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The Formation of the Concept of Smart Sustainable City with the Purpose of Environmental Protection

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Abstract

The article is aimed at identifying the main areas of a smart sustainable city formation that can help to protect the environment.

The article presents the results and definitions of a smart city and its variant, a smart sustainable city. Based on an expert survey, the main areas of a smart sustainable city formation have been identified, some measures recommended for implementation in these areas have been formulated, and examples of their implementation in international practice have been presented.

Keywords: pollution; waste management; climate change adaptation; smart mobility.

JEL Classification: Q52; Q53; O18.

Introduction

Today, one of the best known and most popular concepts for improving people's lives is the concept of a smart city (Letaifa 2015, 1414; Angelidou 2017, 3; Dameri and Benevolo 2016, 693). A significant role in the increased importance of this concept in the modern world is played by the rapid increase in the population of cities and, as a result, the inability of local authorities to ensure the proper functioning of transport and housing infrastructure, prevent the negative impact of pollution, and solve many other urgent problems (Savina *et al.* 2020, 1143; Dudin *et al.* 2020, 409).

The concept of a smart city appeared following the significant spread of information and communication technologies (ICT) in various spheres of life of the population and the functioning of city authorities (Savina 2020,

277). Significant progress in the development of these technologies caused the emergence of special requirements for the components of modern cities and new criteria that make it possible to characterize a city as smart (Savina *et al.* 2020, 1143).

During the Rio+20 conference (2012), where the transformation of the Millennium Development Goals into the Sustainable Development Goals took place, it was identified that sustainable urban development will lead to the creation of an economically, socially, and ecologically developed society. Accordingly, urban development management is a systematic impact aimed at maintaining and improving the functioning of a city according to the set of development goals. The goals of managing sustainable urban development, in turn, include the following: ensuring the attractiveness and adaptability of society, increasing the well-being and unity of citizens, protecting and improving the environment, and responsible use of the resources of a city and its surrounding areas (Van Winden 2008, 197).

1. Literature Review

Despite the fact, that there are many scientific works devoted to smart cities, there is no standard and generally accepted set of terms accurately describing a smart sustainable city. The formalization of the concept of a smart sustainable city and its implementation may contribute to the development of the concept and the spread of sustainable urban development, which includes environmental issues.

Table 1 shows some of the definitions of a smart city, proposed in the literature, which gives an idea of the variety of interpretations.

Table 1. The definition of a smart city

Author (source)	Definition
Beatley T., Collins R. (2000)	A city that monitors and integrates the conditions of its infrastructure and can better optimize its resources, plan its preventive activities, and control aspects of safety, while maximizing services for the citizens.
Hollands (2008)	A city that potentially functions well in six smart areas (economy, people, governance, mobility, environment, and life) according to a rational combination of sources and activities of independent and informed citizens.
Benouaret K. <i>et al.</i> (2013)	A city that connects physical infrastructure, IT infrastructure, social infrastructure, and business infrastructure to use the collective intelligence of the city.
Zygariis S. (2011)	A city that can provide conditions for a healthy and happy community in the changing conditions of global, environmental, economic, and social trends.
Lombardi P. <i>et al.</i> (2012)	A city that is highly productive because of its relatively high proportion of well-educated people, knowledge-intensive jobs, results-based planning systems, creativity, and sustainability initiatives.

To focus on sustainable development during the study of a smart city, as well as to be sure that this aspect will not be ignored by the scientific community, a new term “smart sustainable city”, which can be considered to be a variant of a smart city, was introduced. The term demonstrates the combination of intelligence/reasonableness of the urban environment with sustainability as a key factor (Gorokhova *et al.* 2020, 422; Bondaletova *et al.* 2020, 356; Bogomolova and Ustyuzhantseva 2020, 51).

Table 2 summarizes some of the most commonly accepted definitions of a smart sustainable city.

