AN ESTIMATION MODEL OF COMFORT LEVEL IN URBAN TERRITORIES

Elkhana G. Riabova

Dubna State University branch "Ugresha",
24 Akademika Zhukova Street, Dzerzhinskiy, Moscow region, 140090, Russia

Abstract

This article is dedicated to one of the most important challenges of today – the problem of the estimation of the quality of urban territory and the comfort of urban life. In this article the main existing methods of estimating the urban comfort are given and a proprietary methodology of estimating the urban life comfort in different kinds of settlements, mainly towns and mid-sized cities, is suggested.

Key words: *urban life comfort, towns and mid-sized cities, model development, weight coefficients*

1. INTRODUCTION

When discussing sustainable development, either with respect to a single country or the whole planet, we could not ignore the main human environment, namely the cities. During the development of our civilization, settlements, then towns and cities, played an important role, being the cultural, craft, and trade centres. However, only since the middle of the 20th century, have urbanization rates so increased that Childe (1950) referred to "the urban revolution". According to the UN, the level of world urbanization is currently at 54% (United Nations 2014), and the area coverage of urban territories over the world is 1% (Baloyan & Gitarsky 2014). All these facts indicate that urban territories have become the main living environment for human civilization, and today one of the most important tasks we face is how to make this environment – the urban environment – comfortable for human living.

In Russia, the country's urban population amounts to nearly 74% (Unified Interdepartmental Statistical Information System 2012) with more than 1100 urban settlements in its territory (Federal State Statistics Service 2010) and most of these (85%) are towns and mid-sized cities (Solntseva 2013). Nevertheless, according to Federal State Statistics Service (2009) 65% of the population live in big cities with over 100 thousand citizens. Such variable density is one of the key reasons for different problems in Russian cities. For big cities, these problems are overpopulation, transport and infrastructure issues, and environmental pollution, and as a result, high rates of different diseases and pathologies. In mid-sized cities and especially in small towns, the situation is no better. They also have their own set of problems such as economic decline, a shortage of working places, infrastructure issues, and outward migration of the work force, etc.

Therefore, the crucial task for today is creating and implementing an estimating model that can:

- Present an integrated vision of cityness and quality of urban life;
- Show the key problems of each city or town;
- Provide recommendations for improving quality of urban territory and citizens' life comfort.

Firstly, the real meaning of comfort of urban territory or urban environment should be addressed. This concept is very wide and contains many different, multifaceted and even opposed factors. Here we will use the definition, given by Aleshina (1999, p. 70), which says that: "the comfort of the urban environment is the whole natural space inside definite administrative borders in the aggregate with built-up environment, filled with subjects and signs, fully satisficing individual and social peoples' needs that finally improves the quality of citizens' lives".

As we can see, the comfort of urban territory, or the urban comfort, is a complex definition, which includes either socio-economical or environmental and health parts alongside the city itself. The most elementary relation between the urban parts is demonstrated in Figure 1.



Figure 1. The scheme of the urban system

However, such a model is correct only at first sight. In fact, all of these indicators not only exist in the city at the same moment, but also they are linked and influence each other with positive and negative feedback. Moreover, each of these indicators is de facto a complex and integral system, containing indicators of lower level. Hence, when looking at this complex urban system, it is necessary to create a model to estimate the urban comfort that should take into account all of these integral parts of the city. In fact, there are number of different estimation models available, but most of these have the same problem, namely, they operate only with one or two indicators of the city. Often, these models use economic or socio-economic indicators, rarely they use environmental and health indicators, and very seldom they operate with geoecological or psychological indicators. According to this, we decided to create a new model, which can unite all of these indicators in one model, as shown in Figure 2.

