European Research Studies
Volume XIX, Issue 2, Special Issue, 2016

pp. 34-45

Environment Quality Management in Green Cities

Lyudmila N. Medvedeva[1], Konstantin Y. Kozenko, Olga P. Komarova

Abstract:

The article is devoted to the issues of improvement of quality of urban environment during realization of the project of development of green cities, which combines economic and ecological advantages. The article substantiates top-priority directions of change of approaches to management of urban territories and integration of efforts of science, business, and society in promotion of green technologies. The main methodological approach to provision of ecological balance in green cities consists in development of the most comprehensive complex of ecological and economic indicators of development of the city in view of implementation of progressive technologies of filtration of industrial emissions into the atmosphere, sewage water treatment, waste processing, etc. The article offers methodological substantiation of the system of indicators which include evaluation of anthropogenic influence on urban environment and calculation of integrated economic effect from implementation of green technologies which minimize unfavorable effect of these influences. These indicators include emissions release into the atmosphere, soil pollution, development of green areas, use of urban territories which are taken out from the system of natural use, use of city public transport, etc. The developed indicators can not only reflect the existing ecological state and economic development of the city fully but be used for development of perspective scenarios of development of green urban economy on the basis of industrially developed middle-sized cities of Russia and the CIS.

Key Words: *development of middle-sized cities, single-industry city, urban greening, clever city, city waste utilization.*

[1] All-Russia Research Institute of Irrigative Agriculture, Volgograd, Russia (9 Timiryazeva St., Volgograd, Russia), e-mail: milena.medvedeva2012@yandex.ru

Research methods

For substantiation of the research results, the following methods of scientific analysis were used: systemic, situational, historic, logical, and typological; methods of structural and functional, descriptive expertise, statistical, graphical, and table analysis, economic and mathematical modeling.

Introduction

Swiftness of changes, which take place in the biosphere, their direct interconnection and interdependence with the results of human activities make local city authorities implement modern and safe technological solutions. The ecological doctrine of Russia, which was passed over the recent years, formed legal foundations for ecological management of urban environment and offered to use the mechanism of public-private partnership and organization of small and medium business for these purposes. Contemporary urban management includes the following spheres of activities: provision of population with main services (safe drinking water, high-quality services in healthcare and education); effective use of local resources; formation of ecological frame and innovational infrastructure. During evaluation of urban economy, it is important to provide correct accounting of the level of human influence on the environment [2,3].

Types of human influence on nature include: industrial influence according to sectorial peculiarities; communal and transport influence; influence on nature and landscape environment. The Green Bridge initiative, which appeared in 2012 at the Summit Rio+20, became a practical mechanism of international transition to the "green economy" with focus at technological progress and increase of experience of environment management. Another relevant example is strategic approach to development of cities, established by the European Commission. The documents clearly determined top-priority directions, formulates goals and indicators for each of them (Fig.1). A rather large circle of studies confirms that economy, based on knowledge, became a reality. Knowledge becomes a source of well-being, so it is important to determine which knowledge and management are able to provide competitive advantage for cities. The achieved level of science, education, and production in cities is rather important for solving this issue.