Table 2. The definition of a smart sustainable city

Author (source)	Definition
Neirotti P. <i>et al.</i> (2014)	Smart sustainable cities use ICT to become smarter and more efficient in the use of resources, which results in costs and energy savings, improved service delivery and quality of life, and reduced environmental impact.
Kramers A. <i>et al.</i> (2014)	Smart sustainable cities are implemented through the coordination of two-layer infrastructure that supports consumers' lifestyles along with the urban governance infrastructure that links them together with the help of information technologies.
De Jong M. <i>et al.</i> (2015)	A city is smart and sustainable when investments in human and social capital, as well as traditional (transport) and modern (ICT) infrastructure, ensure sustainable economic growth and high quality of life, as well as effective management of natural resources, through participation in governance.

Research hypothesis: The environment can be protected with the help of some specific measures according to the main areas of a smart sustainable city formation.

Research objectives:

1. to identify the main areas of a smart sustainable city formation;
2. to recommend sets of measures according to the main areas of a smart sustainable city formation.

The article consists of an introduction, literature review, descriptions of research methods, results of the research and their discussion, and conclusion.

2. Methods

To achieve the goal of the study, we identified an indicative list of theoretical and empirical research methods:

- theoretical methods (analysis, synthesis, comparison, and generalization): for the review of the scientific literature on the state of the research problem;
- empirical methods (survey);
- numerical methods (method of mathematical processing of respondents' answers).

The main research method was an expert survey. The experts were asked to fill in a semi-formalized questionnaire voluntarily. Forty experts took part in the survey. The experts were employees of municipal authorities and environmental services, who had worked in the field of environmental protection for more than 10 years.

The experts were asked several questions connected to the main areas of a smart sustainable city formation, possible measures in these areas with their detailed description, and analysis of the existing environmental problems and foreign experience in implementing the concept of a smart sustainable city.

All participants were informed about the purpose of the survey and knew that the authors of the survey would publish the summary of the results.

3. Results

According to the interviewed experts, the main areas of a smart and environmentally sustainable city formation are the following (Table 3).

Table 3. The main areas of a smart sustainable city formation

No.	The main areas	%*
1	Zero pollution	90%
2	Proper waste management	87.5%
3	Climate change adaptation	85%
4	Sustainable and smart mobility	82.5%

Note: compiled based on the expert survey; * – percentage of expert references

Based on these areas, the experts proposed the following measures, necessary for the full implementation of the concept of a smart sustainable city to protect the environment: effective financial solutions, stakeholders' partnership, and infrastructure solutions.

According to the proposed sets of measures, some measures recommended for implementation in the indicated areas were formulated during the expert survey (Tables 4-7).

Table 4. Zero pollution measures

No.	Set of measures	Measures
1	Effective financial solutions	Providing a certain share in financing environmental projects from local budgets; Supporting public initiatives and environmental start-ups with the help of small grants programs; Attracting green investments to cities.
2	Stakeholders' partnership	Conducting information campaigns for the citizens about the importance of environmental issues for their lives and well-being (special attention is given to young people); Organizing and implementing small volunteer initiatives and projects, involving citizens (collecting garbage, cleaning rivers, lakes, ponds, and so on, landscaping, etc.); Ensuring cooperation between government, business, and the public with the help of forums, conferences, and other initiatives; Working systematically with polluting enterprises to find solutions to reduce city pollution; Raising the environmental awareness of citizens, in particular with the help of the involvement of influencers in the promotion of environmental ideas and

No.	Set of measures	Measures
		values and the attraction of the cultural and artistic environment representatives; Providing convenient access to understandable information about the state of the environment in the city.
3	Infrastructure solutions	Pilot/demonstration projects for green infrastructure development; Participation in projects to solve specific environmental problems and find infrastructure solutions.

