicators used to prove or disprove Hypothesis 2.

The Kruskal-Wallis H test was chosen for the calculation because of the ordinal nature of the variables (trust, state support, size, and readiness). Table 3 displays the statistical verification of all three hypotheses. The results argue for the p-values of trust and size variables being below the established significance level of α = 0.05.

Hence, Working Hypothesis 1 was not confirmed because readiness depends on trust and size, not on state support and not on competitive advantage.

Since competitive advantage was a nominal variable, readiness was modified into a dichotomous variable (yes/no) for dependence to be detected with the Chi-squared test (Table 3). As six cells have an expected multiplicity of less than five, the likelihood ratio and the value generated from the Fisher-Freeman-Halton test of statistical significance were calculated and these are shown in Table 3.

They are greater than the significance level (5%), so the null hypothesis was accepted: competitive advantage has no statistically significant effect on the variable of a city's readiness to adopt the Smart City concept.

The correlation between the ordinal variables of trust and state support was ascertained through Spearman's Rho (Table 3). The calculation implies an obvious correlation, namely that the null hypothesis is rejected and Hypothesis 1a is accepted.

Both the degree of adaptation by residents to change and the level of trust in modern applications are ordinal variables whose values range from 1 to 10. The null hypothesis for Spearman's Rho is that the degree of adaption to change does not depend on the element of trust in modern applications. Table 3 presents the calculation revealing an evident dependency at the 5% significance level, where the p-value in both cases takes a value less than 0.05, So the null hypothesis is rejected, and the alternative Hypothesis 2 is accepted.

Table 3. Statistical verification of hypotheses.

			Hypothesis 1		
			Trust	State Support	City Size
Kruskal-Wallis H*			16.598	8.330	61.983
df			8	8	8
Asymptotic sig. (p-value)			0.035	0.402	0.000
	Value	df	Asymptotic Significance (p-value)	Exact Significance	Approximate Significance
Pearson's Chi-squared	4.212a	4	0.378		
Likelihood-ratio	6.226	4	0.183		
Freeman-Halton	3.530			0.475	
Number of respondents	71				
Nominal by Nominal					
Statistical significance				no	
			Hypothesis 1a		
Spearman´s Rho				Trust	State Support
	Correlation coefficient			1,000	0.567**
Trust	P-value			-	0.000
	N (number/amount)			71	71
	Correlation coefficient			0.567**	1.000
State Support	P-value			0.000	-
	N			71	71
			Hypothesis 2		
Spearman´s Rho				Changes	Trust
	Correlation coefficient			1.000	.186**
Changes	P-value			-	0.000
	N			444	444

Trust	Correlation coefficient	0.186**	1.000
	P-value	0.000	
	N	444	444

Note: * Compared group: Readiness; a) Six cells reach the expected number less than 5, the expected number is 0.62; ** Apparent correlation at the level of significance

Main findings from research

Primary research found the national government not doing enough to promote modernisation of cities and low levels of trust in the state, which correlates with data from a 2019 European Union study. It showed 80% of respondents dissatisfied with government support and trust by Slovaks in their national institutions rated at only 4.8 out of 10 points (OECD Economic Surveys, 2019). The consequence of such an assessed low trust in the strategic management of cities in Slovakia has an impact on how procedures are implemented in practice. Any city that desires to become a Smart City should achieve a combined advantage, or to have gained more than just a natural advantage. Research suggests it advisable, when setting out to create smart sustainable cities in Slovakia, to focus on individual cities rather than regions. The argument stems from a finding that regional cities with a higher population have the highest level of readiness. Other experts agree with the assertion, and they believe that cities whose populations are greater than 100,000 have a greater degree of readiness to adopt the Smart City concept (Lopes & Oliveira, 2017; European Parliament, 2014; OECD, 2020).

To summarise, world cities outside Slovakia have a higher level of government support, trust, and willingness among their residents to embrace change. They are implementing more conservation projects and managing limited resources better. Mayors of Smart Cities around the world primarily have a resource management strategy. A surprising finding was that Slovakian cities implement projects without following any strategies. Their method of managing finite resources has not been properly set up. Failure to execute a strategy correctly in the early stages reduces overall effectiveness.

The results of our own research indicate that the elements of trust and city size influence the conceptualisation of smart, sustainable cities, while government support and competitive advantage do not. Therefore, Hypothesis 1 was not confirmed. Nonetheless, since the element of trust influences a city's readiness to adopt the Smart City concept and Hypothesis 1 likewise confirmed the correlation between trust and support, there is a necessity for cooperation and participation in new Smart City projects. It is crucial for people in Slovakia to develop a positive attitude toward change from early childhood since a direct relationship exists between change and trust (expressed by Hypothesis 2). Moreover, research found the change adaptation variable to be extremely low. Table 4 shows it as just 3 out of a possible 10 points. A summary of the main findings from the first part of primary research focusing on Smart City issues can be found in Table 4.

Table 4. Main findings from primary research questions and hypotheses.

Research questions	Results
To what extent are stakeholders satisfied with current state support for urban modernisation?	Smart Cities = 8; Cities in Slovakia = 3 and 5
What is the region's competitive advantage?	Combination of natural and acquired
What is the degree of trust in government institutions?	Smart Cities = 8-9; Cities in Slovakia = 3-5
What is the level of the city's strategic management's readiness to put the Smart City concept into practice?	Low, only 3 on a scale of 1-10
How adaptable are residents to change?	Low, only 3 on a scale of 1-10
How much do residents trust modern applications?	Low in general; highest in Bratislava Region - 6.4 points out of a possible 10
How is the city currently managing finite resources?	Smart Cities = strategy, projects, monitoring Cities in Slovakia = projects, finances, strategy
How many projects involving the management of limited resources have taken place in the last three years?	Smart Cities = 11+; Cities in Slovakia = from 1 to 5
Hypotheses	Results