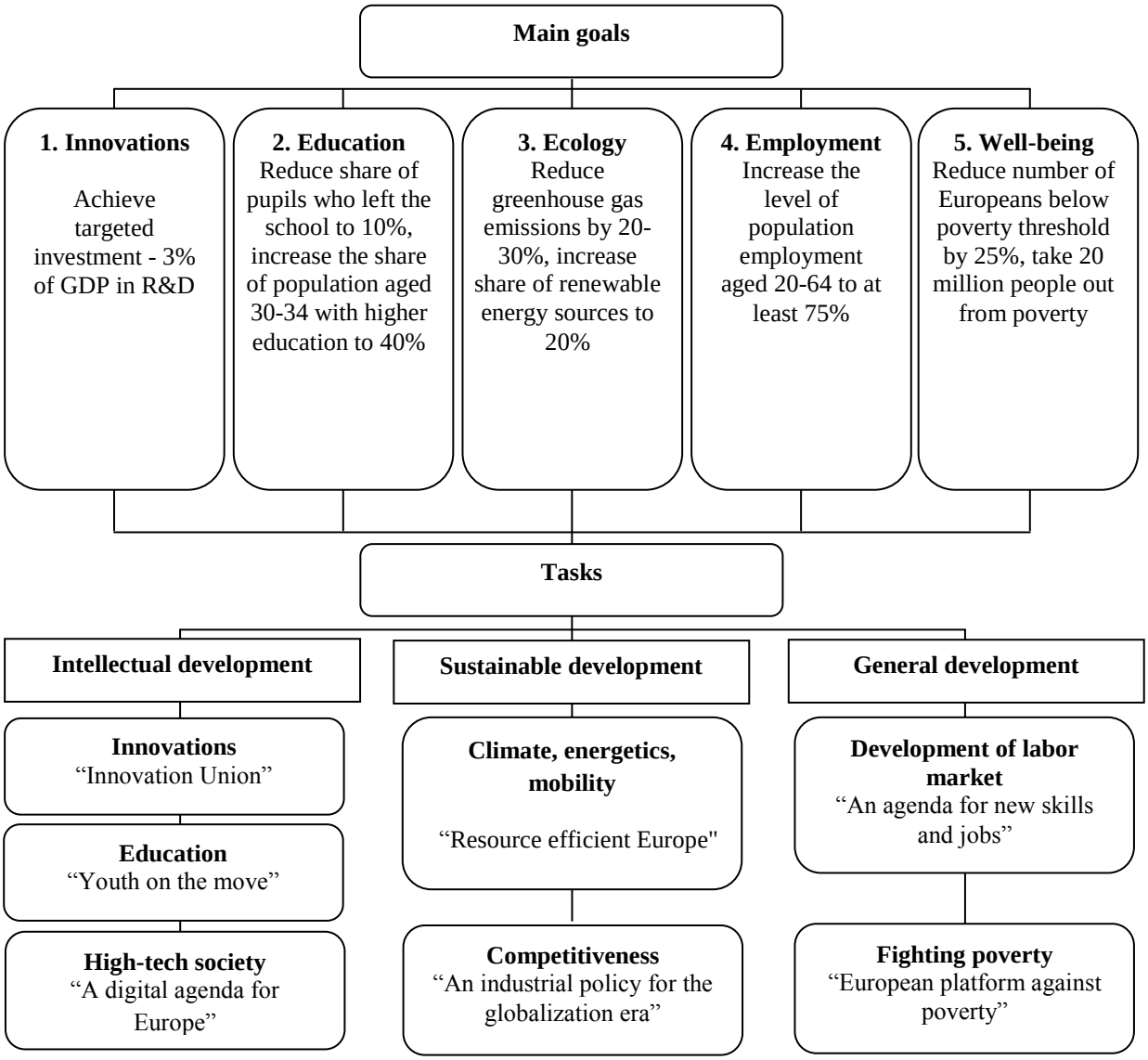

Figure 1. Strategic directions of cities development in the EU

A new view at cities management was developed due to the EU's passing the concept of technological platforms which are to concentrate efforts of authorities, scientists, and entrepreneurs in the sphere of promotion of nature-like and resource renewable technologies [11, 12].

Axiomatical statement that nature can take a lot ceased to be a reality. Load on nature environment became so huge that many cities ceased to be safe for living. A lot of time passed before this was realized, but not amended. It is necessary to change approaches to organization of ecology management in a city: creation of single base of legal and normative regulation; conduct of wide propaganda and explanatory work among population for saving attitude towards urban resources and natural environment; application of modern integral methodologies of calculations and methods of ecology management; use of mechanisms of public-private and municipal-state partnership during realization of infrastructural projects; stimulation of small enterprises' constructing complexes for separate collection of communal waste [8,9].

Table 1 systematizes main factors and indicators of socio-economic development of middle-sized cities.

