

Normalization of green space as a component of ecological stability of a town

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Citation: Yukhnovskiy V., Zibtseva O. (2019): Normalization of green space as a component of ecological stability of a town. *J. For. Sci.*, 65: 428–437.

Abstract: The article analyzes and compares the existing quantitative norms of green space in different cities of Ukraine and other countries. It is substantiated that the index of provision of green space per capita is significantly more informative under the condition of equal density of the urban population and must necessarily be supplemented by the indicator – the level of greening. The comparison of data relative to Ukrainian cities is complicated by the categorization of green plantings adopted in the country, rather than the green spaces, as practiced in most countries. Despite the relatively low density of settlements, the provision of green space per capita in Ukrainian cities often does not meet the requirements of EU and UN. The primary use of the recreational function of green plantations in modern conditions is appropriate to reorient to the ecological function of green spaces and sustainable urban development. We consider necessity to introduce a minimal environmental norm for the total number of green spaces within the city territory regardless of the form of ownership.

Keywords: provision; green plantations; ecological functions; level of planting; sustainable development

One of the important mechanisms of territorial planning of land use is the creation of a coherent system of national standards, norms and rules for sustainable land use. As a function of land management and land use valuation is a limitation of the negative impact on land resources and the environment through the establishment of mandatory standards for such impact.

In order to achieve sustainability of cities, the demand for land resources should be balanced with the support of the minimum aesthetic component required for the formation of environmental services (DHANAPAL, CHAUDHRY 2012). It is necessary to integrate green space planning into urban develop-

ment on the basis of international guidelines such as per capita level, level of landscaping, etc.

LI and PUSSELLA (2017) estimate that green space per capita is a quantitative measurement used to assess the environmental sustainability of the city. However, the current high level of urbanization and its impact reduce green spaces gradually and unpredictably.

There are not many national surveys on urban green space per capita. According to WUSTEMANN et al. (2017) revealed significant differences in the green space provided by the inhabitants of the German cities. The inequality in the provision of green space ranges from 2.5 m² per capita in the city of Schwerin to 36.3 m² in the city of Bergisch-Gladbach.

<https://doi.org/10.17221/85/2019-JFS>

According to Russo et al. (2018) it requires at least 9 m² of available greenery per capita with an ideal value of 50 m² in a modern compact city.

Current studies of Chinese cities (LI et al. 2018) have shown the impact on the number of green areas per capita of the current stage of economic development, namely: the positive impact of GDP per capita and negative – the level of urbanization, secondary industry, population density. A well-developed urban green space system is an integral part of the urbanization process, and high coverage of the green space indicates that there are large potential for further urban transformation (HUANG et al. 2018). However, cities face spatial and financial constraints in creating urban green spaces, and as a result, environmental plans are often postponed indefinitely (KIM et al. 2018). Urbanization, lack of proactive planning and uneven distribution of resources can lead to socio-economic inequalities between cities, to environmental injustice and social unrest (ARSHAD et al. 2018).

The research is carried out within the framework of developing the conceptual foundations of the system of green plantations in small cities of Kyiv region in the context of ecologically balanced development.

The purpose of this study is to obtain a clear picture of the standardization and provision of green space (green plants) per capita in Ukraine in comparison with other cities in the world and to clarify the informatively and objectivity of using this indicator for the assessment of urban greening systems.

MATERIAL AND METHODS

The research is based on a systematic approach, critical and comparative analysis using a wide range of literary sources and statistical information. For research purposes, available literature was obtained using both the Google search engine and the Web of Science Core Collection, using the key combination “green space per capita”. In addition, the choice of literature was adjusted in order to cover more space (more countries) and a comparable time factor.

We take into account that the method of comparison with developed countries has some risks regarding the normalization of recreational and sports spaces: norms have different properties depending on the lifestyle of the population, the density of settlements, occupation, lifestyle and the formation of the urban environment (COŞKUN 2004).