Note: compiled based on the expert survey

Table 5. Proper waste management measures

No.	Set of measures	Measures
1	Effective financial solutions	Providing a certain share in financing waste management projects from local budgets; Supporting public initiatives and start-ups in the field of waste management with the help of small grants programs; Attracting green investments to waste infrastructure.
2	Stakeholders' partnership	Raising the waste management culture with the help of information campaigns, small community initiatives, special educational programs for schools and pre-school organizations, non-formal education, including for adults; Promoting the eco-lifestyle of citizens: reusable bags, avoiding excessive packaging, waste sorting; Partnership between government, business, and the public to address specific waste management issues that depend on the needs of the city; Supporting and popularizing public initiatives for sorting and recycling waste; Working with homeowner associations to attract the largest number of citizens to waste sorting and management.
3	Infrastructure solutions	Pilot/demonstration projects for waste infrastructure development; Participation in projects to solve specific waste management problems and find infrastructure solutions; Waste sorting places, installation of special containers, sorting lines, waste recycling factories.

Note: compiled based on the expert survey

Table 6. Climate change adaptation measures

No.	Set of measures	Measures
1	Effective financial solutions	Attracting green investments to cities; Inclusion the needs for climate change adaptation in the budgets of cities; Allocation of funds from the Development Budget and the Environmental Protection Fund for public projects on climate change adaptation.
2	Stakeholders partnership	Creating climate partnerships between different stakeholders in cities (government-public-business); Involving the public in the development and discussion of strategies for climate change adaptation; Increasing citizens' awareness about the needs of the city to adapt to climate change and increasing their climate awareness, popularizing adaptation solutions; Interaction with other Russian cities to share best practices on climate change adaptation.
3	Infrastructure solutions	Landscaping solutions; Solutions to deal with natural disasters and seasonal climate change; Special attention should be paid to particularly vulnerable cities in riverine and mountainous areas.

Note: compiled based on the expert survey

Table 7. Sustainable and smart mobility development measures

No.	Set of measures	Measures
1	Effective financial solutions	Attracting investments for the development of safe and environmentally friendly transport infrastructure; Supporting public initiatives and start-ups in the field of sustainable mobility; Including funds for environmentally friendly public transport, in particular for the development of electric transport, in the budgets of cities.

2	Stakeholders' partnership	Special trainings and education programs on sustainable mobility for cities; Partnership between government, business, and the public to address specific transport and related infrastructure development issues that depend on the needs of the city; Supporting and popularizing public initiatives for traffic safety and cycling development in cities.
3	Infrastructure solutions	Pilot/demonstration projects for green zones or low emissions zones; Creation of pedestrian zones; Development and creation of bicycle paths; Development of smart applications for sustainable mobility; Parking spaces outside the city center, where people can leave their cars and switch to public transport; Public transport stops adapted to the needs of climate change; Public transport with zero or low emissions; Transport sector digitalization.

Note: compiled based on the expert survey

4. Discussion

As of 26 April 2019, there are 1,117 Russian cities, where 74% of the Russian population live (Morozova 2019, 60).

According to the experts, the most urgent environmental problem for Russian cities is pollution, especially in industrial regions. This issue deals with the quality of air, drinking and bathing water, pollution from industrial plants, and noise and light pollution.

The main pollutants in cities are industry and transport. According to one of the respondents (an ecologist Viktor R.), "Russian cities differ from each other in terms of pollution levels, but their attitude to environmental problems is the same".

According to the experts, local authorities do not pay enough attention to the ecological state of cities and pollution in comparison with the top-priority issues of socio-economic development. In the contest between permission for new large-scale building construction and tree planting in cities, the authorities mainly give priority to the former. Another problem is the lack of proper environmental monitoring in cities. In this regard, public monitoring of air or water quality becomes an important source of information for citizens, but it is not enough.

As an example of the successful implementation of a passive air pollution control system, we cite the city of Bottrop (Germany) (Caragliu *et al.* 2011, 65):

Problem: The city is situated in the center of the Ruhr, a historically coal-mining area. The city received environmental problems related to coal-mining, including active coking plants.

Solution: The city joined the iSCAPE Living Labs research project, which includes six European cities. It is aimed at reducing air pollution by assessing the effectiveness of so-called passive air quality control systems. In Bottrop, the landscaping was chosen as a part of urban planning. The central initiative was the Wandering Trees project, which allowed citizens to be involved in landscaping and increase their awareness of the importance of landscaping. The project was implemented in cooperation between the Technical University of Dortmund, the city administration, the local gardeners association, and citizens.