1: If the city's readiness to implement the Smart City concept successfully depends on the elements (1) trust, (2) state support, (3) city size, and (4) competitive advantage, then cities have the greatest potential to become a Smart City based on sustainable development in Slovakia if they have over 100,000 inhabitants.	Not confirmed
1a: If the successful implementation of the Smart City concept / readiness depends primarily on the element of trust, then there is a positive relationship between state support and trust.	Confirmed
2: If residents are more positive about the changes in their lives, then they will have more confidence in modern technologies / applications.	Confirmed

Discussion, a general model, its benefits, limitations and implementation recommendations

This article suggests a general model for building a smart, sustainable city. It consists of three core layers where social, technological, and managerial aspects are reflected in the centristic oriented level, technology level and strategic management level, respectively. It also includes an environmental aspect in the form of a sustainable development block encompassing a limited resource management strategy and, in a separate block, management's readiness to create and develop a Smart City. The model, shown in Appendix A, builds upon previous research. While the earlier sub-models were designed from secondary data analysis, the model described here is based on primary data from our own research. The hypotheses earlier postulated here have verified some of the elements from the previous sub-models.

The new aspects are mainly outputs from the model that concentrate on sustainable development, readiness and verification of the interrelationships between the key elements that influence the conceptualisation of a Smart City. Individual parts of the model are descriptive, linked to the results in the previous chapter, and include a discussion incorporating the views from other studies authored on the subject.

General model for creating a smart, sustainable city

Centristic oriented level

The model's entry level responds to the trend toward centrism models oriented toward urban residents with the bottom-up vertical relationships referred to in Khalid (2022) and Macke et al. (2019). The core is a psycho-social orientation whose significance has been expressed by Gassman et al. (2020); Grossi et al. (2020); Casey (2020); Fourneris (2020) and Gordon (2020). All of them emphasise key input elements from residents, who have individual, collective and systematic roles in conceptualising a Smart City.

Every resident has their own level of education, awareness, values, and level of change adaptation within the role each individual plays. Those who have lived in Slovakia from infancy have experienced a homogenous culture and values, while residents that have recently immigrated to Slovakian cities have had to adapt their culture and values to a new environment. Adaptation, according to Bull et al. (2018), McGrath and Bates (2015) and the methods of Elisabeth Kübler-Ross, are influenced by an element in the theory of change. In the world's best practice Smart City, Singapore according to the IMD 2020 ranking, children as young as six years of age have learned to cope with unpredictable changes and to perceive both technological development and multiculturalism positively. The more stress academic institutions place on new subjects oriented toward the Smart City concept, conservation, managing limited resources and sustainable development, the greater the awareness of these issues and the higher the population's educational level about them. In the opinion of Wood et al. (2006); Bacon (2006) and Clark (2010), awareness and homogeneous values led liberal communities underscoring urban sustainable development to emerge and play a collective role in the Smart City concept. Here, national governments should be supporting innovative projects, sharing transparent information, and thereby building what is a necessary element in the model, namely trust. Results from research indicate the level of government support influences the level of trust, which in turn has a significant impact on residents' engagement, one of the main outcomes of the model. This view is also shared by authors such as Romano and Akhmouch (2019); Ramadi and Nguyen (2021), Wang et al. (2021), Covey (2008), Zak (2017) and Edelman (2020). Linking individual, and collective roles with the impact of state support builds up the systemic role a holistic Smart City approach plays and emphasises a bottom-up approach that focuses on the role of residents (Sancino & Hudson, 2020; Huovila et al., 2019; Milošević et al., 2019; Muller et al., 2019 and Varsheny, 2020).

Theory of change

Residents would have to change their behaviour and customary lifestyle, way of thinking and their upbringing to adapt to the changes a new Smart City concept would bring and identify with them. These elements are achievable according to the theory of change, whose theoretical significance, as published by James McGrath and Bob Bates, are highlighted in particular by Kübler-Ross and have been applied in practice in Smart City Singapore (McGrath & Bates, 2015). According to Filo, conservation of limited resources is trending as a concern among residents younger than 35 years of age, yet despite the trend, seniors are also interested in the issue (Filo, 2021).

Filo’s own research confirmed the argument, where the importance of conservation was mainly expressed in the 31–45-year age group (49.5% of the total number of respondents) while the figure fell to 12.3% among the senior age group (60+).

Technology level

It is the task of national governments and the state to provide adequate technological equipment for the Smart City concept to work. Data is collected through the Internet of Things (IoT), while the management and presentation of the data is processed and stored through the city’s own dashboards. A detailed description of the technologies can be found in the previous article from the authors (Vodák et al., 2021).

Strategic management level

Support in management and decision-making is a major element in the model’s third level because it has a direct impact on the managerial functions block. Prediction based on machine learning technology can lower the degree of risk in new Smart City concept projects. Delineating potential problems and risks before the planning phase makes it possible to strengthen a city’s readiness to adopt Smart City approaches. Besides machine learning, the entire technology system has an impact on the strategic management level, which is reflected in the elements of the pyramid of vitality. Management structures are updated from data collected in the field, which generates both dynamism and stability in the processes due to their continuous improvement. The pyramid of vitality has a mutual feedback loop with the pyramid of culture that synergises, harmonises, and integrates Smart City approaches, thereby conveying key insights for the management function of planning. The issues have been discussed, for example, by Maca (2013), Števanková (2018), Attenborough (2020) and Harari (2018).

Vision, goals, and factors are the inputs feeding into the managerial functions block from the internal environment. This view is also shared by van Hattum et al. 2017 and Mguni et al. (2015), although they specified no criteria for developing the objectives, something which would be later addressed by Kalenyuk et al. (2022). The vision should be conceived inspirationally, in harmony with the expectations of all stakeholders, collectively in collaboration with residents and over a longer time span for sustainable development, respecting the limits of systemic growth.

The managerial functions block is also influenced by the professional and character qualities of the city’s strategic management, represented at the individual level by a manager. Based on his or her knowledge and experience, the manager applies acquired and innate abilities, such as temperament, to carry out the job and contribute toward achieving results. Because Hypothesis 1 was verified, the relationship between the direct influence of competitive advantage and government support on the readiness of city management to adopt a Smart City concept, which appeared in the previous sub-model, has now been removed.

