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Sustainable development issues of Almaty as the largest metropolis in Central Asia

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Abstract. The research is aimed to examine the sustainability of Almaty city as a largest city in the Central Asia. The literature review revealed lack of methodology for city sustainability assessment in developing countries. Proposed methodology of Denevizyuk was explored to calculate the Sustainable City Index for Almaty and demonstrate it's dynamics in last 9 years. As expected, environmental issues are becoming worse while economic and social parameters have positive trends and smooth out the final index growth.

1. Introduction

More than 50% of the world population lives in cities. It is expected that in 2030 it will be 6 out of 10 people. Cities consume 75 % of the world's energy production and produce 80 % of CO₂ emissions. These figures are indicative of the colossal burden that cities face in the modern world. Therefore, the question of "sustainable" development of countries and cities sharpen in the world. The UN defines "sustainability" as "development without burdening future generations". One of the goals of sustainable development according to the UN is to ensure sustainable development of cities. Cities are one of the main urban, transport, architectural challenges of the 21st century.

Almaty is the largest metropolis not only of Kazakhstan, but of the whole of Central Asia.

From 2010 to 2017 the population of Almaty increased by 23.9 %. As of January 1, 2018, there were 1,801,713 people living in Almaty, the largest agglomeration of the first level is developing around Almaty. In 2014 part of the Almaty oblast with a total area of 23,200 hectares and a population of over 92,000 people were passed to Almaty city. Today the territory of the city is 683.5 square kilometers.

Sustainable development of the city is of great importance, because uncontrolled migration of the population can lead to an excessive burden on the capacity of housing infrastructure, social and economic situation in the periphery of the city, disproportional development of the city, negative environmental consequences and serve as an obstacle to economic diversification.

According to the indices of economy, the development of Almaty corresponds to the level of medium megacities. In accordance with "Financial Post" in 2015, the city entered the top 10 of 96 cities with the fastest growing economy.

By the social context, there is a moderate lag behind the level of medium-sized cities. So, according to "Mercer" – the quality of life index – Almaty is on 176 place among 230 cities (2016),



and by "Economist Intelligence Unit" Index of life quality – on 100 place among 140 megacities (2015).

In terms of infrastructure and environmental issues, Almaty lags far behind the level of developed cities in the world. In the "Mercer" index of infrastructure Almaty is on 178 place among 231 cities, and in the index of "Numbeo" on level of pollution – 214 place from 297 cities.

According to the City Prosperity Index in 2012–2013, Almaty ranked 28th and was included in the second category of cities – "cities with solid prosperity ratios" with a coefficient of 0.83 along with cities such as Ankara, Mexico City, Guadalajara, Bucharest, Shanghai, San Paulo, Moscow, Seoul, Prague, Athens, Budapest and Lisbon. In 2015, Almaty dropped to 33rd place with a coefficient of 0.67.

In order to bridge the gaps in sustainable development, the Almaty 2020 Development Program has been developed and implemented. It covers all major areas of the city's development, including the economy, social sphere, public security and law, infrastructure, ecology and land resources, public services. The Program covers 7 priorities: a comfortable city, a safe city, a socially-oriented city, an economically sustainable city, a city for business and private capital, an integrated city, a city of active citizens.

However, Almaty does not participate in sustainable development indices. For example, ARCADIS, the world's leading consulting company, jointly with the Center for Economic and Business Research (CEBR) calculates the Sustainable Cities Index for 100 cities on the planet based on 32 indicators for People, Planet and Profit. The "green" cities index of Siemens is adapted mostly for the countries of Europe and North America. The United Nations Sustainable Development Index or the OECD Environmental Performance Review focuses on the national level statistics.

In this regard, many countries are developing adjusted sustainable development indices for their cities to monitor and decision-making. For example, the Special Committee for Human Settlements (SCHS) of Chinese Society for Sustainable Development proposed the following indicators for assessing urban sustainability (Urban Sustainability Index): resources, social context, environment, economics and innovation [1].

