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SUSTAINABLE DEVELOPMENT OF CITIES: RATING ASSESSMENT METHODOLOGY AND RISK ANALYSIS (Using Kazakhstan as an Example)[1]

Abstract. World experience shows that in the context of the increase in urbanisation, the achievement of the Sustainable Development Goals largely depends on the sustainability of cities. It was hypothesised that big cities in Kazakhstan are more stable than medium-sized cities and single-industry towns. The study aims to develop a modified rating assessment methodology for sustainable development of cities and test it using cities in Kazakhstan as an example in order to develop tools for planning and monitoring the achievement of the Sustainable Development Goals taking into account country specifics. To this end, such methods as generalisation, concretisation, economic and statistical, factorial and comparative analysis, ranking, and mapping were used. A modified methodology for rating assessment of sustainable development of cities based on social, economic, environmental factors was proposed. The method for the mapping of sustainable development risks was utilised. The research substantiated the criteria and typology of risks of sustainable urban development, which can be adapted to country-specific circumstances. The possibility of its use was demonstrated on the example of different types and categories of cities in Kazakhstan. The study was limited due to the inaccessibility of statistical data, especially for small towns and single-industry towns. The obtained results can be used to simulate and monitor the implementation of socio-economic programmes in cities of Kazakhstan and other countries. The research findings can be used as the basis for mechanisms and tools intended to make decisions by authorities to achieve the Sustainable Development Goals and develop sustainable cities.

Keywords: sustainable development, urbanisation, sustainable city, economic sustainability, social sustainability, environmental sustainability, factors of sustainable city development, sustainable development rating of cities, sustainability risks

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ИССЛЕДОВАТЕЛЬСКАЯ СТАТЬЯ

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Устойчивое развитие городов: методология рейтинговой оценки и анализ рисков (на примере Казахстана)

Аннотация. Мировой опыт показывает, что в условиях роста урбанизации достижение целей устойчивого развития во многом зависит от развития городов. Гипотезой исследования стало предположение, что крупные города Казахстана устойчивее, чем средние и моногорода. Цель настоящего исследования — разработка модифицированной методологии рейтинговой оценки устойчивого развития городов и ее апробация на примере городов Казахстана для создания инструментов планирования и мониторинга достижения целей устойчивого развития с учетом страновой специфики. Для достижения поставленной цели использовались такие методы, как обобщение, конкретизация, экономико-статистический, факторный и сравнительный анализ, ранжирование, картирование. Предложена модифицированная методология рейтинговой оценки устойчивого развития городов на основе трех факторов: социального, экономического, экологического. Использован метод картирования рисков устойчивого развития, обоснованы критерии и типология рисков устойчивого развития городов, которые могут быть адаптированы к страновой специфике. Продемонстрирована возможность использования разработанной методологии на примере разных типов и категорий городов Казахстана. Ограничением исследования является недоступность статических данных для малых и моногородов. Полученные данные могут быть использованы для моделирования и мониторинга выполнения социально-экономических программ в городах Казахстана и других стран. Результаты исследования могут быть положены в основу механизмов и инструментов принятия решений органами власти для достижения целей устойчивого развития городов.

Ключевые слова: устойчивое развитие, урбанизация, устойчивый город, экономическая устойчивость, социальная устойчивость, экологическая устойчивость, рейтинг устойчивого развития городов, риски устойчивого развития.

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1. Introduction

Kazakhstan is a country with an average urbanisation level. The share of the urban population in Kazakhstan was about 40 % in 1960, 58.4 % in 2019, and it will reach 70 % by 2050 according to forecasts. The population of the largest cities in the country has grown, while many medium and small towns have lost a significant part of their population. The population decreased in 32 Kazakhstan towns during the period from 1999 to 2019, including the population decrease from 10 % to 39 % in 21 towns. It shows serious shortcomings in the urban policy, stagnation of economic activity, and a decline in the social infrastructure of some towns. The urban system of Kazakhstan, which includes 88 towns, in 2021 has 5 levels:

— 3 megacities (37.6 % of the urban population);

— 1 city (Baikonur) has a special status (39.1 thousand persons);

— 14 cities are regional centres with a population from 145.0 to 500.0 thousand persons (36.8 % of the urban population);

— 23 towns with a population of 6.7 to 323.1 thousand persons (14 % of the urban population);

— 47 towns with a population from 3.5 to 68.9 thousand persons (11.1 % of the urban population).

The United Nation Development Program has been implementing the project “Sustainable cities for low-carbon development” in Kazakhstan since 2015, and the main topic of the 2019 National Human Development Report in Kazakhstan was the problem of urbanisation, in particular, the report “Urbanisation as an Accelerator of Inclusive and Sustainable Development in Kazakhstan” was prepared. It is noted there that the Sustainable Development Goal 11 achievement rate remains

below the growth rate required to meet the targets by 2030[1]. At the same time, there are no studies with the maximum coverage of different types of towns in Kazakhstan.