External environment

In separate studies, Macke et al. (2019), Obringer & Nateghi (2021) defined the main trends in the external environment that affect the model, namely population growth, migration trends and climate change with its negative impact on limited resources. The trends need to be monitored and analysed as their predictive early detection can eliminate the adverse impact, they would otherwise have on the Smart City concept.

Stakeholders: cities and residents

The stakeholders in the proposed model, according to our own research, include residents and urban strategic management. Residents mediate values, awareness, and expectations, thereby contributing to the creation of centrist models and cities. The strategic management of cities (mayors and city councils) form the foundation for management and coordination. Research results point to the critical nature of government support, which is why the last stakeholder in the model is a particular country's national government and state institutions.

Model outputs

Sustainable development, engagement, efficiency, and effectiveness are among the model’s outputs (see Appendix A). The first of these, sustainable development, depends on quality of life, a criterion understood in the context of this article to mean providing adequate scarce resources for present and future generations, including environmental protection. Besides adopting the approaches followed by the world’s best practice Smart Cities, essential instruments for achieving the criterion include cooperation, trust, and the theory of change for better adaptation by residents.

Engagement reflects receptivity to change and sufficient awareness of the issue. The level of a city’s strategic management level should be high enough to build trust, develop the theory of change and to educate, communicate to, and cooperate with other stakeholders. Effectiveness is linked to state support for financial and technological readiness.

Benefits of the model and how to use it

The model contributes theoretically to the management of scare resources in an urban environment as it fills a research gap in this area with data derived from the results of our own research. Once implemented in practice, the model will convey practical benefits through specified outputs. Fellow researchers and urban strategic management can utilise the findings in this article as a model for conceptualising and developing sustainable Smart Cities whose results will be perceivable by residents.

Limitations of the model

Limitations of the model include the following:

- Research was confined to best practice cities and cities in Slovakia.
- Dependence on a city's size – as such the model is appropriate for a city whose population is greater than 100,000.
- Conditions set out for putting Smart City concepts in practice, such as achieving an adequate level of government support, level of trust and willingness by residents to commit themselves to a Smart City.
- Need for verification of it in practice.

Recommendations for practice based on the research outcomes

The results of our own research show a very low level of trust in state institutions in Slovakia. To increase the level of trust, it is necessary for state institutions to comply with their commitments, actively support new projects, share transparent information, and create credibility for example in the form of consultations, open discussion, or measures to popularize the Smart Cities concept among citizens, etc. According to Covey, an atmosphere of trust is created by the readiness of the city's strategic management based on integrity, intent, competence, and results (Covey, 2008). Filo claims that in order to build an atmosphere of trust in Slovakia, it is necessary for state institutions to have strategic documents, they used knowledge from science and research and had enough skills to implement change in practice (Filo, 2021). The importance of trust and state support in building Smart City concepts is also argued by the opinions of the authors Romano, Akhmouch (2019), Ramadi, Nguyen (2021), Wang et al. (2021), Zak (2017), Edelman (2020) or Tagliaferri (2022).

Based on the comparison of the opinions of Covey and Fil, it is possible to claim that their elements are homogeneous. If the state acts in accordance with its values and intentions, it implements the outlined strategies, competence includes the professional side (knowledge from science and research) and the ability to implement changes in practice represents results. According to the research results, state support affects the level of trust that affects citizens (their values, participation, etc.), thus arguing for its importance.

The recommendation of theory of change is to act on the accepted values recognised by young families and to utilise elements from the theory of change to nurture the next generation. Children should be raised and educated primarily in a family environment. For the approach to work, they need education from an early age, instilled with environmental values, and for resources to be allocated so they can contribute to a better future for all. Therefore, it is crucial to have an active adult population informed about the situation, because if this group takes a positive approach, their educational methods will likewise be transferred to much younger or older segments. Nonetheless, the theory of change should be developed by educational institutions starting at the age of three.

Future research

Future research involves integrated management of key limited resources that respondents (both residents and the cities) consider critical to manage for future generations. Such research is intended to take place. Based on the outputs, a sub-model for the current strategic management block for limited resources will be proposed. Together with this sub-model, and after additional research, verification of the model in urban practice is planned.

Conclusion

Proposed article was aimed to examine what factors do help to transform the cities into sustainable and smart ones. Sustainable urban ecosystems are facing the challenge of the negative impact caused by climate change. An answer to this challenge is the creation of so-called "sustainable Smart Cities", whose solutions will contribute toward the conservation of finite resources for present and future generations. However, some countries like Slovakia have not adequately considered these issues as much as they should. Findings from our own research have filled an existing research gap. Based on the results of our own research, it is possible to summarize the most important conclusions. As part of the primary research questions, information on factors was obtained:

- Level of state support in the area of city modernization.
- Competitive advantage, which is divided into natural (meadows, pastures, etc.), acquired (knowledge and technology), respectively combined (natural and acquired at the same time).
- Level of trust in state institutions.
- The readiness of cities to implement the Smart City concept in practice.

The results show that a city that wants to become a Smart City should achieve a combined advantage or obtained to a greater extent than just a natural one. However, after the verification of the hypothesis, it turned out that the competitive advantage does not affect the readiness of cities to implement the Smart City concept. It depends on the factors of state support, trust, and the size of the city. Primary research found the national government not doing enough to promote modernisation of cities and low levels of trust in the state. It showed that respondents dissatisfied with government support and trust by Slovaks. The output is an evaluation of the low level of trust in state institutions from the perspective of the strategic level of management of Slovak cities. Research suggests it advisable, when setting out to create smart sustainable cities in Slovakia, to focus on individual cities rather than regions. Regional cities achieve the greatest degree of preparedness. The capital Bratislava is the most prepared. To summarise, world cities outside Slovakia have a higher level of government support, trust, and willingness among their residents to embrace change. In this way and with their results, they represent a model according to which Smart Sustainable Cities can be built even in the territory of Slovakia. From the point of view of managing limited resources, it has become clear that the world's Smart Cities primarily manage resources based on strategy, they are implementing more conservation projects and managing limited resources better. It involved the world's best practice Smart Cities and cities in Slovakia, drawing a conclusion that the key elements influencing the creation of a Smart City are primarily the level of trust and the number of city residents. Confidence needs to be secured among residents through government support for urban modernisation. They should also positively embrace change, which can be achieved through the theory of change and effective strategic management within the city.