According to the experts, Russian cities face equally important problems with waste management. Outdated methods of management, overcrowded or unauthorized landfills, lack of opportunities and unwillingness to sort waste, lack of opportunities to recycle various types of waste – all this is an incomplete list of challenges that local authorities face. As a result, this situation affects not only the state of the environment in the city but also has a direct impact on the health and well-being of citizens.

Today, the volume of waste in Russia is 55-60 million tons per year. On average, the waste indicator is 400 kilograms per person per year and tends to increase (Ivantsova 2016, 148). The dominant method of waste management is its removal and disposal in landfills.

Recently, there have been many public initiatives on waste sorting and recycling, such as educational events for citizens and school students. However, they cannot fully meet the needs for solving waste problems in cities.

The experts noted that Russian cities more often suffer from global climate changes, such as floods, abnormal temperature, and natural disasters. According to the experts, typical problems in cities that determine the need for the development and implementation of climate change adaptation measures are dense (sometimes

chaotic) city development, decrease in the number and quality of green areas, backyards paving, concentration of residential buildings near industrial plants, lack of climate change adaptation specialists in city government, planning activities without taking into account climate risks, and lack of cooperation, coordination, and educational work with citizens on the transition to a green economy in the future at the local level.

According to one of the experts (an ecologist Vladimir K.), “the absence of an adequate policy on climate change adaptation at the national level makes cities face a choice: to wait for the reaction of the government and follow their instructions or to start acting independently”. Undoubtedly, the development of a national climate change adaptation strategy would be the best guide for cities to develop their policies and practical solutions. However, today, the best solution may be the preparatory work of cities, which includes assessing the vulnerability of the city to climate change, as well as developing, adopting, and properly implementing a strategy for climate change adaptation.

Following adequate adaptation measures, cities can make citizens’ lives more comfortable, healthy, and environmentally safe. To achieve such goals, it is important to have partnerships between various stakeholders, in particular the government, the public, and business. A city’s status as an active introducer of policies to adapt to climate change can stimulate the attraction of innovative approaches and green investments in various areas: housing, green areas, local production of eco-goods and services.

As an example of adaptation to excessively high air temperatures, let us cite the city of Antwerp (Belgium):

Problem: Significant temperature rises in the city, which negatively affect the health and well-being of citizens and increase the cost of cooling and treatment. The number of days with abnormally high temperatures in Antwerp doubled in 2008-2017.

Solution: The key solution was to make changes to the building standards, which now require:

- all new or repaired roofs with a slope of less than 15% and a total area of more than 20 square meters must be landscaped. This significantly lowers the roof temperature, cools the air by rainwater retention and evaporating, and increases the thermal insulation of buildings.

- all new backyards and parking spaces should be green and nonwatertight. In backyards with a total area of less than 60 square meters, only the area of 20 square meters can be paved and in backyards with a total area of more than 60 square meters, only 1/3 of the area can be paved. All outdoor parking spaces must have a nonwatertight grass surface.

- most of the buildings in the city are historical and plastered over. During their renovation, they should be painted in light colors, preferably white (to reflect sunlight).

Speaking of sustainable mobility, the experts noted that the levels of transport safety, energy consumption, and environmental impact in Russian cities do not meet modern requirements and trends. Pollution caused by transport negatively affects not only the environment but also the health of citizens. The problem of noise pollution of cities caused by transport is one of the most important along with air pollution (Kremcheev *et al.* 2019, 96).

Congestion of cities, lack of environmentally friendly and comfortable public transport, lack of bicycle infrastructure, parking problems, traffic jams, etc. – all this is an incomplete list of problems that Russian cities face.

Conclusion

The concept of a smart sustainable city can be an adequate response to some important global challenges. This presupposes economically feasible environmental friendliness, resource optimization, and improvement of the service sector using computer technology. Although some components of a smart sustainable city include diverse factors, environmental issues are highlighted.