The analysis shows that most of the effort to determine the sustainability of cities focuses on establishing the necessary theoretical basis to measuring sustainability, resulting in a variety of models duplicating each other. At the same time, many methodologies are often focused on the national level or on developed countries. As a result, there is a lack of applicable methodology for measuring the sustainability of cities in developing countries, where the problem is often the most acute.

2. Methodologies for the assessment of sustainable urban development

The City Prosperity Index (CPI) of the UN-Habitat program as a tool for assessing the sustainability of cities is based on six key indicators of city development: 1) productivity; 2) infrastructure development; 3) quality of life; 4) equity and social integration; 5) environmental sustainability; 6) management and legislation. The index calculation takes the following stages: a) the standardization of variables; b) development of specific weights; c) compiling an aggregated index. Standardization converts a variable from its original unit of measurement to a dimensionless value that ranges between 0 and 100. There are different methodologies to develop weights. When developing the CPI, the recommendations Alkire and Foster on weighting scheme for multidimensional poverty index were used [2]. When summarizing their recommendations, the following weight scheme is used: a) the indicators have the same weight in the index b) the sub-indicators are the same weight in indicators c) the variables have the same weight in the sub-indices. This scheme of weights clearly shows the assumption that all selected measurements are equally effective in determining the prosperity of the city [3]. There are cases of specific weights calculation based on the fuzzy logic method [4].

Unlike the City Prosperity Index, the urban sustainability assessment model developed by a group of Iranian authors showed significant differences in the significance of subsystems (social, economic and environmental) sustainability. Researchers took into account seven indicators – existence, effectiveness, freedom of action, security, adaptability, coexistence and psychological need. The final

sustainability calculation showed that the "efficiency" indicator gives the highest value in the developed model. As methods of verification, Delphi and fuzzy logic methods and the Kruskal-Wallis criterion were used [5].

When developing the Urban Sustainability Index by the Chinese Society for Sustainable Development, researchers selected the most accessible indicators in developing countries and the most relevant ones. The Urban Sustainability Index is designed to measure the relative effectiveness of Chinese cities in the overall set of sustainability categories. The authors developed a comprehensive definition of sustainable development based on 18 separate indicators to assess not only the environmental sustainability of the cities analyzed, but also the level of services needed to serve the growing urban population and the effectiveness of the resources of each city. The index measures the effectiveness of the city with respect to five aspects of sustainable development: basic needs, resource efficiency, environmental well-being, engineering communications, commitment to sustainable development.

This Index is based on the demonstrated efficiency of each city, and not on the theoretical absolute potential. After processing the data for consistency, the cumulative score for the average indicators was derived. Weights for individual indicators were not assigned to the overall assessment in order to avoid a priori estimates of the relative importance of indicators that would be difficult to justify. However, the authors experimented with weighting measures based on data quality, but found minor effects, as the data set was rounded. To analyze any correlation between GDP growth and stability, once the index was calculated and adjusted, a series of f-tests were conducted. Although there are more sophisticated methods for weighing factors and validating the test, the study was limited to ANOVA testing, regression, and factor analysis.

Since 2012 the "SGM" Agency conducts evaluation and rating of sustainable development of the Russian Federation cities in accordance with the principles of sustainable development of the country, international organizations practice and scientific community. The research covers 185 cities of the Russian Federation with a population of more than 100 thousand people. The assessment of sustainable urban development is based on an analysis of 42 statistical indicators that characterize the city in three main categories: the state of the economy, the social sphere, and the environmental situation.

To construct the Sustainable Development Index, the indices inside the three blocks are subject to normalization operations. Some of the indices with an obviously asymmetric distribution before normalization were logarithmized in order to "stretch" along the scale small values of the indicator and, conversely, to bring each of its highest values closer to each other. The aggregated index is obtained from the sub-indices by summing up with adjustment coefficient – weights chosen by the expert evaluation method in accordance with international recommendations and the most common practices. The assessment of the "weight" of the group of indicators in the final rating was carried out on the basis of the principle of the main components equity: the social sector, environmental situation, the economy and the level of urban infrastructure development. The final integral index of sustainable urban development is obtained by calculating the mean value among particular indices and can theoretically take values from 0 to 1.