The main take-away is a proposed model for creating a smart, sustainable city, which includes social, technological, environmental, and managerial aspects. Its graphic representation reflects trends toward centrism and a vertical direction of bottom-up relations. The proposed model outlines an implementation pattern especially for strategic urban management and research findings utilisable by fellow researchers. Stakeholders among the population will also appreciably notice the model's positive impacts, in the form of outcomes such as sustainable development, engagement, efficiency and effectiveness. When implementing the model, it is also necessary to take its limitations into account such as its origin from research, conditions for implementing the model and that the size of the city is a limiting factor. Additional research is planned in future for developing a sub-model covering the management of a specific limited resource respondents consider critically important to manage for future generations. Subsequently, verification of the model in urban practice is planned. The research results reflect the assessed issue, i. e. lack of limited resources, population growth in cities and the absence of solutions to the given problem in cities in Slovakia. The research results could be implemented in the practice in the form of recommendations and in the form of implementation of proposed model for creating a smart, sustainable city. Benefits and added value consist of specified outputs such as sustainable development, engagement, efficiency and effectiveness, higher level of trust, state support and better adaptation of citizens through theory of change. It is important to deal with this issue now, because if we want to protect limited resources for future generations, one of the solutions is to build Smart Sustainable Cities, which, however, takes some time.

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References

Adamuscin, A., Golej, J., & Panik, M. (2016). Bratislava Towards Achieving the Concept of Smart City: Inspirations from Smart City Vienna. In: Smart City 360°. 2016. Lecture Notes of the Institute for Computer Sciences, *Social Informatics and Telecommunications Engineering*, 166. Springer, Cham. https://doi.org/10.1007/978-3-319-33681-7_72

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and Smart Cities? *Cities, 60*, Part A, 234-245. https://doi.org/10.1016/j.cities.2016.09.009

Akande, A., Cabral, P., Gomes, P., & Casteleyn, S. (2019). The Lisbon ranking for smart sustainable cities in Europe. *Sustainable Cities and Society*, 44, 475-487. https://doi.org/10.1016/j.scs.2018.10.009

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, 22(1), 3–21. https://doi.org/10.1080/10630732.2014.94209

Al-qudah, R., Khamayseh, Y., Aldwairi, M., & Khan, S. The Smart in Smart Cities: A Framework for Image Classification Using Deep Learning. *Sensors*, 22, 4390. https://doi.org/10.3390/s22124390

Attenborough, D. (2020). Život na našej planéte (A Life on our Planet). Bratislava: Barecz & Conrad Media 2021, 286 p.

Bacon, N. (2006). Northeast London: a case study of globalisation. The Young Foundation. June 2006. Available at: https://youngfoundation.org/wp-content/uploads/2013/06/North_east_London_2006.pdf (accessed on 11 May 2022).

Baculakova, K. (2020). Selected Aspects of Smart City Concepts: Position of Bratislava. *Theoretical and Empirical Researches in Urban Management*, 3, 68-80.

Bakonyi, P. (2020). Evaluation of V4 cities in the area of Smart City. Available at: http://smartpolis.eit.bme.hu/?page_id=153 (accessed on 10 May 2022).

Beaumont, P. (2013). 5 Definitions of Sustainability. Available at: http://blogs.rochester.edu/thegreendandelion/2013/06/5-definitions-of-sustainability/ (accessed on 10 December 2022).

Bibri, S.E. (2018). A foundational framework for smart sustainable city development: Theoretical, disciplinary, and discursive dimensions and their synergies. *Sustainable Cities and Society*, 38, 758–794. https://doi.org/10.1016/j.scs.2017.12.032

Bull, R., Bautista, A., Salleh, H., & Karuppiah, N. (2018). Evolving a Harmonized Hybrid System of ECEC: A Careful Balacing Act. A Case Study of the Singapore Early Childhood Education and Care System. Teachers Collage 2018. Available at: http://ncee.org/wp-content/uploads/2019/03/EA-Singapore-Case-Study-03-26-19.pdf (accessed on 11 May 2022).

Cagáňová, D., Stareček, A., Horňáková, N., & Hlásniková, P. (2019). The Analysis of the Slovak Citizens' Awareness about the Smart City Concept. *Mobile Networks and Applications*, 24, 2050–2058. https://doi.org/10.1007/s11036-018-01210-6

Casey, Ch. (2020). NRDC Sues FERC Over Orders that Threaten NY Clean Energy. Available at: https://www.nrdc.org/experts/christopher-casey/nrdc-sues-ferc-over-orders-threaten-ny-clean-energy (accessed on 11 May 2022).

Clark, G. (2010). Managing Diversity, Integration, and Inclusion in OpenCities. Madrid: British Council, 2010. Available at: https://www.alnap.org/system/files/content/resource/files/main/managing-diversity.pdf (accessed on 11 May 2022).

Covey, M. R. (2008). Důvera: jediná věc, která dokáže změniť vše (The of Speed of trust). Praha: Management Press, 2008.