The main goal of the study is to test the hypothesis that Kazakhstan's large cities are more sustainable than single-industry ones. In this regard, the study aims to create a modified rating assessment methodology for sustainable urban development and test it on the example of cities in Kazakhstan in order to develop tools intended to plan tasks and monitor the achievement of sustainable development goals, taking into account the national specificity.

2. Theoretical Background

Sustainable development is a global phenomenon used as a basis for concepts and strategies of sustainable development of individual countries, areas, regions, cities, and even smaller units (Lutzkendorf & Balouktsi, 2017).

Most of the definitions of sustainable development come down to the fact that it is a model of the socio-economic life of society, whose implementation leads to the satisfaction of the vital needs of the current generation without depriving future generations of the same opportunity. Any system develops steadily if it can maintain balance, effectively using available resources and growth factors with the help of new technologies and advanced management, neutralising internal and external threats.

Some researchers believe that the sustainability aims to maintain the life support system of the territory to ensure survival and meet main human needs (Baumgartner & Quaas, 2010). The statement that the scientific category of sustainable development is considered as the achievement of the desired balance between economic growth, equitable human development, and healthy food ecosystems in the region is fair (Chaikovskaya, 2005).

A sustainable city model should ensure the creation of accessible green spaces, development of environmentally friendly transport, decent housing, increase in the environmental efficiency of towns, expansion of the use of renewable energy sources, prevention of water pollution according to the UN report (UN Habitat, 2009). The most popular models of sustainable urban form are smart and/or compact towns and eco- towns where the man-made environment functions to reduce the use of materials, decrease energy consumption, lessen pollution, and minimise waste, as well as increase social justice, persons' well-being and quality of life (Bibri & Krogstie, 2021; Antwi-Afari et al., 2021).

Recently, the urban metabolism concept has become widely used in the study of sustainable urban development. Xu et al. (2021) showed that gross domestic product per capita, population size and density, climate type of a town are largely related to urban resource consumption.

The problem of many cities is the uneven distribution of housing, which also carries certain risks for sustainable social development (Scheba et al., 2021; Hens, 2010).

It is our opinion that the essence of sustainable urban development can be described as follows: it is the development where the urban system retains its integrity, sustainable ability to reproduce, and social, ecological, and economic balance indefinitely without destroying natural capital reserves under various internal and external influences. In its most general form, the concept of sustainable urban development implies economic prosperity, environmental and social security, rational use, and economic use of resources.

The World Bank, Organisation for Economic Co-operation and Development (OECD), United Nations Commission on Sustainable Development (UNCSD) and World Trade Organisation (WTO) can be mentioned among the institutions which study the problem of sustainable development. These institutions have established systems for assessing sustainable development based on the environmental sustainability index, determination of the ecological footprint, analysis, and coverage of data on the environment, including air, water, forests, and biodiversity, an integrated assessment of the socio-economic system. Many countries are developing adjusted sustainable development indices for their cities for monitoring and decision making. There are various indices and models of sustainable urban development: the UN-Habitat's City Prosperity Index; Sustainable Cities Index; Sustainable Cities Mobility Index produced by ARCADIS and CEBR; Green City Index from Economist Intelligence Unit and Siemens Corporation; Sustainable Urban Development Index from the SGM Agency; City Prosperity Index (Wong, 2014); SDEWES Index (Altamirano-Avila & Martinez, 2021); Urban Sustainability Index from the LEAD; the integral parameter of urban sustainability (Bobylev et al., 2014); urban sustainability assessment model (Jaderi et al., 2014); Reference system for sustain-

[1] UNDP. (2019). Urbanization as an Accelerator of Inclusive and Sustainable Development / National Human Development Report 2019: Kazakhstan. Retrieved from: http://hdr.undp.org/sites/default/files/nhdr _2019_kaz.pdf (Date of access: 11.03.2021).

able cities (RFSC)[1]. Most of them are designed for countries in Europe and North America.

The development of sustainability indices is usually closely related to the development of ratings. However, it is not always possible to trace the actual development dynamics of a particular city behind the dynamics of the integral parameter and ratings. Therefore, the study of the sustainable urban development problems today is represented by many aspects. Methods of justification of the sustainability boundaries or sustainability corridors for urban development in time are of great interest (Denevizyuk, 2012).

Many of the known methods for assessing city sustainable development are limited to the largest cities. Bahers et al. (2018) note that research on urban metabolism is mainly focused on capitals and metropolitan areas, while the metabolic processes in intermediate cities, medium and small towns need to be studied.

Thus, urban sustainability assessment has some features and difficulties. First, it differs significantly from the sustainable development measurement of other territories (countries and regions), since it is influenced by some additional factors, such as the level of migration and urbanisation, living security, comfort, the urban environment arrangement, and the presence of marginalised outskirts. Secondly, environmental factors in cities have a stronger impact on sustainable development due to the high density of population and housing development, traffic capacity. The ecological situation in cities can be aggravated by the influence of epidemiological factors. Thirdly, many statistical data required to measure urban sustainability, especially for small and single-industry towns, are not always available. This is especially true for information about towns in many developing countries. Fourth, towns in developing countries tend to lag behind the cities in developed countries in many respects of sustainable development. Fifth, statistical accounting methods at the level of small towns can vary significantly. Besides, even the concept of a city or a small town has different meanings in different countries. Therefore, it is often difficult to assess urban sustainability in developing countries, as well as to compare them and determine the rating. At the same time, the problems of cities can be specific in different countries. All these facts determine the complexity in the development of a methodology intended to assess the sustainability of the economy and social sphere in cities.