The most perspective concept of city development in the XXI century, in view of ecological limitations (environment's possibility to accept and absorb various types of waste and pollution of human activities; level of non-return of natural resources, spent by human) – green cities. Main approaches to provision of development of green cities to their ecological balance could be formulated in the following way: urban planning should be started from analysis of plans of development of the country and region and have full analysis of ecological indicators of the city development [9].

Table 1. System of factors, criteria, and indicators of socio-economic development of middle-sized city

Factors Indicators Criteria		Title	
	Economic level	*Factors*	
		- natural resources, main funds	- environment, land, property
		Indicators	
		- city domestic product, RUB million. - city domestic product per capita, RUB thousand, - level of investments into basic capital and innovations per capita, RUB million.	- level of investments into resource-saving technologies of the city, % It-e = I_{sav} / I_{mf} + I_{cons}, where: I_{t-e} – systemic parameter of technical and economic level; I_{sav}– investments into saving technologies; I_{mf} – investments into main funds; I_{cons} – level of consumption
	Social level	*Factors*	
		- human resources	-socio-economic, demographic, behavioral
		Indicators	
		- household's consumption, in general volume of consumption, %, - ratio of real wages and living wage, %, - share of people with high, medium, and low level of income in the structure of population, % - level of average pension, RUB.	- ratio of average level of labor payment in the budget sphere to living wages, % Is-e = P av / W liv, where: I_{s-e} – systemic parameter of socio-economic level; P_{av} – average level of labor payment; W_{liv} – living wages
	Organizational level	*Factors*	
		- technologies, innovations, investments, public-private partnerships	- technologies, SME, system of quality management
		Indicators	
		- developed production, innovational, and social infrastructure	- availability of organizational technologies Io-x = 0 – 1, where: Io-x1 = 0 – absence of standard organizational technologies; Io-x2 = 0.5 –technologies which do not conform to system's possibilities; Io-x3 = 1 – availability of standard organizational technologies

Contemporary view at issue of economy in middle-sized city should be based on the idea that balance of ratio of socio-economic needs and rational nature use should be equal.

This could be determined with the help of the following formula:
$Ft (L, K, P, I) \leq Ft+1(L, K, P, I)$, (1)
where: Ft (L, K, P, I) – function of sustainable development;
L, P – labor and natural resources;
K – artificially created (physical) capital, production means;
I – institutional factor;
t – time factor (at $0 \leq t$).
The main ecological indicator, which should be taken into account by local authorities, include:
1. Indicator of atmospheric pollutant emissions:
$Bn = \sum_{i=1} (1- \Delta Bi / Boi)$, (2)
where: Boi – total pollutant emissions for i-th component at the beginning of the forecast period, thousand tons per year;
Δ Bi – reduction of pollutant emissions for i-th component at the end of the forecast period by means of nature protection measures, thousand tons per year;
- indicator of waste water discharge into water basin:
$Cn = \sum_{i=1}(1- \Delta Ci / Coi)$, (3)
where: Coi – total pollution discharge for i-th component at the beginning of the forecast period, million cubic meters per year;
Δ Ci – reduction of pollution discharge for i-th component at the end of the forecast period by means of nature protection measures, million cubic meters per year;
2. Indicator of soil pollution in city:
$On = \sum_{i=1}(1 - \Delta Oi / Ooi)$, (4)
where: Ooi – volume for i-th type of waste at the beginning of the forecast period, thousand tons per year;
ΔOi – reduction of volume for i-th type of waste at the end of the forecast period by means of nature protection measures, their secondary use or processing, thousand tons per year;
3. Indicator of area of greening of city territory:
$Sn = \sum_{i=1}(1 - \Delta S / SПКo)$, (5)
where: SПКo – area of green plantings at the beginning of the forecast period, thousand hectares per year;
Δ S – growth of area of green plantings at the end of the forecast period, thousand hectares per year.
Ecological indicators include:
4. Indicator of the use of city territory, taken out from the system of city nature use:

$Fn = \sum_{i=1}(1 - \Delta F / F_З)$, (7)

where: $F_З$ – area of real estate development at the beginning of the forecast period, thousand square meters per year;

ΔF – growth of real estate development at the end of the forecast period, thousand square meters per year.