Russian scientists propose an integral index of urban sustainability. It is based on the concept and methodology of calculating the index of adjusted net savings. In order to assess the sustainability of urban development, taking into account economic, social and environmental factors, the authors propose to allocate three relevant sub-indices: gross fixed capital formation, human capital development expenditures and damage from environmental pollution in cities. The proposed author's system of indicators for Russian cities reflects the most hot topics of sustainable development of Russian cities and the quality of life of citizens, and is also adequate to the capabilities of Russian statistics. Key indicators were proposed reflecting important economic, social and environmental city priorities: economic indicators; energy efficiency; transport; social and institutional indicators; air and climate; water resources; waste; specially protected natural territories; noise effect [6].

To evaluate the sustainable development of Almaty, the authors of the given paper used the methodology proposed by Denevzyuk [7]. Integrated indicators of subsystems – economic, social, ecological – are built for its calculation.

The index of sustainable development of the city is calculated as follows:

$$I_{CSD} = \sum_{i=1}^n w_i I_i$$

$$I_i = \frac{1}{m+k} \left[\sum_{j=1}^m I_{ij}^+ + \sum_{j=1}^k I_{ij}^- \right]$$

$$I_j^+ = \frac{I_j - I_{min}}{I_{max} - I_{min}}$$

$$I_j^- = 1 - \frac{I_j - I_{min}}{I_{max} - I_{min}}$$

where

I_{CSD} – city sustainability index;

I_i – integral index of the corresponding subsystem (economic, social, ecological)

w_i – the weight coefficient of the corresponding subsystem satisfying the following conditions: $w_i \geq 0, \sum w_i = 1$;

m – number of positive indicators;

k – number of negative indicators;

I_j^+ – standardized value of j-th positive indicator, i.e. at increase of which the subsystem improves;

I_j^- – standardized value of the j-th negative indicator, i.e. at increase of which the subsystem deteriorates;

I_{min} – minimum value of the j-th indicator;

I_{max} – maximum value of the j-th indicator.

This index was calculated on the basis of 33 statistical indicators characterizing sustainable development of the city in three main blocks: economic, ecological and social. At the same time, the system of indicators for each of these subsystems was constructed by the authors taking into account the following principles:

- availability of statistical materials. All used data are placed on official websites and databases of the Committee on Statistics of the Ministry of National Economy of the Republic of Kazakhstan, Statistics Department of Almaty.
- comparability of data. Only those indicators that can be compared with each other are used, which allows correct comparisons.
- Maximum relevance of indicators. Only those indicators that are relevant to the characteristic of sustainable development are used.
- The same proportion of all indicators forming an index of sustainable development. This is a common practice in the formation of multidimensional indices.

The proposed methodology for an integrated assessment of the city sustainable development is reliably applicable both for conditions with minimal initial data, and for conditions with a wide range of indicators [8].

The indicators for the period from 2008 to 2016 were used for research. The statistical base of the research can be increased. The index of sustainable development of the city was calculated in comparison by years, therefore the change of the period under consideration will lead to a change in the value of the index itself.

Thus, the city sustainable development index takes the following form:

$$I_{CSD} = w_{EcD} I_{EcD} + w_{SocD} I_{SocD} + w_{EnvD} I_{EnvD}$$

I_{ECD} – index of economic development of the city;

I_{SocD} – index of social development of the city;

I_{EnvD} – the index of environment development of the city.

The index of sustainable development lies in the range from 0 to 1. The interpretation of the results of the sustainable development assessment is based on the established limits of the allowed values (Table 1).

Table 1. Integral indicators of sustainable development

The range of values of the integral assessment	Boundaries	Interpretation of integral evaluation
Sustainable	0.85–1.00	High level of sustainable development
	0.65–0.85	Sustainable development
Quasistable	0.50–0.65	Development level close to sustainable
	0.25–0.5	Development level with signs of instability
Unsustainable	0.1–0.25	Unsustainable development
	0.00–0.1	Critical state of sustainability

Note – Compiled by the authors on the basis of the source [9]

3. Research results

According to the presented methodology, calculations of the indicators for the period from 2008 to 2016 were carried out. The integral indices of each subsystem are obtained (Table 2).