The literature review showed that the world and domestic science and practice has accumulated considerable experience in the development of criteria, indices and indicators of environmentally sustainable development in the regional context. But the assessment of the urban sustainability level causes the greatest difficulties also because it is not always possible to establish the causal connection of the mutual influence of various factors on the scale of a city. At the same time, municipal government bodies need convenient tools to assess the key components of sustainable development for effective management and appropriate decision-making. Thus, Kazakhstan needs tools to monitor and plan future initiatives of sustainable urban development for the successful implementation of sustainable development goals in cities.

3. Methodology

Within the framework of commitments to achieve the Sustainable Development Goals, Kazakhstan developed a system for monitoring of 280 indicators, including 162 global indicators unchanged, 44 global indicators with changes, 30 alternative indicators, 44 additional indicators. 25 indicators, including 15 global, 2 global with minor changes, 6 alternative national indicators, 2 additional national indicators were recommended for monitoring Goal 11 “Sustainable Cities and Human Settlements”[2].

This system of indicators has some significant drawbacks that limit the possibility of its application in Kazakhstan. First, data are not available for 5 indicators, including 4 global ones. It is not possible to obtain data for such global goals as the proportion of population that has convenient access to public transport (by sex, age, and persons with disabilities). There is no information on urban territories with open access for all, the proportion of persons who were subject to physical and sexual harassment, and the construction of environment-oriented, reliable, and resource-efficient buildings.

Second, some of the proposed alternative indicators are expressed in absolute measurement units (the number of persons living in unfit buildings; the number of victims and deaths because of natural emergencies), while other indicators do not accurately characterise the problem.

[1] European Commission. (2018). Indicators for sustainable cities. Retrieved from: https://data.europa.eu/doi/10.2779/121865 (Date of access: 10.03.2021).

[2] Monitoring of the Sustainable Development Goals 2030. Retrieved from: https://stat.gov.kz/official/sustainable_development_goals (Date of access: 11.03.2021).

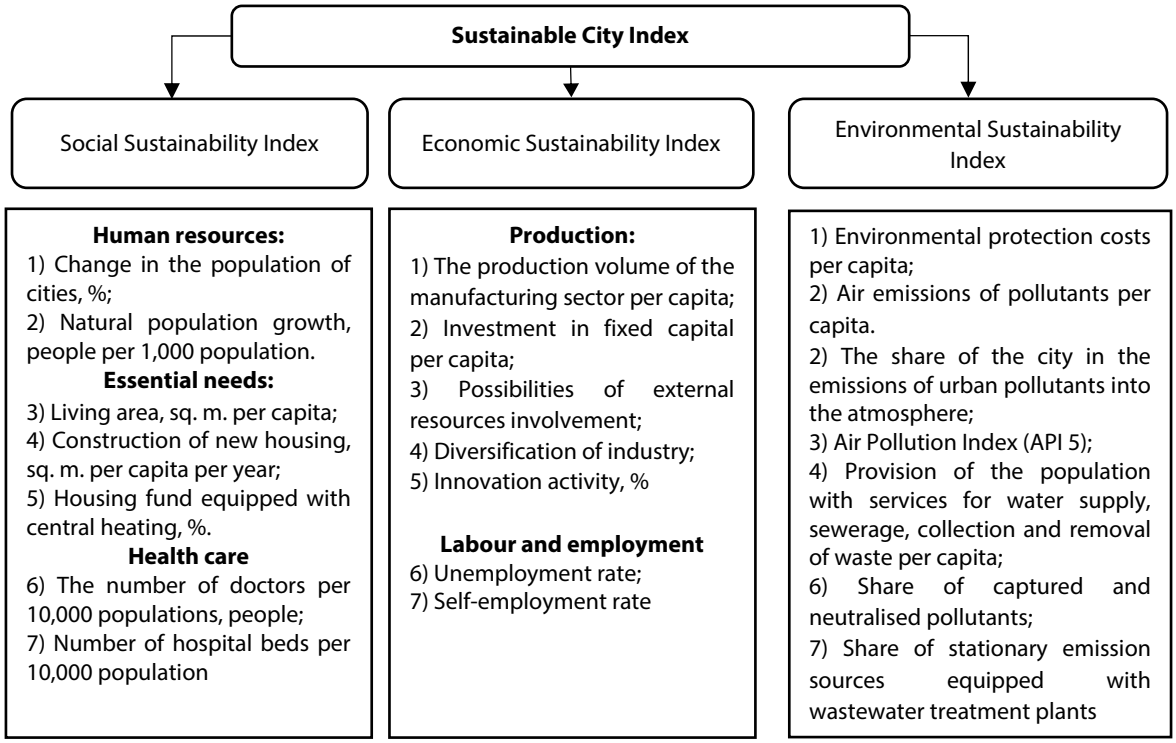

Fig. 1. *Structure of Sustainable City Index*

Third, the proposed system of indicators does not sufficiently consider the climatic features of cities, which determine the needs for energy and the task to expand the use of energy sources that are less aggressive to the environment. Kazakhstan is a country with one of the most extreme temperature regimes from +50°C to –60°C. It is necessary to mention Astana that is the second coldest capital in the world.