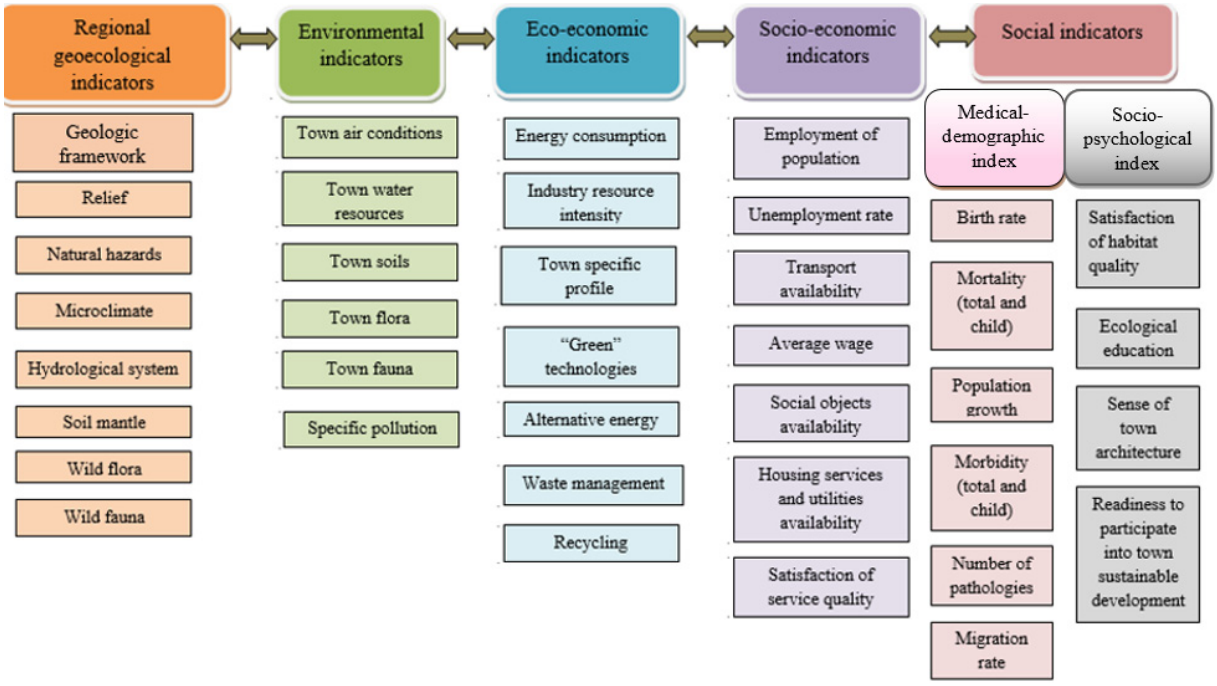


Figure 2. The model of comfort estimation of urban territories

2. BACKGROUND THEORY

2.1. Creating the model

As demonstrated in Figure 2, the new model consists of five blocks (the last one is doubled). Each of these blocks describes one of the important parts of urban territory, and together they can show the city conditions rather well. Every block includes a number of factors, describing their effect, and each of these factors is the integral indicator.

The first block corresponds to the *"Regional geoecological indicators",* as its name implies, this block describes not the city condition, but gives a characteristic of all specific features of that region where the city exist. It allows better knowledge of the city's external natural, ecologic and socio-economic features, which can influence the urban comfort. For example, knowledge about the regional microclimate, such as average temperature and insolation, helps in developing an effective system of power management and energy demand. Knowledge of the regional ground water specifications allows construction (or reconstruction) of an effective town water system to provide citizens with good-qualitative drinking water. Rational usage of the regional natural resources gives the opportunity of planning the strategy for sustainable urban development.

The "Regional geoecological indicators" block (Figure 3) consists of eight factors, and each one of them is also the integral indicator. This block (except for flora and fauna factors) was constructed in terms of the table "The estimation of natural and sanitation conditions in the cities" by "Construction standards and regulations and experts' estimations" suggested by Likhachyova and Timofeev in 2004 and cited by Evseeva and Osintseva (2013) in their "Ecological geomorphology" textbook.

In this table, every factor is rated from zero to three, where zero is the most negative natural phenomenon, and three is the most positive one.

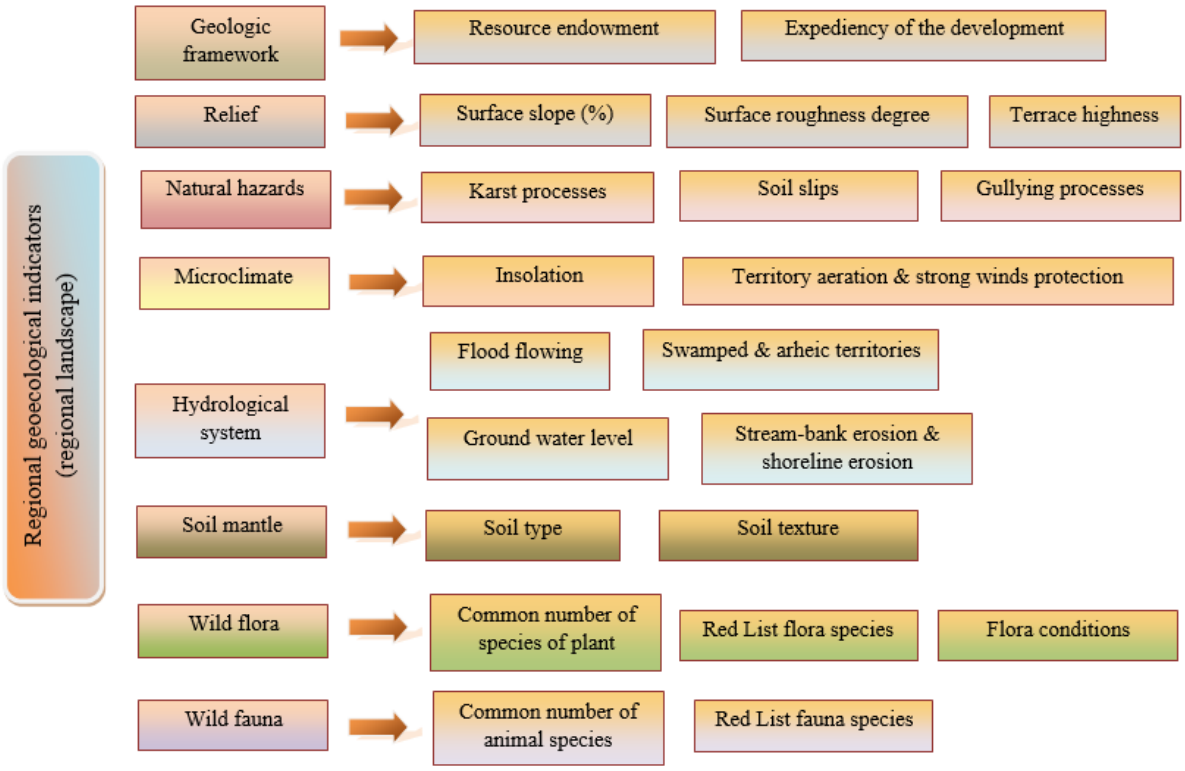


Figure 3. The scheme of the "Regional geoecological indicators" block

The second block, as demonstrated in Figure 4, is the *"Environmental indicators"* block. This block describes the environmental conditions inside the city. Its main key factors are the air, water and soil pollution, as well as specific kinds of pollution, like noise and light pollution, heat pollution (urban heat island) and nuclear pollution. In this block we also estimate quantity and quality of the municipal parks, urban flora conditions and urban animal problems (mainly the problem of homeless animals and the quantity of working shelters both municipal and private).