Table 2. Integrated indicators of subsystems and the index of sustainable development of Almaty, 2008–2016

Year	I_{ECD}	I_{SocD}	I_{EnvD}	I_{CSD}	Level of sustainability of development
2008	0.22	0.39	0.62	0.38	Development level with signs of instability
2009	0.14	0.33	0.59	0.32	Development level with signs of instability
2010	0.24	0.34	0.58	0.35	Development level with signs of instability
2011	0.33	0.36	0.59	0.39	Development level with signs of instability
2012	0.43	0.48	0.58	0.48	Development level with signs of instability
2013	0.57	0.59	0.59	0.58	Development level close to sustainable
2014	0.72	0.55	0.33	0.57	Development level close to sustainable
2015	0.76	0.56	0.38	0.59	Development level close to sustainable
2016	0.89	0.65	0.33	0.67	Sustainable development

Note – Compiled by the authors

Economy subsystem. The economy of the city shows rapid growth. Investments in fixed assets increased by 20 %, in housing construction – 33 %. During the period under review, the gross regional product of Almaty increased 3.5 times, the gross regional product per capita – 2.8 times, and industrial production – 2.1 times. The remaining indicators also show positive dynamics. The role of small and medium-sized businesses in the city's economy has increased. Thus, the share of its gross added value in GRP increased from 27.8 % to 33.7 %. The level of innovative activity of firms has grown from 6.4 % to 7.6 %, while the volume of innovative products has increased by 6.1 billion tenge, which exceeds the level of 2008 by 55 %. There is a reduction in the unemployment rate by 28 %. Due to the positive dynamics of economic indicators, the integral indicator of the economic subsystem showed an increase from 0.22 to 0.89.

Social subsystem. Due to an increase in the housing stock by 84 %, the provision of housing for a person by the population grew by 42 %. At the same time, the housing construction in water supply systems in 2016 was 100 %, with sewage systems – 97 %, with water supply systems – 70.2 %. The number of fixed Internet subscribers increased by 5.5 times, while the share of Internet users aged 16-74 grew from 23 % to 86.2 %. To date, there is a digitalization of society and the economy of the city. The number of hospital organizations and doctors has increased, but the number of hospital beds per 10,000 population has decreased. The number of students in colleges fell by 3 327, universities – by 64 460. The crime rate increased 3.5 times, the number of criminals increased 2.2 times. Despite the fact that in the presented subsystem fluctuations of indicators were observed during the considered period, the social subsystem of the city in 2008 showed development with signs of instability, in 2016 it became more stable.

Environment subsystem. To protect the environment of Almaty in 2016, 2.8 billion tenge was allocated, which is 39 % higher than in 2008. However, the amount of emissions in comparison with this year has significantly increased. So, emissions of solid pollutants increased by 2.3 times, liquid and gaseous pollutants – 3 times, pollutants into the atmosphere – 2.8 times. The pollution of the city during the period under review was very high. Pollutants were captured and rendered harmless 8 times more than in 2008, only 3.3 thousand tons were disposed of, which is 19 % of the 2008 level. Significant fluctuations in the indicators of the city's ecological development led to the instability of the development of this subsystem. If in 2008 its development was close to a stable state, then in 2016 there are signs of its instability.

4. Conclusion

During the period under study, the economic and social subsystems for the sustainable development of the city of Almaty showed positive dynamics, while the ecological subsystem was negative. However, the instability of one subsystem was compensated by the higher value of stability of others, therefore the Almaty city sustainability index is defined as increasing. In 2016, the development of Almaty became stable due to the high level of economic subsystem stability. The social subsystem was also stable. The development of the ecological subsystem showed the presence of signs of instability. The obtained results confirm the results of international rating. In the development of Almaty, much attention should be paid to environmental issues, as well as stabilization of the economic and social sustainability of urban development.

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