Fourth, the indicators are overly aggregated and monitored in the context of the urban population in 15 regions and three cities of republican significance – Astana, Almaty, Shymkent. The presentation of sustainable urban development processes in this setting is vague, poorly controlled, and managed. It is not possible to obtain data for all cities in Kazakhstan at the same time.

Thus, for example, these indicators that directly reflect urban development, such as the level of infrastructure provision (density of the road network, the share of public transport, passenger traffic, etc.); comfort (the landscape level, the presence, and variety of leisure facilities, the availability of market infrastructure, etc.); safety (the share of emergency housing stock, the number of crimes per 10 thousand of the population, etc.) are not taken into account in the statistics of most cities in Kazakhstan.

There are no comprehensive studies for the sustainable development of Kazakhstan cities. Either only one city (Alibekova et al., 2018; Shmelev et al., 2018), or just one sustainability aspect (Pakina & Batkalova, 2018; Nurlanova & Kireyeva, 2013) are considered. 2019 Kazakhstan Human Development Report is the most complete one. This Report uses two indices: the Urban-Adjusted Human Development Index (UA-HDI) for the 16 regions and the Habitat Commitment Index (HCI) applied to 30 biggest cities.[1]

For the development of the rating of city sustainable development were selected 39 cities of three categories: cities of the republican level, regional centres, and cities of regional subordination.

The indicators for 2019 obtained from the Bureau of National Statistics of the Republic of Kazakhstan, the national reporting platform for Sustainable Development Goals, statistics departments in regions and cities, the Kazakhstan Medical Statistics Database, Committee on the Legal Statistics, Kazhydromet and the IQAir platform were studied.

Three key blocks of urban sustainability indicators — social, economic, environmental ones — were identified in the methodology. Three intermediate indices and an integral index were calculated on their basis (Fig. 1).

[1] UNDP. (2019). Urbanization as an Accelerator of Inclusive and Sustainable Development / National Human Development Report 2019: Kazakhstan. Retrieved from: http://hdr.undp.org/sites/default/files/nhdr _2019_kaz.pdf (Date of access: 11.03.2021).

The methodology identified three key blocks of indicators of city sustainability: social, economic, environmental ones. Three intermediate indices and an integral index were calculated on their basis (Fig. 1).

The indicators of the cities' sustainability are relative, which makes it easier to use them for rating assessment. Data were normalised on a scale from 1 (worst) to 9 (best).

A scale from 1 to 9 is used to convert the values of indicators to a score and ranking of cities, calculated using the following formula:

$$V_{scaled} = 8 \cdot \frac{\left(V_{current} - V_{\min}\right)}{\left(V_{\max} - V_{\min}\right)} + 1. \quad (1)$$

The formula takes the following form for the indicators in which a higher value indicates a worse result (2). At the same time, 1 is the lowest score, 9 is the best score.

$$V_{scaled} = -8 \cdot \frac{\left(V_{current} - V_{\min}\right)}{\left(V_{\max} - V_{\min}\right)} + 9, \quad (2)$$

where, V_{scaled} — normalised indicator; $V_{current}$ — value of the current indicator; $V_{\max}$ — maximum value of the indicator; $V_{\min}$ — minimum value of the indicator.

Three intermediate indices were calculated using the arithmetic mean of the corresponding indicators. The integral sustainable city index (*SCI*) was calculated as the sum of intermediate indices (3):

$$\begin{cases} SCI = IS_{Social} + IS_{Econ} + IS_{Env}, \\ IS_{Social} = \dfrac{\sum_{i=1}^{n} x_i}{n}, \\ IS_{Econ} = \dfrac{\sum_{j=1}^{n} y_j}{n}, \\ IS_{Env} = \dfrac{n\sum_{k=1} z_k}{n}, \end{cases} \quad (3)$$

where *SCI* — Sustainable City Index; IS_{social} — Social Sustainability Index; IS_{Econ} — Economic Sustainability Index; IS_{Env} — Environmental Sustainability Index; x_i — Normalised i-indicator of Social Sustainability, $i = \overline{1, 7}$; y_j — Normalised j-indicator of Economic Sustainability, $j = \overline{1, 7}$; z_k — Normalised k-indicator of Environmental Sustainability, $k = \overline{1, 7}$; n — Number of analysed indicators.

The values of the private indices of city sustainability are in the range from 1 to 9 of the composite city sustainable development index from 1 to 27.