Among all four factors of the *"Urban air conditions"* indicator, the two most important are the "Total air pollution index", which describes the level of air pollution, and the "Air self-cleaning index" which shows the ability of the atmosphere to self-clean. These two factors determine the quality of urban air. The next two factors mostly describe the main sources of air pollution, including stationary sources such as factories, and automotive sources such as transport.

The "Total air pollution index" (RD 52.04.186-89, 1991) can be obtained from the sum of five or more air pollutants (mainly: benzapyrene, formaldehyde, phenols, ammonia, nitrogen dioxide, carbon dioxide, carbon bisulphide, etc.).

The air pollution index for *one pollutant* is given by the following equation (Formula 1):

$$I_i = (q_{av.i}/MPC_{d.a.i})*K_i, \text{ where}$$

I_i is the air pollution index for the i^{th} substance;

$q_{av.i}$ is the month- or year-average concentration of the i^{th} substance;

$MPC_{d.a.i.}$ is the daily average maximum permissible concentration of the i^{th} substance;

K_i is the toxic rate coefficient comparatives with a substance of 3^{rd} hazard category (1.7 for the 1^{st} substance hazard category; 1.3 for the 2^{nd} substance hazard category; 1.0 for the 3^{rd} substance hazard category; and 0.9 for the 4^{th} substance hazard category).

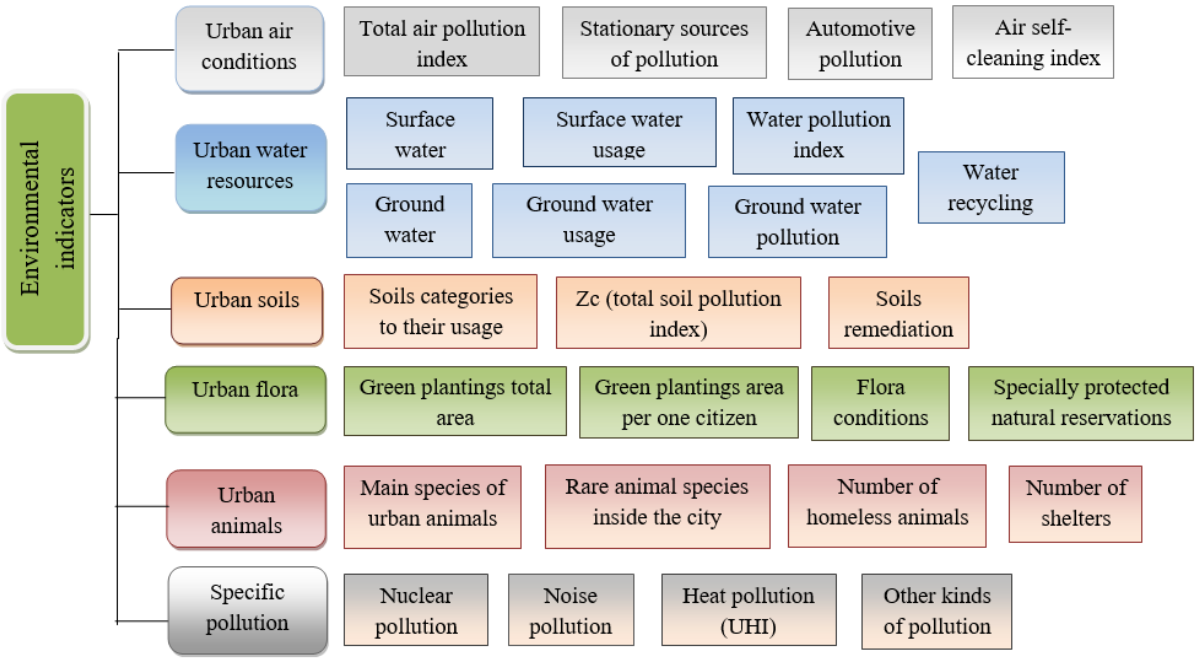


Figure 4. The scheme of the "Environmental indicators" block

Hence, the "Total air pollution index" (RD 52.04.186-89, 1991) is given by the following equation (2)

$$TIi = \sum_{i=1}^{n} Ii, \text{ where}$$

TIi is the total index of air pollution;

Ii is the air pollution index for the i^{th} substance.

The "Air self-cleaning index" is the reciprocal of the impurities accumulation and is given by the following equation (3):

$$Isc = 1/Ai, \text{ where}$$

Isc is the air self-cleaning index;

Ai is the impurities accumulation.

The impurities accumulation (Ai) (Selegey 1989) can be calculated as a relation between accumulating and dispersing conditions using the following equation (4):

$$Ai = \frac{(Fww+Ffog)}{(Fsw+Ffall)}, \text{ where}$$

Fww is the frequency of weak winds;

Ffog is the frequency of fogs;

Fsw is the frequency of strong winds;

Ffall is the frequency of falls.

According to Equation (4), the estimation of meteorological conditions will have rates as follows:

Ai < 0.8 – adverse conditions for dispersing pollution;

0.8 < Ai < 1.2 – bounded favourable conditions for dispersing pollution;

Ai > 1.2 – favourable conditions for dispersing pollution and atmospheric self-cleaning.