5. Indicators of the use of public transport (passenger turnover of public transport):

$Tn = \sum_{i=1} (1-\Delta Ti/Toi)$, (8)

where: Toi – passenger turnover of i-th type of public transport at the beginning of the forecast period, billion passenger-km per year;

Δ Ti – growth of passenger turnover of i-th type of public transport at the end of the forecast period, billion passenger-km per year.

6. Indicator of the time of excess of the normed pollution of the atmosphere (number of days in a year with pollution, which exceeds average daily maximum permissible discharges in the atmosphere):

$Qni = \sum_{i=1} \Delta Qi /365$, (9)

where: Δ Qi – number of days with concentration of i-th component which exceeds average daily maximum permissible discharges in the atmosphere at the end of the forecast period, days; 365 – number of days in a year;

7. Indicator of ecological investments (investments into basic capital, aimed at protection of environment and rational use of natural resources):

$In = \sum_{i=1}(1 - \Delta I / I_З)$, (10)

where: $I_З$ – investments into basic capital, aimed at protection of environment and rational use of natural resources at the beginning of the forecast period, RUB thousand per year;

Δ I – increase of investments into basic capital, aimed at protection of environment and rational use of natural resources at the end of the forecast period, RUB thousand per year.

For city authorities, it is important to found on generalizing ecological indicator during economic decisions making:

$E t = Bn \times Cn \times On \times Sn$, (6)

where: Bn, Cn, On, Sn – particular adjustable indicators of pollutant emissions into atmosphere, waste water discharges, soil pollution, and greening area. Value $Et < 1$ shows improvement of the quality of city environment [9]. The main social indicators, which should be taken into account by city authorities during strategic planning, are shown in Table 2.

Table 2. Main indicators of development of middle-sized city social sphere

Category	**Indicators examples**

Labor market quality, demographic situation	Quantity of population, indicators of sex-age structure. Expected life span. Economically active population: quantity, sex-age structure, education structure. Unemployment level and migration indicators
Living standards	Indicator of city product per capita. Average wages level. Money income, wages in real value (in % to previous year). Structure of expenses by population groups. Gini index and fund coefficient. Decile coefficient
Quality of educational services	Coverage of pre-school institutions by microdistricts. Quantity of educational institutions and students. Quantity of students of secondary professional and higher educational establishments per 1,000 people. Share of working age population with higher education
Quality of healthcare services	Quantity of day care establishments, hospital beds, doctors and paramedical personnel per 10,000 people. Morbidity rate per 1,000 people. Average size of subsidies for medical care, share of population receiving subsidies. Quantity of specialized medical establishments and healthcare programs
Quality of services of cultural and sports sphere	Quantity of establishments of culture, clubs, establishments of physical culture and sport, creative areas, step ways per 10,000 people. Quantity of sports competitions and population coverage by physical culture and sports
Quality of transport and communication services	Main types of transport and passenger turnover per year. Quantity of cars per 1,000 people. Share of population with subsidies for transportation. Population coverage by TV and radio, landline, mobile communications, Internet
Quality of environment	Expenses for protection of environment, % to gross city product. Main sources of pollution of environment. Share of population in ecologically unfavorable conditions
Quality of housing and communal services	Quantity of square meters of accommodation and green plantings on the whole and per capita. Share of expenses for payment for communal services in family expenses. Share of substandard housing. Index of prices for communal services, share of families which receive subsidies
Provision of citizens security	Expert evaluations of state of security. Number of establishments which are responsible for population security, their manning level. Crime rate, including among minors

The above indicators cannot fully show the picture of economic life in a city. International practice uses two indices for determination of the level and perspectives of city development: share of city product per capita (which is an analog of GDP at the city level, reflecting the volume of city production) and *city development index (CDI).* Index of city development CDI reflects average level of citizens' well-being and perspectives of city development. It includes: state of city

infrastructure (residential accommodation equipped with water pipeline, sanitary piping, electricity, and landline); organization of collection and deletion of waste (wastewater treatment, solid waste disposal); state of population's health (average life span, child mortality); state of population education (level of literacy of adult population, total indicator of quantity of students of higher educational establishments); volumes of city products (share of total volume of production of basic spheres of economy). High strategic significance and value of index show that it is not only a reflection of real development of city but creates preconditions for preparation of development scenarios. For the very first time, the index was calculated for the UN Conference on problems of inhabited localities (Habitat II)[2][10].