These factors have different significance for sustainable development in different types of cities. So, for single-industry towns and small towns the priority is given to the problems of economic diversification, deterioration of infrastructure, loss of human capital (Fauzer et al., 2021); for large cities the problems of air, soil and water pollution come to the fore[1]. Therefore, equal weighting was given to the factors for the rating.

It is proposed to use the method of mapping the risks of sustainable development for each city (Table 1).

Risks of sustainable urban development are possible processes and limitations, hazards and threats, the impact of which violates the social, environmental and economic balance of the urban system, its integrity and ability to reproduce, destroying the stock of natural capital, the conditions of life of present and future generations.

The proposed methodology takes the data availability into account, ensures comprehensiveness and considers the most important urban development factors: possibility of operational monitoring of economic, social, demographic, and environmental aspects of urban development; possibility of its use by urban management bodies for decision-making in the field of sustainable urban development.

4. Results and Discussion

Based on the selected indicators, a rating of sustainable development of cities in Kazakhstan was compiled[2] (Table 2).

Values of integral indices are in the range from 10 to 17. 2 megacities (Astana and Almaty), 7 large cities and 1 medium-sized city (Aksu) were included in the top 10. The third megacity of Kazakhstan, Shymkent, was included in the last ten of the rating.

Analysis of the data shows a very large variation by cities, meaning that a place in the ranking does not give a complete understanding. That is why sustainable development risks were mapped by three factors and all indicators.[3] The

[1] UNDP (2019) Urbanization as an Accelerator of Inclusive and Sustainable Development / National Human Development Report 2019: Kazakhstan. [Electronic resource]. URL:http://hdr.undp.org/sites/default/files/nhdr _2019_kaz.pdf (Date of access: 11.03.21)/

[2] The initial data and calculations of the authors can be found at the following link: https://1drv.ms/x/s!AjPNG8Xu0qzagWl63LmwvcLZv1XP?e=91ZJ36/

[3] The initial data and calculations of the authors can be found at the following link: https://1drv.ms/x/s!AjPNG8Xu0qzagWl63LmwvcLZv1XP?e=91ZJ36.

Table 1

Criteria for the development of a sustainable city risk map

Indicators	No	High risk	Medium risk	Low risk
Social sustainability				
Change in the population of cities, %; (1999-2019)	*B*1	$B1 < 100$	$100 \le B1 \le 123.5$	$B1 > 123.5$
Natural population growth, people per 1,000 population	*B*2	$B2 < 10$	$10 \le B2 \le 14.56$	$B2 \ge 14.56$
Living area, sq. m. per capita (Anker & Anker, 2017)	*B*3	$B3 < 21.9$	$30 > B3 \ge 21.9$	$B3 \ge 30$
Construction of new housing, sq. m. per year per capita	*B*4	$B4 < 0.6$	$1 \ge B4 \ge 0.6$	$B4 > 1$
Housing fund equipped with central heating, %	*B*5	$B5 < 56.5$	$71.9 \ge B5 \ge 56.5$	$B5 > 71.9$
The number of doctors per 10,000 populations, people (He, 2010)	*B*6	$B6 < 26$	$26 \le B6 \le 40$	$B6 > 40$
Number of hospital beds per 10,000 population*	*B*7	$B7 < 52$	$71 \ge B7 \ge 52$	$B7 > 71$
Economic sustainability				
The production volume of the manufacturing sector per capita, thousand tenge	*B*8	$B8 < 493$	$493 \le B8 \le 719.3$	$B8 > 719.3$
The average annual volume of investment in fixed capital per capita (for 5 years, thousand tenge)	*B*9	$B9 < 1572$	$1572 \le B9 \le 2572$	$B9 > 2572$
Possibilities of external resources involvement (distance to the nearest railway station, km.) (Kolomak, 2014)	*B*10	$30 < B10$	$1 < B10 \le 30$	$B10 \le 1$
Diversification of industry (Herfindahl–Hirschman Index) (Grebenkin, 2018)	*B*11	$018 < HHI \le 1$	$0.1 \le HHI \le 0.18$	$HHI < 0.10$
Innovation activity, % (Share of enterprises implementing innovations)	*B*12	$B14 < 11.3$	$11.3 \le B14 \le 13$	$B14 > 13$
Unemployment rate, %;	*B*13	$B12 > 5$	$4.8 \le B12 \le 5$	$B12 < 4.8$
Self-employment rate, %	*B*14	$B13 > 23.9$	$12 \le B13 \le 23.9$	$B13 < 12$
Environmental sustainability				
Environmental protection costs per capita, tenge	*B*15	$B15 < 12\,500$	$12\,500 \le B15 \le 27\,500$	$B15 > 27\,500$
Air emissions of pollutants from stationary sources per capita, kg	*B*16	$B16 > 500$	$100 < B16 \le 500$	$B16 \le 100$
Air Pollution Index (API 5)**	*B*17	$B17 \ge 7$	$5 < B17 < 7$	$B17 \le 5$
The share of the city in the emissions of urban pollutants into the atmosphere, %	*B*18	$B17 > 3$	$1 \le B17 \le 3$	$B17 < 1$
Provision of the population with services for water supply, sewerage, collection, and removal of waste per capita, thousand tenge	*B*19	$B18 < 14.5$	$14.5 \le B18 \le 21$	$B18 > 21$

* European Health Information Gateway. Retrieved from: https://gateway.euro.who.int/en/indicators/hfa_476–5050-hospital-beds-per-100–000/ (Date of access: 11.03.2021).