Currin, A., Flowerday, S., de la Rey, E., van der Schyff, K., & Foster, G. (2022). A smart city qualitative data analysis model: Participatory crowdsourcing of public safety reports in South Africa. *The Electronic Journal of Information Systems in Developing Countries*, 88(6), e12232. https://doi.org/10.1002/isd2.12232

D'Auria, A., Tregua, M., & Vallejo-Martos, M.C. (2018). Modern Conceptions of Cities as Smart and Sustainable and Their Commonalities. *Sustainability*, 10, 2642. https://doi.org/10.3390/su10082642

Digital transformation strategy of Slovakia 2030. (2020). Strategy for the transformation of Slovakia into a successful digital country. Available at: https://www.mirri.gov.sk/wp-content/uploads/2019/06/Strategia-digitalnej-transformacie-Slovenska-2030.pdf (accessed on 10 May 2022).

do Livramento Gonçalves, G., Leal Filho, W., da Silva Neiva, S., Borchardt Deggau, A., de Oliveira Veras, M., Ceci, F., Andrade de Lima, M., & Salgueirinho Osório de Andrade Guerra, J.B. (2021). The Impacts of the Fourth Industrial Revolution on Smart and Sustainable Cities. *Sustainability*, 13, 7165. https://doi.org/10.3390/su13137165

Dupont, J. (2020). Global Trends 2020. Available at: https://www.ipsos.com/en-dk/global-trends-2020 (accessed on 10 May 2022).

Edelman. (2020). Edelman Trust Barometer 2020. Available at: https://www.edelman.com/sites/g/files/aatuss191/files/2020-01/2020%20Edelman%20Trust%20Barometer%20Global%20Report.pdf (accessed on 11 May 2022).

Elgazzar, R., & El-Gazzar, R.F. (2017). Smart Cities, Sustainable Cities, or Both? A Critical Review and Synthesis of Success and Failure Factors. In Proceedings of the 6th International Conference on Smart Cities and Green ICT Systems (SMARTGREENS 2017), Porto, Portugal, 22–24 April 2017, pp. 250–257. DOI:10.5220/0006307302500257

ESPAS. (2020). European Strategy and Policy Analysis System – The Megatrends 2030. Available at: https://ec.europa.eu/assets/epsc/pages/espas/chapter1.html (accessed on 10 May 2022).

European Parliament. (2014). Mapping Smart Cities in the EU. Available at: https://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf (accessed on 10 May 2022).

Filo, J. (2021). Naša klimatická zmena. Sprievodca pre tých, čo sa nechcú prizerať (Our climate change. A guide for those who do not want to stare). Bratislava: Petit Press, 175 p.

Fisk, P. (2019). Megatrends 2020-2030 … what they mean for you and your business, and how to seize the new opportunities for innovation and growth. Available at: https://www.peterfisk.com/2019/12/mega-trends-with-mega-impacts-embracing-the-forces-of-change-to-seize-the-best-future-opportunities/ (accessed on 10 May 2022).

Fourneris, C. (2020). Climate control: Stockholm named world´s smartest city as it aims for climate positive footprint. Available at: https://www.euronews.com/2020/01/27/climate-control-stockholm-named-world-s-smartest-city-as-it-aims-for-carbon-positive-footp (accessed on 11 May 2022).

García Fernández, C., & Peek, D. (2020). Smart and Sustainable? Positioning Adaptation to Climate Change in the European Smart City. *Smart Cities*, 3, 511-526. https://doi.org/10.3390/smartcities3020027

Gassman, O., Böhm, J., & Palmié, M. (2020). Smart Cities – Introducing Digital Innovation to Cities. UK: Emerald Publishing Limited.

Giffinger, R., Fertner, Ch., Kramar, H., Kalasek, R., Pichler-Milanović, N., & Meijers, E. (2007). Smart Cities: Ranking of European medium-sized cities. Centre of Regional Science, Vienna UT. Available at: http://www.smart-cities.eu/download/smart_cities_final_report.pdf (accessed on 10 December 2022).

Gordon, P. (2020). London City mayor launches green energy company. Available at: https://www.smart-energy.com/regional-news/europe-uk/london-city-mayor-launches-green-energy-company/ (accessed on 11 May 2022).

Grossi, G., Meijer, A., & Sargiacomo, M. (2020). A public management perspective on Smart Cities: 'Urban auditing' for management, governance and accountability. *Public Management Review*, 22(5), 633-647. https://doi.org/10.1080/14719037.2020.1733056

Guillén, M. F. (2020). 2030: How Today´s Biggest Trends Will Colide and Reshape the Future of Everything. 1st ed., New York: St. Martin´s Press.

Hajek, P., Youssef, A., & Hajkova, V. (2022). Recent developments in Smart City assessment: A bibliometric and content analysis-based literature review, *Cities*, 103709. https://doi.org/10.1016/j.cities.2022.103709

Harari, Y. N. (2018). Sapiens – stručná história ľudstva (Sapiens – A Brief history of Humankind). Bratislava: AKTUELL, 2018. ISBN: 978-80-89873-06-7.

Huovila, A., Bosch, P., & Airaksinen, M. (2019). Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when? *Cities*, 89, 141-153. https://doi.org/10.1016/j.cities.2019.01.029

Husar, M., & Ondrejicka, V. (2019). Social Innovations in Smart Cities – Case of Poprad. *Mobile Networks and Applications*, 24, 2043–2049. https://doi.org/10.1007/s11036-018-01209-z

Chism, M. (2014). Future State 2030 KPMG: The global megatrends shaping governments. Available at: https://assets.kpmg/content/dam/kpmg/pdf/2014/02/future-state-2030-v3.pdf (accessed on 10 May 2022).

IMD. (2020). IMD and SUTD´s unique ranking shows importance of citizens´ needs in policymaking. Available at: https://www.imd.org/smart-city-observatory/smart-city-index/ (accessed on 13 May 2022).

Ismail, N. (2017). What will the Smart City of the future look like? Available at: https://www.information-age.com/will-smart-city-future-look-like-123468653/ (accessed on 10 May 2022).

Kalenyuk, I., Tsymbal L., & Uninets, I. (2022). Smart-City Development Management: Goals and Instruments. International *Journal Of Computer Science And Network Security*, 22(1), 324-330. https://doi.org/10.22937/IJCSNS.2022.22.1.46

Khalid, A. (2022). Smart, Sustainable Vertical City. *Russian Journal Of Building Construction And Architecture,* 1, 106-120. https://doi.org/10.36622/VSTU.2022.53.1.010

Kjaer Global. (2020). The Trend Compass synthesise and link macro trends in an easy-to-navigate overview. Available at: http://kjaer-global.com/trends/ (accessed on 10 May 2022).