The CDI is calculated by the following formula:

$$CDI = \frac{1}{n}\sum_{j=1}^{n} I_{ij},$$

where: I_{ij}– subindex of i-th city of j-th indicator,
n– number of indicators.

Any component of generalized index is also an integral indicator and is calculated with the formula that includes particular generally accepted characteristics of development level. For example, infrastructure includes: 25 × water pipeline + 25 × sanitary piping + 25 × electricity + 25 × phone (cell phones per 1,000 people); waste: wastewater treatment × 50 + solid waste disposal x 50; healthcare (average life span – 25) × 50/60 + (32 – child mortality) × 50; education – literacy × 25 + combined group of students × 25. Value of combined index changes from 0 to 100 – the closer it is to 100, the higher is the level of development achievement of socially important landmarks. This methodology was used for calculation of the index of development of middle-sized industrially developed cities in the RF in 2014. (Table 2)

Table 3. Indices of development of middle-sized industrially developed cities, 2014

No.	Cities	Index of city development	Including sub-indices				
			infrastructure	Housing comfort	population health	education of population	city product
1	Magnitogorsk	68.58	60.20	89.0	41.90	82.70	69.10
2	Nizhny Tagil	65.60	60.10	90.50	41.10	80.10	53.60
3	Volzhskiy	58.82	59.40	91.00	44.50	83.00	38.70

[2] *The City Development Index (CDI) / The State of the World's Cities. UNCHS (Habitat), 2001. – P. 116 –119.*

4	Cherepovets	75.16	60.80	89.50	40.80	82.00	81.70
5	Surgut	75.90	67.70	90.50	42.20	83.60	95.70
6	Sterlitamak	60.98	60.00	90.00	42.00	83.40	29.50
7	Komsomolsk-on-Amur	58.50	65.20	88.30	41.60	80.70	16.70
8	Taganrog	58.24	60.40	87.90	43.20	80.90	18.30
9	Nizhnevartovsk	95.50	67.70	89.0	42.20	85.50	193.10
10	Bratsk	60.24	61.60	86.40	39.40	84.00	29.80
11	Novorossiysk	57.84	63.80	86.10	42.30	82.70	14.30
12	Nizhnekamsk	82.86	62.70	91.10	42.80	82.20	135.50
13	Stary Oskol	68.42	59.50	89.30	42.80	84.00	66.50
14	Norilsk	76.22	68.90	90.90	41.70	83.40	96.20
15	Dzerzhinsk	59.82	58.00	89.40	41.30	84.50	25.90
16	Orsk	58.38	61.60	90.60	41.80	82.20	16.70

The performed calculations showed that economic development is decisive in calculation of CDI, i.e., the city with higher level of budget revenues has higher development index. The most satisfactory is infrastructure index, which was received by means of high level of accommodation equipment level, 100% provision with electricity, achieved level of water pipeline and waste disposal development. Indicator "degradation of natural environment – collection and disposal of waste" is rather weak. With all importance of development of city economy, technical perfection and competitiveness, improvement of human environment and provision of favorable conditions for future generations become more important. A new global trend: *from minimization of influence on environment to minimization of harmful influence on human,* is no more than a motto. The future of Russian cities lies in the plane of use of principles of green economy and clever technologies. According to the UN, "green economy" is economy which raises people's well-being, provides social justice, significantly reduces negative influence on environment, and forms ecological mentality with the population [4,5,6].