** *B*ureau of National Statistics (2015). Methodology for the formation of indicators of environmental statistics. Retrieved from: https://adilet.zan.kz/rus/docs/V1500012931 (Date of access: 20.05.2021).

risk map is summarised in Table 3. This approach not only shows the city rank but also draws attention to different groups of problems in the cities of Kazakhstan.

Sustainable urban development risks are those processes that can result in an imbalance in the triad "society — economy — nature", have consequences in urban development in the form of deterioration of social conditions and loss of human resources, reduced economic sustainability, depletion of natural resources and harmful effects on the environment.

Three levels of risks were identified: high, medium and low. When the risk levels were assessed, the average indicators for Kazakhstan, for the analysed group and for the group of countries were used. Standardised criteria were used for certain indicators (the RSI5, the Herfindahl-Hirschman Index). Colour indicators were assigned reflecting the high (red), medium (medium) and low (green) risk level for the data obtained using conditional formatting.

Social sustainability of cities. The urban population grew by 123.5 % in Kazakhstan from 2009 to 2019. This level can be taken as a benchmark intended to assess the sustainability level of population growth in cities in Kazakhstan. High risks of human capital loss arose in cities where the population had declined. These cities are less competitive in terms of attraction of human resources. This situation is observed in 6 of 39 cities. Cities, where the population growth was registered but lagged behind the urbanisation level in the country, were classified as medium-risk cities.

Table 2

Ranking of sustainable cities in Kazakhstan

	ISsocial	Rank	ISecon	Rank	ISenv	Rank	SCI	Rank
Astana*	7.13	1	5.39	6	4.75	28	17.28	1
Aktau**	6.74	2	4.73	24	5.62	9	17.09	2
Kokshetau**	5.44	5	4.95	12	5.80	7	16.19	3
Atyrau**	5.46	4	5.82	4	4.74	29	16.03	4
Taldykorgan**	5.49	3	4.72	25	5.51	11	15.72	5
Aktobe**	5.21	7	4.84	16	5.00	24	15.05	6
Almaty*	5.21	6	5.06	10	4.70	30	14.97	7
Ust-Kamenogorsk**	4.44	12	5.27	7	5.18	18	14.90	8
Pavlodar**	4.43	13	5.05	11	5.40	16	14.87	9
Aksu	3.37	28	6.08	2	5.41	15	14.85	10
Petropavl**	4.30	15	4.49	29	5.93	3	14.72	11
Zhanaozen	4.21	17	4.88	14	5.62	8	14.71	12
Karaganda**	5.00	9	4.79	20	4.81	26	14.61	13
Zhezkazgan	3.93	20	5.11	9	5.47	12	14.51	14
Kostanay**	4.46	11	4.72	26	5.32	17	14.50	15
Oral**	4.77	10	4.64	28	5.00	23	14.41	16
Saran	2.63	38	5.85	3	5.81	6	14.29	17
Fort-Shevchenko	4.36	14	4.81	18	5.09	20	14.26	18
Lisakovsk	3.58	24	4.67	27	5.98	1	14.22	19
Satpayev	3.79	23	4.80	19	5.41	14	14.00	20
Karazhal	2.84	37	6.80	1	4.33	33	13.96	21
Stepnogorsk	3.32	30	4.75	22	5.86	4	13.93	22
Kyzylorda**	5.09	8	4.94	13	3.89	37	13.92	23
Ridder	3.16	34	4.74	23	5.96	2	13.87	24
Kurchatov	3.35	29	5.49	5	4.80	27	13.64	25
Semey	4.04	19	4.39	32	5.14	19	13.58	26
Balkhash	3.57	25	4.87	15	5.09	21	13.53	27
Taraz**	4.24	16	4.45	30	4.82	25	13.51	28
Rudny	3.38	27	3.63	36	5.81	5	12.83	29
Shakhtinsk	2.97	35	4.81	17	5.02	22	12.81	30
Ekibastuz	3.47	26	5.26	8	3.74	39	12.48	31
Temirtau	3.29	31	4.79	21	4.39	32	12.46	32
Shymkent*	4.15	18	4.42	31	3.75	38	12.32	33
Kentau	3.25	32	3.44	38	5.42	13	12.11	34
Priozersk	3.80	22	4.21	33	4.08	35	12.09	35
Turkistan **	3.87	21	3.89	34	3.98	36	11.74	36
Tekeli	2.02	39	3.77	35	5.52	10	11.31	37
Arkalyk	3.17	33	3.56	37	4.08	34	10.80	38
Arys	2.90	36	2.61	39	4.61	31	10.13	39

Note: * — megacity; ** — regional centre.