Laconte, P. (2017). Smart and Sustainable Cities: What Is Smart? What Is Sustainable? In: Bisello, A., Vettorato, D., Laconte, P., Costa, S. (eds) Smart and Sustainable Planning for Cities and Regions. SSPCR 2017. Green Energy and Technology. Springer, Cham. https://doi.org/10.1007/978-3-319-75774-2_1

Lim S.B., Abdul Malek J., Hussain M.Y., & Tahir Z. (2021). Malaysia Smart City Framework: A Trusted Framework for Shaping Smart Malaysian Citizenship?. In: Augusto J.C. (eds) Handbook of Smart Cities. Springer, Cham. https://doi.org/10.1007/978-3-030-69698-6_34

List of cities in Slovakia. (2022). Available at: https://sk.wikipedia.org/wiki/Zoznam_miest_na_Slovensku (accessed on 10 May 2022).

Lombardi, P., Giordano, S., Caragliu, A., Del Bo, C., Deakin, M., Nijkamp, P., & Kourtit, K. (2011). An advanced triple-helix network model for smart cities performance. In: Research Memorandum; No. 2011-45. Amsterdam: Faculty of Economics and Business Administration. Available at: https://research.vu.nl/ws/portalfiles/portal/2947217/rm+2011-45.pdf (accessed on 10 December 2022).

Lopes, M. I., & Oliveira, P. (2017). Can a small city be considered a smart city? *Procedia Computer Science*, 121, 617-624. https://doi.org/10.1016/j.procs.2017.11.081

Lynas, M. (2020). Šesť stupňov – posledné varovanie (Six degrees – Our final warning). Bratislava: Premedia, 310 p.

Maca, R. (2013). Implementation of PM in the organization. Department of software engineering in Prague, 2013. Available at: https://www.slideshare.net/radekmaca/mi-prm-6-implementace-pm-do-organizace (accessed on 11 May 2022).

Macke, J., Sarate, J. A. R., & de Atayde Moschen, S. (2019). Smart sustainable cities evaluation and sense of community. *Journal of Cleaner Production,* 239, 118103. https://doi.org/10.1016/j.jclepro.2019.118103

Manville, C., Cochrane, G., Cave, J., Millard, J., Pederson, J., Thaarup, R., Liebe, A., Wissner, W. M., Massin, W. R., & Kottering, B. (2014). Mapping Smart Cities in EU. Department of Economic and Scientific Policy. Available at: https://www.europarl.europa.eu/RegData/etudes/etudes/join/2014/507480/IPOL-ITRE_ET(2014)507480_EN.pdf (accessed on 10 December 2022).

Mao, S., & Deng, H. (2022). Regional Ecology Supporting Sustainable Development. Sustainability, 14, 7302. https://doi.org/10.3390/su14127302

Marshall, T. (2018). Rozdelený svet (The divided world). Bratislava: Premedia, 247 p.

Maxton, G. (2020). Zmena alebo kolaps. Prečo potrebujeme radikálny obrat (Change or collapse. Why we need a radical turnaround). Banská Bystrica: PRO vydavateľstvo, 127 p.

McGrath, J., & Bates, B. (2015). 89 nejdůležitejších manažerských teorií pre praxis (89 most important management theories for practice). Praha: Management Press, 261 p.

Mguni, P., Herslund, L., & Jensen, M. B. (2015). Green infrastructure for flood-risk management in Dar es Salaam and Copenhagen: exploring the potential for transitions towards sustainable urban water management. *Water Policy,* 17(1), 126-142. https://doi.org/10.2166/wp.2014.047

Milošević, M. R., Milošević, D. M., Stević, D. M., & Stanojević, A. D.(2019). Smart City: Modeling Key Indicators in Serbia Using IT2FS. *Sustainability* 2019, 11(13), 3536. https://doi.org/10.3390/su11133536

Ministry of Economy of the Slovak Republic. (2017). Support of innovative solutions in Slovak cities. Available at: https://www.mhsr.sk/uploads/files/n5m7duxS.pdf (accessed on 10 May 2022).

Ministry of Investments, Regional Development and Informatization of the Slovak Republic. (2020). Proposal for the Vision and Development Strategy of Slovakia until 2030 - a long-term strategy for sustainable development. Available at: https://www.mirri.gov.sk/wp-content/uploads/2021/01/SLOVENSKO-2030.pdf (accessed on 10 May 2022).

Mordor Intelligence. (2022). SMART CITIES MARKET - GROWTH, TRENDS, COVID-19 IMPACT, AND FORECASTS (2022 - 2027). Available at: https://www.mordorintelligence.com/industry-reports/smart-cities-market (accessed on 10 May 2022).

Muller, E., Héraud, J.-A., Ardizzon, F., Pellegrin, J. (2019). Smart Cities and clusters. Available at: http://www.evoreg.eu/docs/files/shno/Note_evoREG_41.pdf (accessed on 11 May 2022).

Obringer, R., & Nateghi, R. (2021). What makes a city 'smart' in the Anthropocene? A critical review of Smart Cities under climate change. *Sustainable Cities and Society,* 75, 103278. https://doi.org/10.1016/j.scs.2021.103278

OECD Economic Surveys. (2019). Slovak Republik Overview 2019. Available at: https://www.oecd.org/economy/surveys/Slovak-Republic-2019-OECD-economic-survey-overview.pdf

OECD. (2020). Measuring Smart Cities´ Performance. Do Smart Cities benefit everyone? Available at: https://www.oecd.org/cfe/cities/Smart-cities-measurement-framework-scoping.pdf (accessed on 10 May 2022).