The urban greening system in Ukraine is usually planned using recreational standards (YUKHNOVSKYI, ZIBTSEVA 2019). At present, neither the concept of green space nor green infrastructure is used in Ukraine, and as in the former Soviet Union, the concept of “green stands” has traditionally been used (YUKHNOVSKYI, ZIBTSEVA 2018a). Therefore, comparing data on Ukrainian cities is complicated by the accepted categorization of green stands rather than green spaces, and the fact that Ukrainian standards explicitly only regulate green stands for public use. There is an urgent need to provide clear definition and development of standards for green spaces in accordance with the contemporary needs of society, to improve the existing national classification of green stands (YUKHNOVSKYI, ZIBTSEVA 2018b).

For indicators on urban green spaces in different regions of Ukraine, the materials of the public forms of state statistical reporting “Green economy” for 2012–2014 were used as well as statistical data on the population in terms of administrative areas. The provision for green plantations of the inhabitants of the regions was made according to generally accepted methods (ZIBTSEVA 2017).

RESULTS

Green space planning was launched in the United Kingdom at the end of the seventeenth century and since then has been an integral part of city planning policy (MARYANTI et al. 2016). The presence of urban green space has become an important aspect of planning and research as an environment for the well-being of city dwellers (KABISCH et al. 2016). At present, municipalities in the European Union use different indicators in this area. Some cities provide the limit values of urban green space per capita; some have recommendations for a minimum distance to the green space, and some do not have recommendations at all. Universal gradients for assessing the urban environment are difficult to find because the shape and size of the city as well as the available information are very different (ANDERSSON et al. 2009). A multidimensional gradient is needed to not just compare cities, but also to determine how urbanization affects ecology in different parts of cities. Urban Green Infrastructure is a key element in improving the quality of life and sustainable urban development, and urban green

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Table 1. Norms of green space in European cities (COŞKUN 2004)

City	Country	Norm (m ² per capita)		
		urban	including	suburbany
London	England	70	20 – neighbouring park, 10 – sports ground, 40 – urban park	8
Stockholm	Sweden	39.4	5.6 – neighbouring park and quarter park, 10 – sports ground, 23.8 – city park	48.1
Rome	Italy	27.8	3.2 – playground, 5.5 – adjacent park, 11.6 – city park	18
Amsterdam	Netherlands	15.5	9 – city park, 6.5 – sports ground	30
Hannover	Germany	5	1 – playground, 1 – sports ground, 3 – free playground	–

space per capita is used as a quantitative indicator of its assessment (BADIU et al. 2016).

Green space standards are determined by such criteria as geographical location, climatic conditions, city size, density and population needs, etc. (COŞKUN 2004). Usually, with the increase in population, the norm decreases.

By COŞKUN (2004) definition the hierarchy and green space valuation system in the United States is the best model of rules that are periodically reviewed. The method of valuation of green space in the United States is due to the urban landscape and culture of lifestyle, different from the European one. In the modern regulatory framework, the city system is considered from the standpoint of integrity, and the norms must ensure the fulfilment of five goals: rearrangement of open spaces; rehabilitation of the urban environment; protection of natural sources; protection of historical and geographical values; Preventing Private Ownership. Currently, the system of norms of green space is being applied in the USA, which decreases with increasing population, that is, acts from the local to the regional and national levels. At the city level, with a population density of 250 people per hectare, the norm of the green space is 40 m² per capita. The norm of green space for cities with a population of more

than 0.5 and more than 1 million habitants is 20 and 13 m² per capita correspondingly.

Quantitative green space standards are widespread in the UK and in Europe, but are usually applied locally, not at the national level, because of local development plans. The integral norm of the green space system in Europe is differed the amount of norms of the United States Green Space System (COŞKUN 2004). Population growth is accompanied by an increase in green space standards. Norms of green space in European cities vary significantly (Table 1). Thus, the lowest green space is noted in Germany (Hanover) and is 5 m² per capita including 1, 1 and 3 m² per capita for playground, sports ground and free playground correspondingly. An integrated system planning of the green space of Rome moves from the neighbourhoods to the regional level. The norm of green space in England is 70 m² per capita of urban greenery including 20, 10 and 40 m² per capita of adjacent park, sports ground and city park respectively.

The list the of the green space norms for some cities and countries in the order of their decrease is given in Table 2 (MARYANTI et al. 2016). The norms are ranging from 48.5 m² per capita in Los Angeles to 5.2 m² per capita in Pakistan, which, of course, are due to their geographical location.