Most of the proposed practical solutions can be applied in Russia: measures to achieve zero pollution, proper waste management, climate change adaptation, and sustainable and smart mobility.

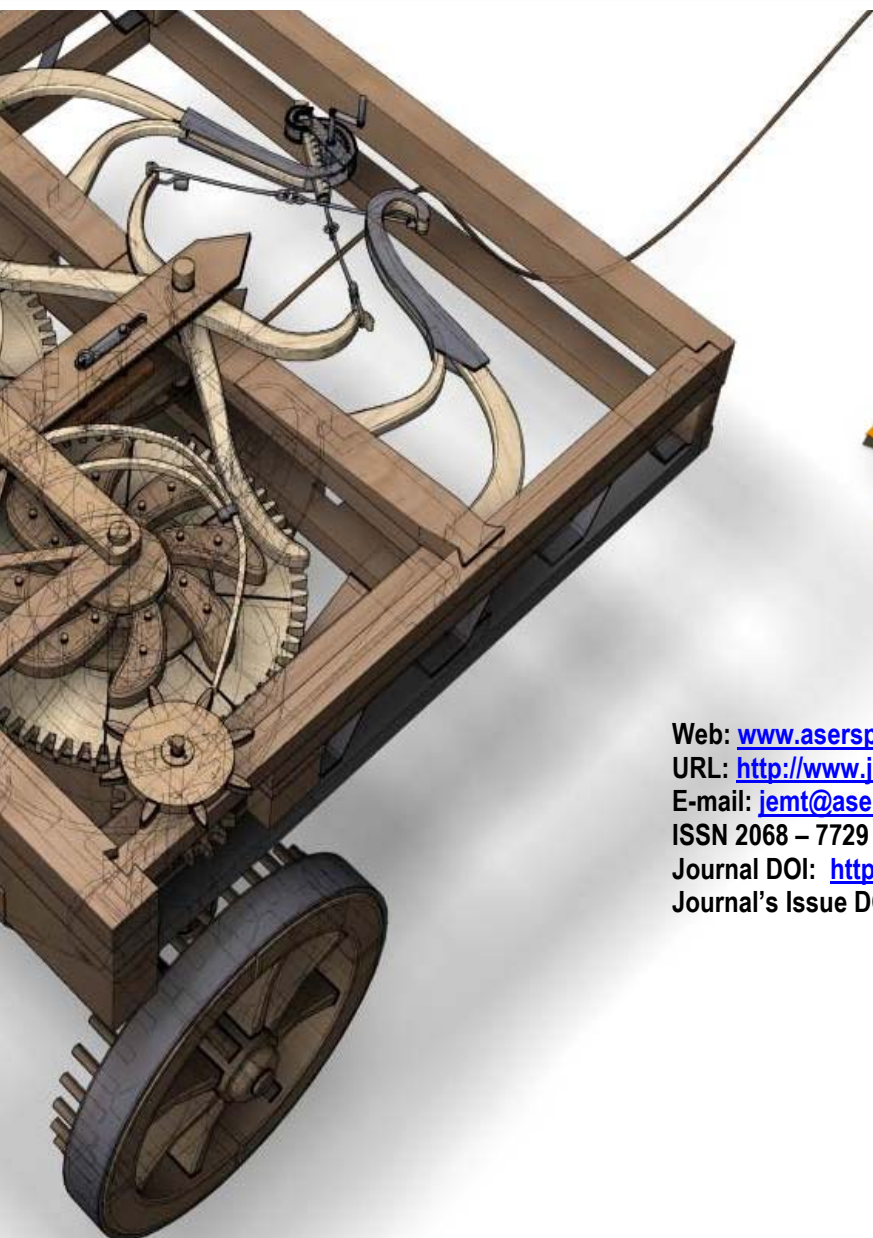
Thus, the research hypothesis that the environment can be protected with the help of some specific measures according to the main areas of a smart sustainable city formation was confirmed.

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