The last two factors are also correlated with the first one. According to Perevedentsev and Khabutdinov (2012) "Total air pollution index" has a 77% dependency on another three factors. Therefore, knowing the main sources of pollution and the index of atmosphere self-cleaning, we can correctly calculate the "total air pollution index" and determine air conditions inside the city.

The next main indicator inside this block is the *"Urban water resources"*, which influences not only the urban environment, but also the sanitary and hygienic conditions of the urban comfort. Urban water resources are characterized by two key parts: the surface water resources and the underground water. In most urban territories, the first of these is used mainly for recreation or for engineering purposes and the second source is used for drinking and domestic water.

For the surface water conditions, the most important factor is the *"Water pollution index*" (RD 52.24.643-2002., 2004), which indicates the level of water pollution inside the city. This index is calculated by following a series of steps. Firstly, we should indicate the frequency of the water body pollution by 15 or more pollutants. Then we calculate the rate of MPC expansion (only for pollutants whose actual concentration is higher than the MPC level) using the following equation (5):

$$E_{MPC} = \sum \frac{Ci/MPCi}{Nex}, \text{ where}$$

E_{MPC} is the MPC expansion rate;

Ci is the actual concentration of the i^{th} substance;

MPCi is the MPC level of the i^{th} substance;

Nex is the number of substances whose concentration exceeds the MPC level.

Using the method (RD 52.24.643-2002., 2004) we calculate individual rating points of the pollution frequency (Sa_i) and the pollution exceedance (Sb_i), and then we calculate a total rating point (St_i) for each i^{th} substance, using the following equation (6):

$$St_i = Sa_i * Sb_i, \text{ where}$$

St_i is the total rating point for the i^{th} substance.

Finally, the "Water pollution index" is calculated using the following equation (7):

$$Iw = \frac{\sum Sti}{N}, \text{ where}$$

Iw is the water pollution index;

$\sum St_i$ is the sum of all total rating points for all substances;

N is the number of substances.

According to the "Water pollution index", surface water separates into five classes, where the 1^{st} class is the cleanest water, and the 5^{th} class is the most polluted water.

Ground water conditions mainly depend on water quality (water pollution) and water supply. In this case it is also important to account for water loses during consumption and the possibility of water recycling.

The next important part of this block is the *"Urban soils"*. It is well-known that soils take part in gaseous exchange, elements and water cycles and also play a role in accumulating pollutants. In the latter case, soil pollution can influence citizens' health. For example, our earlier research (Riabova 2014), demonstrated a correlation between soil pollution with heavy metals and respiratory and musculoskeletal system diseases. For this reason, the "Soil pollution index" is one of the most important key factors inside the "Urban soils" indicator.

The "Soil pollution index" is a total sum of all over-MPC concentrations of pollutants, accumulated by soils (Federal Hygiene and Epidemiology Centre 2005), and is obtained using the following equation (8):

$$Zc = \sum Kci - (N - 1), \text{ where}$$

Zc is the total "Soil pollution index";

Kci is the coefficient of concentration of the i^{th} substance in the soil and equals the ratio of actual and background concentrations of the i^{th} substance, given by (9):

$$Kci = \frac{Cfi}{Cbi}, \text{ where}$$

Cfi is the actual concentration of the i^{th} substance;

Cbi is the background concentration of the i^{th} substance;

N is the number of pollutants, for which Kci > 1.

The next important part of the "Urban soils" indicator is the ranking of the urban soils by different categories according to their condition and location. For example, the most common soils inside the city are "urbanozems" – the soils without any separated horizons to the depth of 0.5 m. Another spreading kind of urban soil is industrial soil. Industrial soils are often the most polluted and anthropogenically changed. The next type is the soil of urban green areas, including parks, urban forests, etc. This kind of soil is less anthropogenically changed. Soils of old and green burial places, so-called "necrozems", often have the same quality as previous ones. We can also consider soils of commuter areas or under social buildings, like schools and kindergartens. In such places, local urbanozems or fill-up grounds should be clean and safe for people.

In such a way, using the "Soil pollution index", we can map regions of least and most polluted soils and then give recommendations as to their remediation.

The next important parts of the "Environmental indicators" block are the *urban flora and fauna*. In this article, we will consider these together. The "Urban flora" index includes such factors as total green planting area inside the city and green area per capita, as well as plant conditions. These three factors allow estimating, at first, the sufficiency of urban green territories for the comfort of citizens' life, and, secondly, the level of anthropogenic pressure on the urban flora. According to Gorokhov (1991, pp. 135-136), green areas per one citizen range from 2 m^2 for Far North regions to 20 m^2 for the resort cities. Maximal green area is nearly 70 m^2 per one citizen. It should be added that these norms do not take into account urban forests, which are estimated separately with their own norms: 50-70 m^2 per citizen for towns, 70-100 m^2 per citizen for mid-sized cities and 150-200 m^2 per citizen for big cities.

Areas such as "special protected natural reservations" are not used for all urban territories, but only in such cities where these natural reservations exist. This factor strongly increases the quality of the urban territory, but it also demands additional actions for protection and sustainable usage of such territories.