Table 2. The norms of urban green space in some cities and countries (MARYANTI et al. 2016)

City	Country	Population (thousands)	Norms of urban green space (m ² per capita)
Los Angeles	USA	4,000	48.5
Cambridge	England (United Kingdom)	124	46
London	United Kingdom	8,900	40
Washington City	USA	633	38
Kansas	USA	2,912	36.4
Minneapolis	USA	422	20
Bristol	USA	536	10
–	India	–	8
–	Pakistan	–	5.2

<https://doi.org/10.17221/85/2019-JFS>

Table 3. Standards for China's "National Garden Cities" (LIU 2008)

Norms for city-gardens	City Location	Large cities	Medium cities	Small towns
Provision of public green space (m ² per capita)	South	6.5	7	8
	North	6	6.5	7.5

The standards of green space in the UK (London, Edinburgh, Cambridge and Bristol) are different in size per 1000 inhabitants. According to the World Health Organization (WHO), each city is recommended to provide a minimum of 9 m² per capita of accessible, safe and functional urban green space. The ideal size of the WHO's green space is 50 m² per capita (MORAR et al. 2014). The liveliest city is considered to provide the maximum amount of green space for its population. Vienna is the most vibrant city in the world according to a poll conducted in 2016. It has 1.7 million people with 120 m² per capita of urban green space. Singapore, the third-largest city in the world, was able to provide the population with green space of 66 m² per capita.

The standard approach is clear and simple to apply as an instant recommendation. The original idea of standards is used as a benchmark among local authorities. At the same time, most local authorities failed to reach standards due to limited urban space, land scarcity, high levels of consolidation and urbanization. Therefore, the Penangy Town Hall (Malaysia) accepted a standard of only 4 m² per capita (MARYANTI et al. 2016).

The international minimum standards introduced by WHO are 9 m² per capita (KUCHELMEISTER 1998). Provision of green space per capita in the 26 big European cities is about 104 m² including: France – 80 and Netherlands – 228 (KONIJNENDIJK 2003); Australia – 80 (BRACK 2002); USA – 32 and China – from 10.3 to 44.3 (JIM, WENDY 2009); Gon Kong – 3, Singapore – 7.5, Delhi – 21 and Chandigarh – 55 m² per capita.

Green Standards were adopted in Great Britain in 2013. Well-maintained green space was 65 m² per capita and public natural green spaces – 32 m² per capita. The minimum quantitative standards of green space were 20 m² per capita, equipped playgrounds – 0.5 and leased land plot – 3.4 m² per capita. The minimum multifunctional green space for the city was 70, for rural settlements – 20 m² per capita. At the same time, the UK Government believes that open space standards are best defined at the local level. According to the "Six Acre Standard" (NPFA 2005), the minimum standard in Scot-

land is 2.4 ha (6 acres) of free play space per 1,000 inhabitants (24 m² per capita), including 1.6 ha for outdoor sports and 0.8 ha for children's games.

Regional urban plans in Italy set the minimum size of the green space for a living area of 26.5 m² per capita. The standard of green space in Spain is 5 m² per capita. State regulation sets two types of requirements for the number of green areas: for less than 500 residential premises – 18 m² per dwelling or for every 100 m² 500 and more residential premises – 21 m² per dwelling or for every 100 m² per building.

China has clear national and professional standards for planning urban green spaces, including "Normative documents for the planning and establishment of urban greenery" (1993); "Norms for national garden cities" (2000) and others (LIU 2008). Among the other "Normative documents on planning and creating urban landscaping", among other provisions are the provision of public green space until 2010, which is similar to the former Soviet planning of green public utilities: for cities with an area of development up to 75 m² per capita, provision of public green space should not be less than 6 m² per capita; for cities with buildings 75–105 – not less than 7 m² per capita; more than 105 – not less than 8 m² per capita. China's average small-town population is about 31,000. List of the norms of the public green space for the Chinese national garden towns is in Table 3.

As can be seen from Table 3, the norm of green space depends on the latitudinal location of the city (South and North) and its size, determined by the population. That is, we can trace the dynamics of the norm, closer to the norms of the USA than European countries.

State norms of green space per capita in residential areas of Iran make not less than 30–50 m², and according to UN recommendations – from 20 to 25 m² (BEIRANVAND et al. 2013). According to regulations adopted in Turkey, green areas should be 4 m² per capita. Currently, green space is below the regulatory level in cities of Turkey such as Istanbul, Ankara, Izmir, which is 2.1, 2.3 and 2.8 m² per capita respectively (COŞKUN 2004).