Ofoezie, E.I., Eludoyin, A.O., Udeh, E.B., Onanuga, M.Y., Salami, O.O., & Adebayo, A.A. Climate, Urbanization and Environmental Pollution in West Africa. *Sustainability,* 14, 15602. https://doi.org/10.3390/su142315602

Patrão, C., Moura, P., & De Almeida, A. T. (2020). Review of Smart City Assessment Tools. *Smart Cities*, 3(4), 1117-1132. http://dx.doi.org/10.3390/smartcities3040055

Ramadi, K. B., & Nguyen, F. (2021). Rapid crowdsourced innovation for COVID-19 response and economic growth. *npj Digital Medicine*, 4. https://doi.org/10.1038/s41746-021-00397-5

ReportLinker. (2022). Smart Cities Market - Growth, Trends, COVID-19 Impact, and Forecasts (2021 - 2026). Available at: https://www.reportlinker.com/p06039479/Smart-Cities-Market-Growth-Trends-COVID-19-Impact-and-Forecasts.html (accessed on 30 September 2022).

Romano, O., & Akhmouch, A. (2019). Water Governance in Cities: Current Trends and Future Challenges. *Water,* 11(3). https://doi.org/10.3390/w11030500

Safiullin, A., Krasnyuk, L. & Kapelyuk, Z. (2019). Integration of Industry 4.0 technologies for "smart cities" development. IOP Conference Series: Materials Science and Engineering, Volume 497, International Scientific Conference "Digital Transformation on Manufacturing, Infrastructure and Service" 21–22 November 2018, Saint-Petersburg, Russian Federation, 497, 012089. https://doi.org/10.1088/1757-899X/497/1/012089

Sancino, A., & Hudson, L. (2020). Leadership in, of, and for Smart Cities – case studies from Europe, America, and Australia. *Public Management Review*, 22(5), 701–725. https://doi.org/10.1080/14719037.2020.1718189

SHMÚ. (2021). Manifestations of climate change at the global level. Available at: http://www.shmu.sk/sk/?page=1379 (accessed on 10 May 2022).

Schellens, M.K., & Gisladottir, J. Critical Natural Resources: Challenging the Current Discourse and Proposal for a Holistic Definition. *Resources,* 7, 79. https://doi.org/10.3390/resources7040079

Schiavo, F.T., & Magalhães, C.F.D. (2022). Smart Sustainable Cities: The Essentials for Managers' and Leaders' Initiatives within the Complex Context of Differing Definitions and Assessments. *Smart Cities,* 5, 994-1024. https://doi.org/10.3390/smartcities5030050

Singh, T., Solanki, A., Sharma, S. K., Nayyar, A., & Paul, A. (2022). A Decade Review on Smart Cities: Paradigms, Challenges and Opportunities. *IEEE Access,* 10, 68319-68364. https://doi.org/10.1109/ACCESS.2022.3184710

Slovak Environmental Agency. (2015). Report on the state of the environment of the Slovak Republic. Available at: https://www.enviroportal.sk/uploads/report/megatrendy.pdf (accessed on 10 May 2022).

Slovak republic – summary statistics. (2022). Available at: http://www.sodbtn.sk/obce/statistika_obce.php (accessed on 10 May 2022).

Slovakia – regional geography. (2022). Available at: https://geography.upol.cz/soubory/lide/smolova/RGSR/ucebnice/portrety/poloha.html (accessed on 10 May 2022).

Slovakia. (2022). Available at: https://sk.wikipedia.org/wiki/Slovensko (accessed on 10 May 2022).

SmartCity. (2020). IMD Smart City Index. Available at: https://www.smartcity.gov.sk/projekty-v-zahranici/imd-smart-city-index/index.html (accessed on 13 May 2022).

Suvarna, M., Büth, L., Hejny, J., Mennenga, M., Li, J., Ng, Y.T., Herrmann, C., & Wang, X. (2020). Smart Manufacturing for Smart Cities—Overview, *Insights, and Future Directions. Advanced Intelligent Systems,* 2, 2000043. https://doi.org/10.1002/aisy.202000043

Szalai, P. (2019). Climate change in Slovakia threatens drinking water. Available at: https://euractiv.sk/section/voda/news/klimaticke-zmeny-na-slovensku-ohrozuju-pitnu-vodu/ (accessed on 10 May 2022).

Števanková, I. (2018). Analysis of Smart City from the point of view of IT management. Faculty of Informatics, Brno 2018. Available at: https://www.itspy.cz/wp-content/uploads/2018/11/IT_SPY_2018_Informacni_letak_49.pdf (accessed on 11 May 2022).

Šulyová, D., & Kubina, M. (2022). Sustainable Development of Smart City Concept Linked to Limited Resources Abroad and in Slovakia. IOP Conference Series: Earth and Environmental Science, 1077, 012001, Global Sustainability Conference 2022 17/04/2022 - 05/05/2022 Online. https://doi.org/10.1088/1755-1315/1077/1/012001

Šulyová, D., & Vodák, J. (2020). The Impact of Cultural Aspects on Building the Smart City Approach: Managing Diversity in Europe (London), North America (New York) and Asia (Singapore). *Sustainability,* 12, 9463. https://doi.org/10.3390/su12229463

Šulyová, D., & Vodák, J. (2021). The impact of trust on the effective building of Smart City approaches. CER Comparative European Research 2021 [electronic]: proceedings / research track of the 16th Biannual CER Comparative European Research Conference. - 1. vyd. - London: Sciemcee. 9-12 pp. [CD-ROM].

Šulyová, D., Vodák, J., & Kubina, M. (2021). Effective Management of Scarce Water Resources: From Antiquity to Today and into the Future. *Water,* 13, 2734. https://doi.org/10.3390/w13192734

Tagliaferri, M. (2022). Reviewing the Case of Online Interpersonal Trust. Foundations of Science 2022. https://doi.org/10.1007/s10699-022-09836-2

Treude, M. (2021). Sustainable Smart City-Opening a Black Box. Sustainability, 13, 769. https://doi.org/10.3390/su13020769

Van Hattum, T., Jensen, M. B., Blauw, M., & De Bruin, K. (2017). Towards Water Smart Cities. Available at: https://www.researchgate.net/publication/313504987_Towards_Water_Smart_Cities (accessed on 11 May 2022).