The key factor in the "urban fauna" index is the prevalence of homeless animals. It is notorious that bands of homeless animals, especially dogs, seriously decrease comfort conditions in the city, as well as having an influence on some wild species of animals, including rare ones. For highlighting this problem, we enrolled two factors in our model, namely the "number of homeless animals" and the "number of shelters". The real number of homeless animals per year is counted by the following equation (10):

$$Ni = (Ni\text{-}1 - Ni_{taken}) \times (1 + [Qp \times Qn\text{-}s \times Qsex]), \text{ where}$$

Ni is the real number of homeless animals in the year;

Ni-1 is the number of animal units (both male and female) taken out of the population at the end of last year;

Ni_{taken} is the number of animal units (both male and female) taken out the population at the beginning of this year;

Qp is the average quantity of puppies from one female unit per year;

Qn-s is the part of non-sterilized female units from total female units in the population;

Qsex is the sex ratio inside the population.

Therefore, we can also calculate the population growth (Ilinskiy 2011) to forecast the number of homeless animals under the same conditions in the next year (11):

$$Ni\,\Delta = Ni - Ni\text{-}1, \text{ where}$$

Ni is the number of animals in the population at the end of the current i^{th} year;

Ni-1 is the number of animals in the population at the end of the last the i^{th} year.

Another important factor in the "Urban fauna" index is the urban biodiversity, which includes both main urban species of animals and rare species, living full or part-time inside the city's territory. These factors are important for saving urban biodiversity as well as for the citizens' environmental education. We can count the urban biodiversity using a variety of methods, for example, by the diversity index of Shannon or by the diversity index of Simpson (Zalepukhin 2003).

The last index of this block is the *"Specific pollution"*. Here we estimate some unusual kinds of pollution, like nuclear pollution, urban heat island (UHI), light and noise pollution. Nuclear pollution is appraised for new buildings in keeping with national building standards. Unfortunately, the situation with the other specific kinds of pollution is worse. While some standards exist, regulating noise levels during the daytime and night-time, only a few studies estimating UHI in big cities, like Moscow, have been conducted. As for the "other kinds of pollution" like light pollution, vibration pollution and electromagnetic pollution, their influence on urban comfort should also be estimated.

The third block to be considered is the *"Ecologic-economic indicators"*. This block (see Figure 5) demonstrates on the one hand the economic part of the city, including energy demand and resource consumption; and on the other hand it takes into account both ecological and economic factors like waste management, including recycling or alternative energy sources, or the introduction of modern environmental-friendly ("green") technologies.

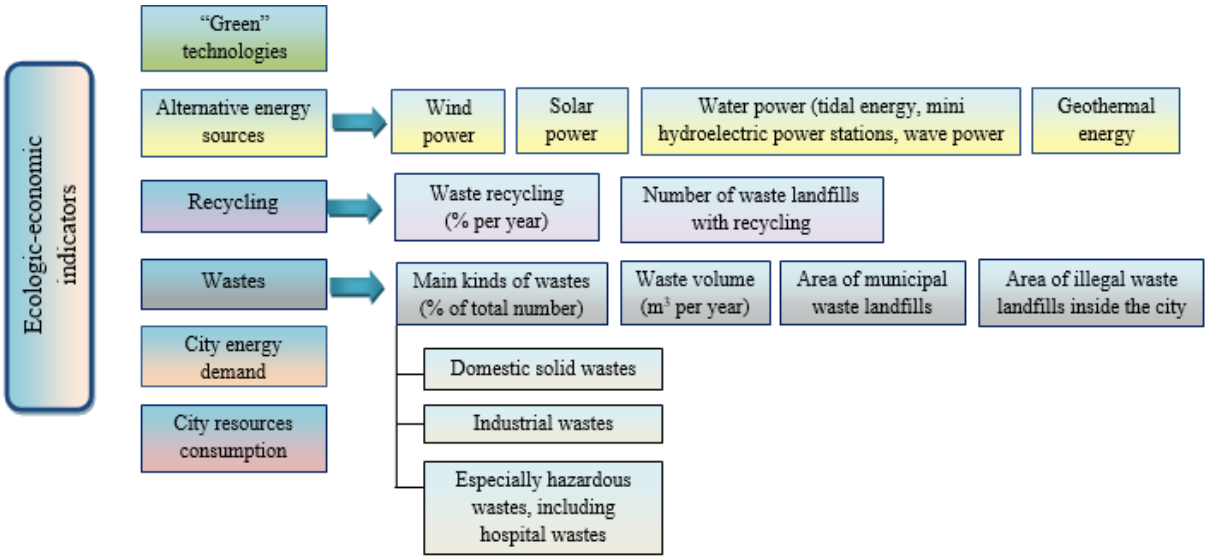


Figure 5. Scheme of the "Ecologic-economic indicators" block

Indexes such as the energy demand and the resource consumption demonstrate the city's consumption of energy or different resources for its business activity and development. Here we should note that "resource consumption" is a wider concept, which can also include energy consumption. However, for rational city management it is better to separate these two indexes for viewing and ruling both resources (natural, technical and human) and energy consumption.

The *"City energy demand"* index shows the amount of energy resource consumed by the city for its activity, and it is calculated as the ratio of the total quantity of the energy resource (tons of oil equivalent) to the gross municipal product (GMP). Equation (12) presents this ratio:

$$Ed = \frac{Qe}{GMP}, \text{ where}$$

Ed is energy demand by the city;

Qe is the total quantity of the energy resources (TOE);

GMP is the gross municipal product.