The most important elements of the system of establishment of ecological mentality with urban dweller are: *education, upbringing, and practical activities of people.* Ecological mentality of urban dwellers is a many-aspect notion which determined nature-like type of human behavior, who is directed by the principles of preservation of environment by means of reduction of the level of consumption and realizes the necessity for preservation of bio-diversity in living nature. Foundation of ecological mentality of personality is ecological mindview. There are three approaches of formation of ecological mindview with population: anthropocentrism (determined by motto "Human is a king of nature", spirit of unlimited consumption); radical biospheres-centrism (movement with a motto for return to nature); *moderate biosphere-centrism* (formed views with population according to principles of green economy). Moderate biosphere-centrism is coordinated with the N.N. Moiseev's

principle on co-adaptation of humanity and biosphere, at which human rings his activities in correspondence to economic volume of the biosphere [7]. A working form of formation of such mindview with urban dwellers is participation in public ecological events and actions. According to general acknowledgement, the sense of contemporary education consists in bringing up a person who creates something new and does not do damage to nature. Ecological culture of cities is formed as a result of ecological education which includes: development of habits for observation of ecological norms with practical examples, ecological education, and formation of value orientation with young population. Analyzing complex character of the problem of valeology, Canadian scientists noted that human health is formed primarily under the influence of such factors as human biology, living environment, way of life, and medical healthcare, while scientists from the Institute of Medicine from the Academy of Sciences (USA) distinguished the following reasons of long life: way of life – 53%, environment – 21%, heredity – 16%, system of healthcare – 10% [1]. Thus, one of the components of human health is the state of nature environment in which he lives. There are different views on ecological education – in some cases, it is conducted by stages: systemic upbringing (from the moment of birth to end of life), systemic teaching (age 10 – 14); systemic education (age 15 – 28). Each of these stages is necessary, as it provides corresponding subject, essential, and spiritual load and develops a certain part of mechanisms of functioning of comprehensive ecological system of education in the country. Ecological culture of cities is formed as a result of: children's acquiring habits of observation of ecological norms with practical examples, ecological enlightenment (distribution of ecological knowledge through mass media), and ecological education – the process of teaching foundations of ecology in various types of educational establishments. The world has more that abstract logical notions can convey. Human must learn to co-exist with nature, co-obey its laws, and cooperate with it in the process of development of society.

Acknowledgement

This article was prepared as part of the grant RFH No. 15-02-00580 "Concept strategy of" green cities" based on the middle-sized industrialized cities of Russia and CIS countries."

References

«Health of the human – 7»: VII International Valeology Congress. – SPb.: SPbGMU, 2014. – P. 123.

Decoupling natural resource use and environmental impacts from economic growth. UNEP, 2011.

Ecosystems and human well-being. Evaluation of the Millennium Ecosystem. Island Press, Washington, Covelo, London, 2005.

Medvedeva L.N. Management of medium-sized towns in urban era (methodology and practice). Volgograd, VSTU Publishing, 2011, 222 p.

Medvedeva L.N. Medium-sized Russian city: social and cultural potential as a foundation for economic development / L.N. Medvedeva, S.O. Lebedeva, Y.M. Starovoytova // XXXVII International Research and Practice Conference «Forms of social communication in the dynamics of human society development». December 05–10, 2012. London (UK) – URL: http://www.http://gisap.eu/ru.

Medvedeva L.N., Starovoytova Ya.M. Strategy of development of Russian cities. Horizons of economy, 2013, No 2 (7), pp. 89-95.

Moiseev N.N. Mankind ecology by mathematician's eyes (Person, nature and future of a civilization). – M., 1990.

Pagiola S., von Ritter K., Bishop J. Assessing the Economic Value of Ecosystem Conservation. World Bank, 2004.

Starovoytov M.K., Medvedeva L.N. The environmental component in urban development. Interaction research units of industrial enterprises and universities to improve the efficiency of management and production: Materials 5th Interregional Scientific.-Pract.Conf. Volzhsky, 24-25 April 2009 Volzhsky Polytechnical Institute (branch) VSTU, Volgograd, 2010, pp. 23-26.

The City Development Index (CDI) / The State of the World's Cities. UNCHS (Habitat), 2001. – P. 116 –119.

Towards a "green" economy: Pathways to Sustainable Development and Poverty Eradication – a synthesis report for the representatives of power structures. UNEP, 2011.

World Wide Fund for Nature. Living Planet Report. 2007.