The provision of green plantations of such large cities as Osaka, Tokyo, Nagoya, Kobe, New York and London is 2.9, 4.5, 5.3, 13.5, 14.0 and 17.0 m² per capita respectively (YAMAMOTO 2010). The data indicate that the green space is the lowest in Osaka (2.9 m² per capita), in Tokyo it is lower than in New York three times, and compared with London – almost four times, which explains, in turn, high population density in Japanese cities and limited urban areas for expansion.

The analysis of the urban green space dynamics is considered as the first step in its planning (BEIRANVAND et al. 2013). At the same time, the green space per capita is not proportional to the universal standard and may vary over the years with varying intensity.

Compact European cities, which combine small size and high density, are characterized by very low green space per capita. The indicator ranges from 3–4 m² per capita in Cadiz, Almeria (Spain) and Reggio Calabria (Italy) to over 300 m² per capita in Lecce (Belgium), Oulu (Finland) and Valenciennes (France) (Fuller and Gaston 2009). At the same time, according to KOPECKÁ et al. (2017), the green space in Bratislava is 121 m² per capita, 112 in the compact city of Trnava, and 136 m² per capita in Zhilina.

In the cities of India, open spaces with growing urbanization are decreasing (DHANAPAL, CHAUDHRY 2012), but in the cities of Chandigarh and Gandigarh, where urban greenery has been

pre-integrated into the General Plans, green space per capita is much higher compared to traditional green cities such as Bangalore, and is respectively 55 and 160 m². The average for the 21 experimental Asian cities in 2015 was 38.6 m² per capita, in Hanoi 11.2 and the highest in Guangzhou was 166.3 m² per capita (NGUYEN 2018).

Urban green space encompasses mostly recreational space and excludes agricultural land and forests that may be important for recreation in some countries (ELMQVIST et al. 2013). According to him, with increasing population growth, the provision of green space of European cities is increasing. Provision of green space up to 10 m² per capita had a city with a population of up to 200 thousand; 11 to 20 m² per capita – with population 200–400 thousand; 21–30 m² per capita – with a population of 400–600 thousand and over 31 m² per capita – with a population of more than 600 thousand (Fig. 1).

It is noted that the data on the provision of green spaces for people from different sources varies widely: twice or even more (PAFI et al. 2016). Instead, effective urban planning and urban green space management require actual and reliable data (FELTYNOWSKI et al. 2018). At present, national green space systems are based on different definitions, data sources, selection methods, periods and scales, which pose serious challenges for planning, managing and researching green urban infrastructure. Comparison of data from five sources revealed

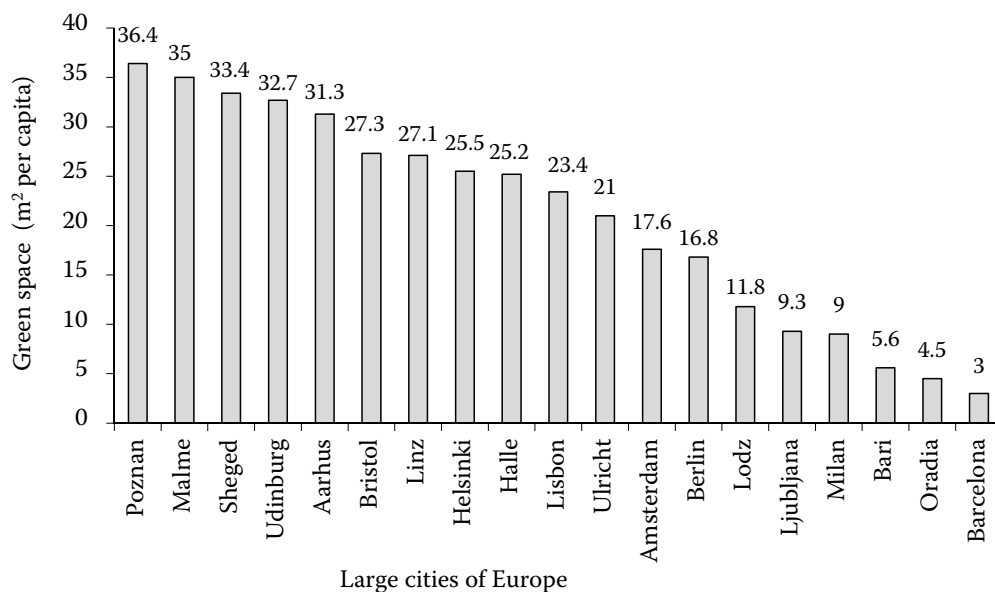


Fig. 1. Provision the green space of European cities (ELMQVIST et al. 2013)