Gross municipal product is comprised of parts such as own-produced goods and services; turnover of retailing; public catering and volume of commercial and social services; and agricultural production of local companies (Beliakova & Frolova 2011). According to this, GMP is obtained using the following equation (13):

$$GMP = GS + Rt + Ct + Vc + Vs + Ap, \text{ where}$$

GS is the municipal own-produced goods and services;

Rt is the retailing turnover;

Ct is the catering turnover;

Vc is the volume of commercial services;

Vs is the volume of social services;

Ap is the municipal agricultural production.

Therefore, having information about the total amount of energy resource which the city uses, and finding the GMP, we can calculate the "City energy demand" index. It is clear that the higher this index, the less effectively the city uses its resources. Additionally, knowing the key parts of the GMP, we can find where energy resources are used least effectively and develop methods for more sustainable energy consumption.

The *"City resources consumption"* index is counted in the same way as the "City energy demand" index. It is the ratio (equation 14) between all the resources which the city needs and the GMP.

$$Rc = \frac{Cres}{GMP}, \text{ where}$$

Rc is the city resources consumption;

Cres is the total number of all kinds of city resources.

In the case of the energy demand we can calculate where resources are used in the least effective ways, and introduce some methods of more sustainable management, like different kinds of resource-saving technologies, waste and water recycling, etc.

Such indexes as the *"Alternative energy sources"*, the *"Green technologies"* and *"Recycling"* are not used by all types of cities, but only for some of them. However, if municipal authorities decide to introduce any of those technologies, they would consider them during the next comfort estimation of the city.

The last, and very important, index of this block is the *"Waste"* index. It includes all municipal wastes, like domestic solid wastes, industrial wastes and even hazardous wastes, for example from municipal hospitals or some kinds of hazardous backbone enterprises. Although nationwide industrial wastes are prevalent, for urban territories, the most serious problem is domestic wastes, because of their unsustainable management. In fact, no useful separating system is available, even in big and modern cities, and the only way of waste utilization is waste burial at special landfills, which results in many environmental, economic and social problems.

The "Waste" index contains factors such as the main waste types, depending on city specialization; the volume of each kind of waste per year; municipal landfill area and the area of illegal landfills. Consequently, this index allows the key problems of this sector to be highlighted and addressed.

The next block is the *"Socio-economic indicators"* which is one of the most important parts of the comfort estimation because it includes such important indexes as: employment, average wage, transport and social objects availability and the quality of social services. This is shown at Figure 6.

The first two important indexes are the *employment of citizens* and the *unemployment rate*. They demonstrate how easy it is for a person to find work in the city. The level of employment is calculated by the following equation (15) as the ratio of employed people at working age to all people at the inspected age in the defined territory, as described by the following equation:

$$El = \frac{Pw}{Pall}, \text{ where}$$

El is the employment level;

Pw is the number of working people;

Pall is the number of all people at the working age.

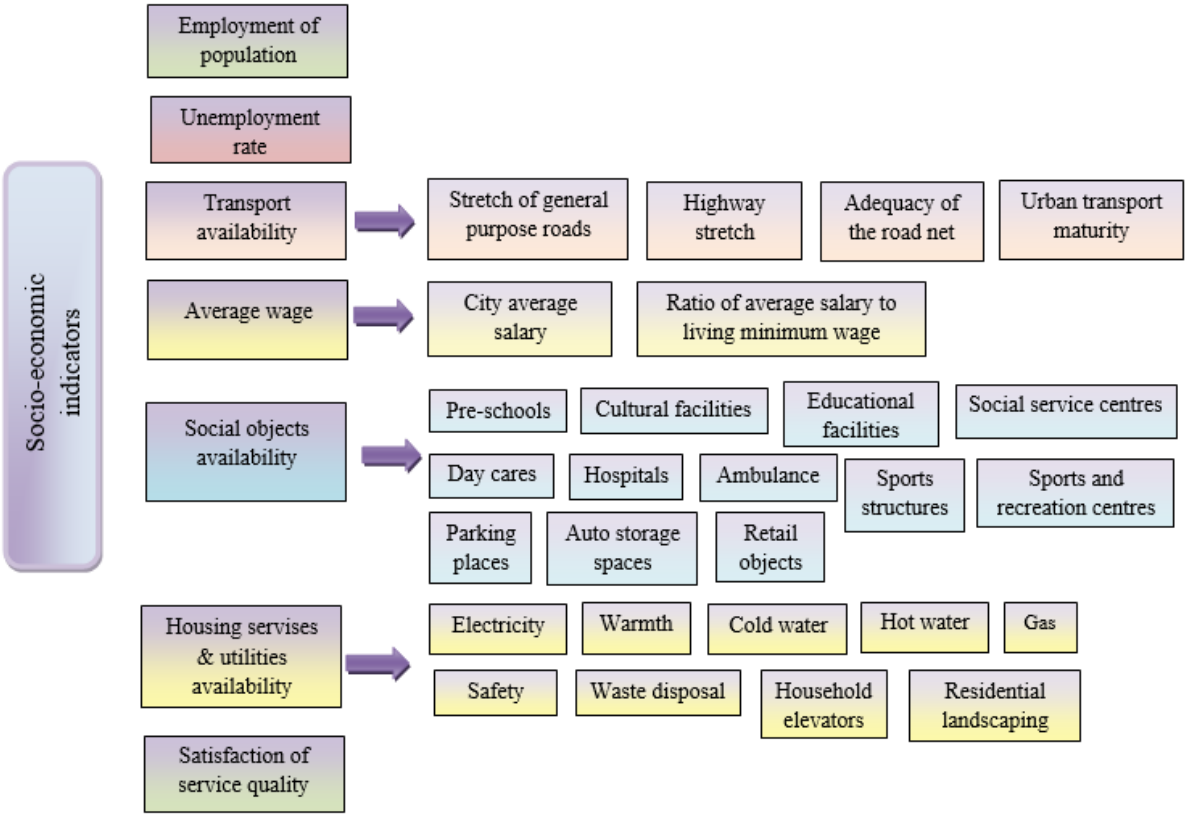


Figure 6. Scheme of the "Socio-economic indicators" block

The *"Unemployment rate"* is calculated by the following equation (16) as the ratio of the unemployment totals (Ut) to labor power (Lp) multiplied by 100%:

$$Ur = \frac{Ut}{Lp} * 100\%, \text{ where}$$

Ur is the unemployment rate;