The natural increase rate was 14.56 in Kazakhstan in 2019 while it was higher and equalled 14.64 for the urban population. Two cities, Ridder and Rudny, showed the negative natural increase rate. This indicator ranges from 1 to 10 in 18 cities. These cities were classified as high risk. Another 10 cities were included in the group with an average risk.

Cities with high population growth levels were categorised as low risk in terms of human resources. At the same time, it should be noted that the excessively rapid growth of the urban population has other risks associated with overloading of the urban infrastructure and other aspects of urban life.

The housing quality indicators were considered among the essential needs. A person's living space should be at least 30 square meters according to modern standards (Anker & Anker, 2017, p. 129). There are, however, 21.9 sq. m. of living floor space per inhabitant in Kazakhstan.

To provide housing of 30 sq. m per person in Kazakhstan, it is necessary to build more than 1 sq.

Table 3

Sustainability risk map for cities in Kazakhstan

	High risk	Medium risk	Low risk
Social sustainability	Turkistan. Shakhtinsk. Ekibastuz. Kentau. Temirtau. Tekeli. Stepnogorsk. Saran. Rudny. Ridder. Priozersk. Kurchatov. Karazhal. Balkhash. Arys. Arkalyk. Aksu	Almaty. Shymkent. Petropavl. Pavlodar. Karaganda. Kokshetau. Taraz. Zhanaozen. Fort-Shevchenko. Semey. Satpaev. Lisakovsk. Zhezkazgan. Zhanaozen. Ust-Kamenogorsk. Oral	Astana. Aktau. Aktobe. Atyrau. Kyzylorda. Taldykorgan
Economic sustainability	Shymkent. Turkistan. Shakhtinsk. Ekibastuz. Kentau. Tekeli. Semey. Rudny. Priozersk. Arys. Arkalyk	Almaty. Aktau. Karaganda. Kokshetau. Kyzylorda. Petropavl. Taldykorgan. Taraz. Oral. Fort-Shevchenko. Stepnogorsk. Satpayev. Saran. Lisakovsk. Zhezkazgan. Kurchatov. Balkhash. Zhanaozen	Astana. Atyrau. Ust-Kamenogorsk. Temirtau. Ridder. Aksu. Karazhal
Environmental sustainability	Astana. Shymkent. Atyrau. Karaganda. Kyzylorda. Turkistan. Arkalyk. Balkhash. Zhezkazgan. Priozersk. Temirtau. Ekibastuz	Almaty. Aktobe. Kostanay. Taldykorgan. Taraz. Oral. Ust-Kamenogorsk. Zhanaozen. Karazhal. Kurchatov. Rudny. Saran. Semey. Tekeli. Shakhtinsk. Kentau	Aktau. Kokshetau. Pavlodar. Petropavl. Aksu. Arys. Ridder. Lisakovsk. Satpayev. Stepnogorsk. Fort-Shevchenko

m per inhabitant per year against 0.6 sq. m in recent years. Cities with high, medium, and low risk in the provision of housing conditions were identified based on these estimates. Most cities characterised by a higher housing provision than the republican level, nevertheless, fall into the category with low housing construction rates.

The medical service density indicator with more than 26 persons per 10,000 population is the main (standard) for secondary modernisation (He, 2010). 17 high-risk cities were identified based on this criterion. The average medical service density is 40 persons in Kazakhstan; therefore, the average level of risk falls into cities with a provision of 26 to 40 persons per 10,000 population. The risk will be low for the rest of the cities.

The hospital bed provision index is 52 units in Kazakhstan, and 71 in CIS countries[1]. The two largest cities, Almaty and Astana, were included in the high-risk group, along with medium and small cities under this parameter.

Economic sustainability of cities. Kazakhstan has adopted a number of 5-year industrial programmes, including the Industrial Development Programme 2015–2019, and each region implements its own industrialisation maps. The average annual investment in fixed capital per capita in Kazakhstan in the period 2015–2019 was 2,579.0 thousand KZT. The cities were grouped by risk level under these indicators.

The important parameter of economic sustainability is the diversification of the urban economic structure. This indicator was calculated based on the Herfindahl-Hirschman index. Another important condition for urban development is the ability to involve external resources that depend on transport infrastructure, in particular on the distance to the nearest railway station (Kolomak, 2014). 7 of 39 cities do not have direct rail access. The most remote is Fort-Shevchenko (144 km). Although the Mangistau region has a powerful transit potential with access to the multinational system of the Caspian region, the weak infrastructure connecting Fort-Shevchenko with the country's internal economic space is a significant restriction for the development and use of the unique natural and geographical potential of the town.

Innovation activity is an important indicator of urban economic potential. Analysis of the data showed that many medium-sized towns have innovation activity above the national average one.

Significant sustainability risks are associated with employment conditions. Overall, urban unemployment rates are not critical. However, one of the acute and urgent problems is the spread of unstable employment, including various self-employment forms. On average, the share of employers does not exceed 4 % among the self-employed in Kazakhstan. The rest is involved in various forms of vulnerable employment and has instability risks. Significant self-employment levels are usually associated with a high proportion of agricultural employment and lack of standard jobs with social safety nets. The large self-employment scale in cities poses great economic and social risks.