Varsheny, M. (2020). Understand standards in Smart Cities. Available at: https://www.slideshare.net/madhuvarsha/understand-standards-in-smart-cities (accessed on 11 May 2022).

Vodák, J., Šulyová, D., & Kubina, M. (2021). Advanced Technologies and Their Use in Smart City Management. *Sustainability,* 13, 5746. https://doi.org/10.3390/su13105746

Vukovic, N. A., Larionova, V. A., & Morganti, P. (2021). Smart Sustainable Cities: Smart Approaches and Analysis. *Ekonomika Regiona (Economy of Region),* 7(13), 1004-1013. https://doi.org/10.17059/ekon.reg.2021-3-20

Wahl, D. CH. (2020). Sustainability – What Is It? Definition, Principles and Examples. Available at: https://youmatter.world/en/definition/definitions-sustainability-definition-examples-principles/ (accessed on 10 December 2022).

Wang, Ch., Wang, Z., Wang, G., Lau J. Y.-N., Zhang, K., & Li, W. (2021). COVID-19 in early 2021: current status and looking forward. *Signal Transduction and Targeted Therapy,* 6. https://doi.org/10.1038/s41392-021-00527-1

Wood, P., Landry, Ch., & Bloomfield, J. (2006). Cultural Diversity in Britain. 1st ed., Joseph Rowntree Foundation: York, UK.

Yar, L., Koreň, M., Szalai, P., & Gabrižová, Z. (2018). What should Slovakia be like in 2030? The new economic strategy does not have a clear answer. Available at: https://euractiv.sk/section/ekonomika-a-euro/news/ake-ma-byt-slovensko-v-roku-2030-nova-hospodarska-strategia-nema-jasnu-odpoved/ (accessed on 10 May 2022).

Zak, P. J. (2017). The Neuroscience of Trust. Harvard Business Review. January/February 2017. Available at: https://hbr.org/2017/01/the-neuroscience-of-trust

Appendix A

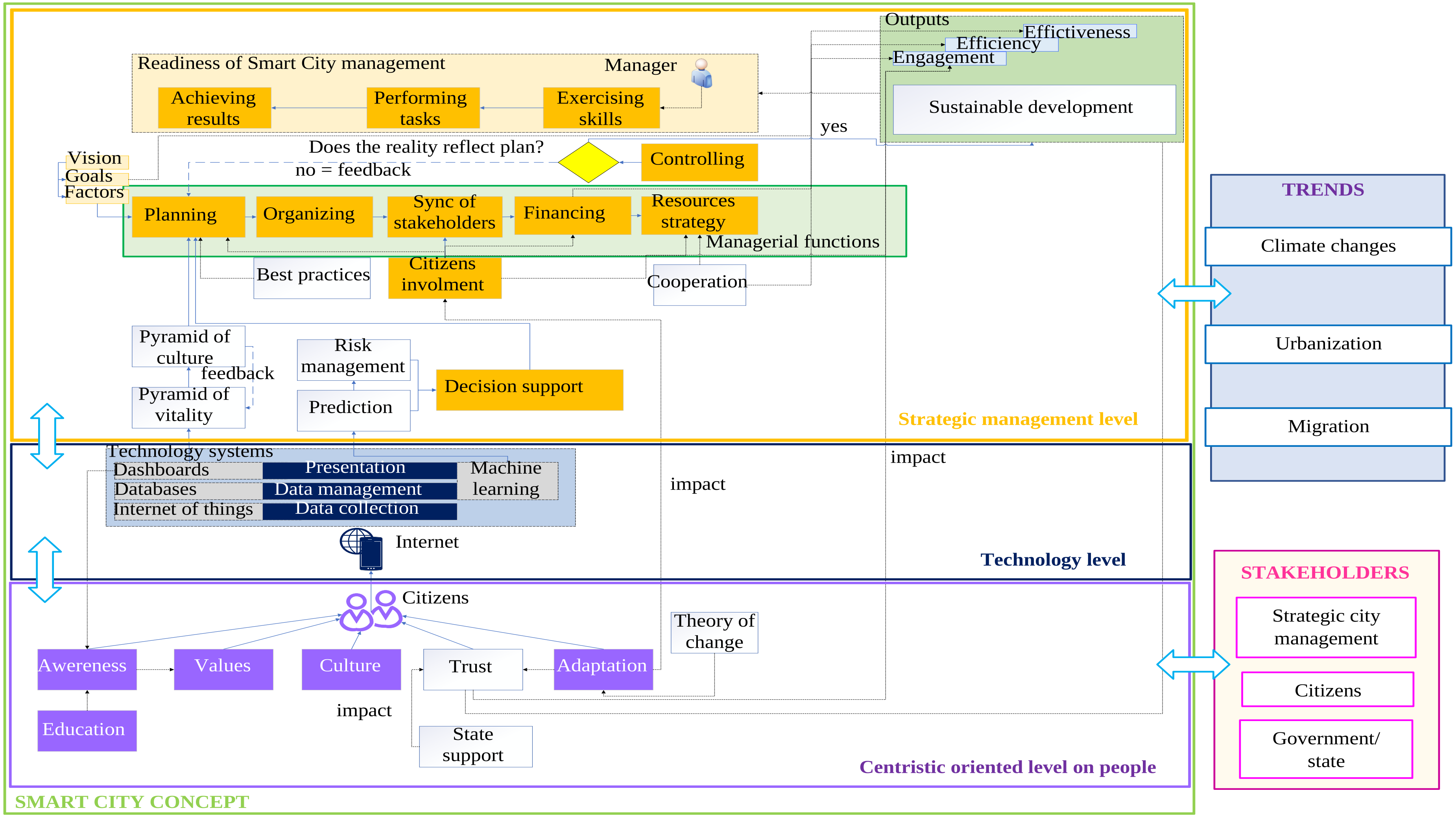

Fig. A-1. General model for creating sustainable Smart Cities.
Source: processed by the authors from article results