After obtaining the employment and unemployment rates of citizens, it is important to consider the payment level in the city. This index shows the average salary per year in the city and its sufficiency for comfort living. According to this, the *"Average wage"* index consists of two key factors – the "average salary" and the "ratio of average salary to the living minimum wage". The "Average salary" is the statistical data, which city companies reveal in year-end reports. With this data it is possible to calculate both the total city average salary and the average salary for each of the city's business areas. The "Living minimum wage" is also statistical data, which is individual to each region and officially published by quarter.

Having all these data it is possible to calculate the salary which is sufficient for different citizen categories for living, or for comfort living. It also demonstrates the city's attraction for native and potential citizens. It is well-known that big cities with different kinds of jobs and high salaries are much more attractive for migrants and native citizens, than towns with a shortage of jobs and small salaries.

With reference to comfort living, we understand that the availability of work and high salaries are not enough to make a city or a town comfortable. Citizens also need transport, different social objects and, of course, modern conveniences for their homes. Hence, we also include such indexes into our model. The next two indexes we will view together are the *transport* and *social objects availability*. These indexes describe the number of different kinds of social infrastructure that make human life more

comfortable. According to the "Social objects availability", this index includes the sufficiency of factors such as:

- educational facilities: pre-schools and kindergartens, educational objects (schools, colleges, vocational and technical institutions and universities);
- cultural facilities: cultural objects, like art and music schools, culture and art centres etc.;
- social help availability: for example, social service centres for different groups of citizens, including invalids, retired people, homeless people, teenagers with deprived backgrounds and others;
- medicine and health objects: day cares, hospitals and ambulances availability;
- sport availability: like sport centres and complexes, swimming pools and different kinds of sport structures, both open-air and indoors;
- car owner support: including parking places (both free and paid) and special places for auto storage;
- trade support: with different retail objects, supermarkets and weekend markets.

This index is calculated from a sum of all factors as a percentage to a regional normative. This normative of social objects availability was taken from the urban planning standards of the Moscow Region Government (2015).

To calculate indicators such as the "Transport availability" we use the integral index of transport availability by Engel – Yuzuru Kato formula (17):

$$Ta = \frac{Le}{\sqrt{SH^2}}, \text{ where}$$

Ta is the transport availability;

Le is the length of the used track of the transport network in km;

S is the area of the territory, in hundreds km^2;

H is the population, in tens of thousands people.

Additionally, we also take into account factors such as the total stretch of roads and the highway stretch, as well as the adequacy of the road network, and of course, important factors such as the urban transport maturity. In the last case, we count the number of transport units, the transport frequency, and the capacity, etc. The main way of calculating these factors is by using data of passenger traffic flow and any kind of transport used in passenger transportation.

The last two indexes we consider are the *"Housing services"* and the *"Satisfaction of service quality"*. Here we set the normative of housing services equal to 100%, and then count the real availability as a percentage of 100 by the following equation (18), suggested by Piliavsky and Rozhkov (2007):

$$Sa = \sum_{i=1}^{n} pi * Sfi, \text{ where}$$

Sa is the housing services availability;

Sfi is the factual services availability;

pi is the weight coefficients of the ith service, (Piliavsky & Rozhkov (2007));

n is the number of services, (n = 9).

The *"Satisfaction of service quality"* index, obtained by opinion poll, is calculated as a percentage, where 100% is maximal satisfaction, and 0% is minimal satisfaction, with the step size of 25%:

0% is totally unsatisfied:

25% is mainly unsatisfied;

50% is middle rate of satisfaction;

75% is mainly satisfied;

100% is totally satisfied.

The last block is the *"Social indicators"*, which includes two big parts (or sub-blocks): *"Medical-demographic indicator"* and *"Socio-psychological indicator"*, each of them has its own kit of indexes (see Figure 2).

The first sub-block – the *"Medical-demographic index"* – characterizes mainly the physical health of citizens and the dynamic of its population. Here we use factors such as birth rate, total and child mortality, population growth, total and child morbidity, number of pathologies and migration rate. All these indexes give us the important information about health conditions of this territory as well as how suitable the city is for comfort and healthy living. If the city has good health conditions, we will see a high birth rate, low mortality and morbidity, a small number of pathologies as well as a high rate of immigration in the city. In the opposite case, there will be high morbidity and mortality, low birth rate with a high quantity of different pathologies and high emigration rate, where people try to escape this city to another which is more suitable for comfortable living.