[1] European Health Information Gateway. Retrieved from: https://gateway.euro.who.int/en/indicators/hfa_476-5050-hospital-beds-per-100-000/ (Date of access: 11.03.2021).

Environmental sustainability of cities. According to Kazhydromet, the following cities are characterised by high pollution under the Air Pollution Index: Temirtau, Astana, Almaty, Aktobe, Atyrau, Ust-Kamenogorsk, Karaganda, Balkhash, Zhezkazgan, and Shymkent.

Four cities (Pavlodar, Aksu, Temirtau, and Ekibastuz) produce 52 % of emissions in the considered group of cities. Therefore, a high level of risk is associated with these cities. The second group of cities is responsible for 1 to 5 % of the emissions, the third group of cities — for less than 1 % of the emissions.

Environmental protection costs amounted to 12.05 thousand KZT per capita and 38.11 thousand KZT in the analysed group of cities in 2019. There are significant cost differences from 0.09 thousand to 301 thousand KZT in cities. Accordingly, cities where expenses are below the national average, are classified as high-risk ones. The largest cities of Kazakhstan fall into this category. The designation of industrial cities to the low-risk group does not alleviate the problem of air pollution. It reflects the extent of efforts for remediation and maintenance of the environment.

The mining and export of commodities is an important source of growth for Kazakhstan, as for many developing countries. The Republic's oil and mining cities are more stable, while single-industry towns are less stable. The phenomenon of "energy poverty" is noted in studies of Kazakhstani scientists.

There are regional differences in the availability of cleaner fuel sources in Kazakhstan, the share of coal use (up to 40 % of households) for heating housing and other purposes remains high, gas is used mainly for cooking (Kerimray et al., 2018).

As experts noted[1], low commodity prices in the world markets and a decline of commodity export earnings in many producing countries limit opportunities to mobilise investment for sustainable development. Along with the underdevelopment of capacities required to process energy resources and infrastructure for distribution, the effect of losses increases many times over.

Serious efforts to protect the environment are needed to achieve the Sustainable Development Goals. The generation of hazardous waste (all hazard levels) in Kazakhstan was 9.75 tonnes per capita, of which 225 kg of hazardous waste ("red" and "amber" levels of danger) per capita according to the Sustainable Development Goals monitoring panel in 2019. The share of recycling and disposal of municipal solid waste is only 14.9 %.

The study considered such indicators as the share of captured and neutralised pollutants and the share of stationary sources of emissions equipped with treatment facilities. Overall, average neutralisation for pollutants in the cities of Kazakhstan is 61 %, and the share of stationary sources of emissions equipped with wastewater treatment facilities is 8 % on average. Obviously, the environmental sustainability risks are quite high in cities.

5. Conclusion

The results of the development and testing of the rating assessment methodology of the Kazakhstan cities by sustainable development allow us to draw the following conclusions and proposals.

Firstly, there has been a negative natural population growth in some Kazakhstan cities in recent years, which indicates possible ageing of the population in cities, decrease in the quality of the health care system and living standard. The consequence of the urbanisation peculiarities in Kazakhstan is the overpopulation of the largest cities, the development of infrastructure of which lags behind the growing needs of city residents. The urbanisation processes in Kazakhstan are developing unevenly, along with the growth of the largest cities, risks increase or economic activity decreases in medium, small and single-industry towns. In general, the current situation can be characterised as inequality of cities in the achievement of Sustainable Development Goals.

Secondly, sustainable urban development in Kazakhstan is at an average level according to the results of the authors' rating. Some medium cities are more stable than the megacities Almaty and Shymkent, however, in single-industry towns of Kazakhstan, sustainable development risks are higher than in other cities of the country.

Thirdly, scientifically based recommendations on the application of the methodology for assessing sustainable urban development will contribute to the improvement of statistical accounting of the main indicators of the development of the economy, social sphere, and environment of cities in Kazakhstan. At the same time, it is necessary to improve national regional statistics with the separation and expansion of urban statistics.

Fourthly, this study can serve as a basis for the following studies. Thus, it is necessary to conduct research (on pilot projects) on the materials of one or two cities to develop a mechanism for monitoring the social and economic development of re-

[1] UNCED. (1992). Report of the United Nations Conference on Environment and Development. Retrieved from: https://undocs.org/en/A/CONF.151/26/Rev.1(vol.I) (Date of access: 11.03.2021.

gional systems, which ensures the adoption of informed decisions on the choice of priorities and the achievement of a balanced state of the ecological, social and economic spheres of activity.

The application of the methodology developed by the authors will improve the tools for monitoring and assessing city sustainable development. Inclusion of the indicators of sustainable development proposed by the authors in the system of urban planning and forecasting makes it possible to use them on-line for making decisions on the strategic management of the development of the city, its social sphere, economy, and environmental situation.

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