The final part of our model is the *"Socio-psychological index"* sub-block, which describes the perception of the urban territory by its own citizens. Here we operate psychological factors such as the sense of urban architecture, satisfaction of urban quality, and also such important characteristics like ecological education of citizens and their ecological activity, which means understanding the importance of eco-friendly city development and readiness to take part in it, using their own ecological knowledge. The factor of *"Ecological education"* is counted (in percent) as the number of educational organizations which fulfil ecological educational programs to all educational organizations in the city at all levels (kindergartens, schools, colleges and universities). For adults, we inserted the *"Ecological activity"* factor, demonstrating the level of public involvement in the solutions to the city's environmental problems. This factor is counted as a part of ecological questions among all the questions, sending to the government at the same period.

3. PRACTICAL IMPLEMENTATION

3.1. Calculating weight coefficients

It is well-known that only considering comfort factors is not sufficient to fully estimate the urban territory. We also should know the importance of each factor to the citizens. According to this, our second step was calculating the weight coefficients for all existing factors. Weight coefficients show the contribution of each factor to the eventual result, presented as fractions or percent (Korobov 2013).

For our estimation model, we chose the Analytic Hierarchy Process (AHP), based on pair-wise comparison of all elements with the special estimation scale, created by Saaty (1980). Firstly, we compared all comfort factors, and then built a square matrix with a monic diagonal, since a comparison factor with itself results in unity. The square matrix was created in the *Microsoft Excel* program, and weight coefficients were calculated in the *MathCad* program. After the calculations, we used a normalization procedure with a scale [0;1]. Next, using equation (19), we calculated the weight coefficients of each block of the model.

$$Bw = \sqrt{\sum_{i=0}^{last\ (W)} (wi)^2}\ , \text{where}$$

Bw is the weight coefficient of each block;

i = 0 is the weight of the first factor in each block;

last (W) is the weight of the last factor in each block.

The results of our calculations are shown in Table 1.

Table 1. Weight coefficients of each block of the comfort model

Block of the model	Weight coefficient amount
"Regional geoecological indicators" block	w = 0.216
"Environmental indicators" block	w = 0.428
"Ecologic-economic indicators" block	w = 0.369
"Socio-economic indicators" block	w = 0.588
"Social indicators" block	w = 0.527*

* Where the "Medical-demographic index" weights (w = 0.507) and the "Socio-psychological index" weights (w = 0.143).

As can be seen from Table 1, the most important factors for the citizens are economical and social factors, like salary, social objects, healthcare, and transport, etc. Environmental quality of the urban territory is also important, because its block ranks in third place in the Table. This means that many citizens understand the influence of ecological factors on their life comfort and want to have good environmental conditions in the city. On the other hand, the weight coefficient of the "Socio-psychological index" demonstrates that only a small number of citizens are ecologically educated and want to take active involvement in changing urban conditions. Additionally, factors of the "Ecologic-economic indicators" block, including "green" technologies, or alternative energy, as well as sustainable waste management, are not popular enough or wide-spread within Russian cities. The median weight coefficient of this block demonstrates that not all citizens understand the importance of the factors of this block, or maybe they do not believe in the reality of their implementation. "Regional geoecological indicators" block has the lowest rate, because of the usual citizens hardly ever connect regional geoecological factors with the city comfort, so this field remains within the field of the experts.

3.2. Integral indicator of urban comfort

The last part of our work on this model was the calculation of the integral indicator of urban comfort. This integral indicator can be calculated in two ways. The first way (Equation 20) is as a sum of all factors, each multiplied by its own weight coefficient:

$$I_{comf} = \sum_{i=1}^{n} Fi * Wi, \text{ where}$$

Icomf is the integral indicator of urban comfort;

Fi is the amount of the i^{th} factor in the model;

Wi is the weight coefficient of the i^{th} factor;

n = 58 is the total number of all factors in the model.

The second approach is shown by Equation (21), where we sum the amount of each block (the sum of its inside factors, normalizing in a scale [0;1]) multiplied by individual weight coefficients of the block:

$$Icomf = RGi*W_{RG} + Eni*W_{En} + EEi*W_{EE} + SEi*W_{SE} + Soi*W_{So}, \text{ where}$$

Icom is the integral indicator of urban comfort;

RGi is the total amount of the "Regional geoecological indicator";

W_{RG} is the weight coefficient of the "Regional geoecological indicator";

Eni is the total amount of the "Environmental indicator";

W_{En} is the weight coefficient of the "Environmental indicator";

EEi is the total amount of the "Ecological-economic indicator";

W_{EE} is the weight coefficient of the "Ecological-economic indicator";

SEi is the total amount of the "Socio-economic indicator";

W_{SE} is the weight coefficient of the "Socio-economic indicator";

Soi is the total amount of the "Social indicator";

W_{So} is the weight coefficient of the "Social indicator".

After the above calculations, we receive the final value of the integral indicator of urban comfort which ranges within the scale [0;1], where:

0 is the least comfortable urban territory;

1 is the most comfortable urban territory.

In this way, our model demonstrates a real situation in the city and estimates the comfort level of the urban territory. This model will be useful for municipal governments wishing to improve city or town living conditions, as well as urbanists, estimating and comparing urban territories in any region.

4. CONCLUSIONS

To summarize this article we can give the following conclusions:

- It was demonstrated that the city is a complex system, demanding an integral estimation of all its parts.
- The integral model of estimation of comfort level within urban territories was suggested, including all key blocks of this model.
- The main factors of the integral indicator of each block were demonstrated with the calculations.
- The formula of the integral indicator of urban comfort level was suggested.
- This model will be used in the estimation of the real situation in the city, including all its key parts: economic, social, environmental, as well as health conditions and regional specifications.

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