<https://doi.org/10.17221/85/2019-JFS>

Table 4. Indicators of landscaping in other countries of the world

City	Country	Area (km ²)	Population		Capacity (m ² per capita)	Greening rate (%)
			total	density (persons/ha)		
Stockholm	Sweden	216	711.119	33	84.3	27.8*
Berlin	Germany	891	3,471.418	39	27.0	11.0
New York	USA	833	7,322.564	88	23.1	20.3*
Montreal	Canada	177	1,017.665	58	21.6	13.1
Paris	France	105	2,154.678	205	10.1	20.7*

*our data calculation

significant differences in quantity of urban green spaces. Thus, in Lodz, according to state statistics, green spaces make up only 11.8% of the city's territory, while according to the National Land Management Agency – 61.2% (FELTYNOWSKI et al. 2018).

Even in the data provided by us, the indicators of the provision of green space to a number of cities according to the various authors differ significantly even with a slight time period: New York – 14.0 (YAMAMOTO 2010) and 23.1 (COŞKUN 2004); Berlin – 27 (COŞKUN 2004) and 16.82 (ELMQVIST et al. 2013); Milan – 16.2 (FRATINI, MARONE 2011) and 8.98 (ELMQVIST et al. 2013), as well as for Vienna and Rome.

Reporting data on urban green space has methodological and prospective drawbacks (BADIU et al. 2016), and the norm of 26 m² per capita of green space for all Romanian cities is impossible. In order to achieve the goals of sustainable development, such characteristics of cities as the density of the built-up area, proximity to the main transport infrastructure, the period of foundation and geomorphology must be taken into account. According to data (COLESCA, ALPOPI 2011), over the last 20 years in the cities of Romania, 20 million square meters of greenery disappeared at a rate of 250 hectares per year. As a result of the expansion of the building, over the past two decades there has been a reduction of green space in all 319 cities, and at present the amount of green space is 18 m² per capita, while EU standards require 26 (CHIRIAC et al. 2009) and WHO – 50 m² per capita. At the same time, in Stockholm and Vienna, the average green area is 70 m² per capita, in Bucharest – only 9.7 m² per capita. Among the Romanian cities with a population of 20 to 100 thousand, only five cities have an index higher than the European standard and 12 more cities – more than 20 m² per capita. Among 213 small towns with a population of up to 20 thousand, the amount of green space ranges from 0.6 to 665 m²

per capita. There are newly created cities that do not have green plantations at all.

Table 4 shows the indicators of landscaping in the capitals and major cities of the world by COŞKUN (2004).

An addition to the indicator is the provision of green space by another indicator – the level of greening, which characterizes the relative area of green space, makes the picture more objective, allows somewhat offset the impact of different density of population in cities.

DISCUSSION

According to KHALIL (2014) and WHO, the standards of living in green space per inhabitant in the Americas and the EU are 9 and 18 m² per capita respectively. Fig. 2 illustrates the norm by comparing the value of the norm of green space and the provision of green space per inhabitant in 18 cities in order of decreasing, which is borrowed from the aforementioned literary data of various authors.

Real provision green space is below the adopted norm in 39% of the figures shown and 7 of 18 exceeded the norm – at 33%.

Solving the problems of territorial planning of land use is possible provided that a harmonized system of national standards, norms and rules is created. The existing system of regulation of land relations is characterized by unsystematic, dispersed and fragmentary. Most often non-specific systems of normative documents are used, in particular: in the field of urban planning and in the sphere of sanitary and hygienic welfare of the population (sanitary norms). There are practically no standards for determining the norms of the optimal ratio of land, land classification and a set of quantitative and qualitative indica-

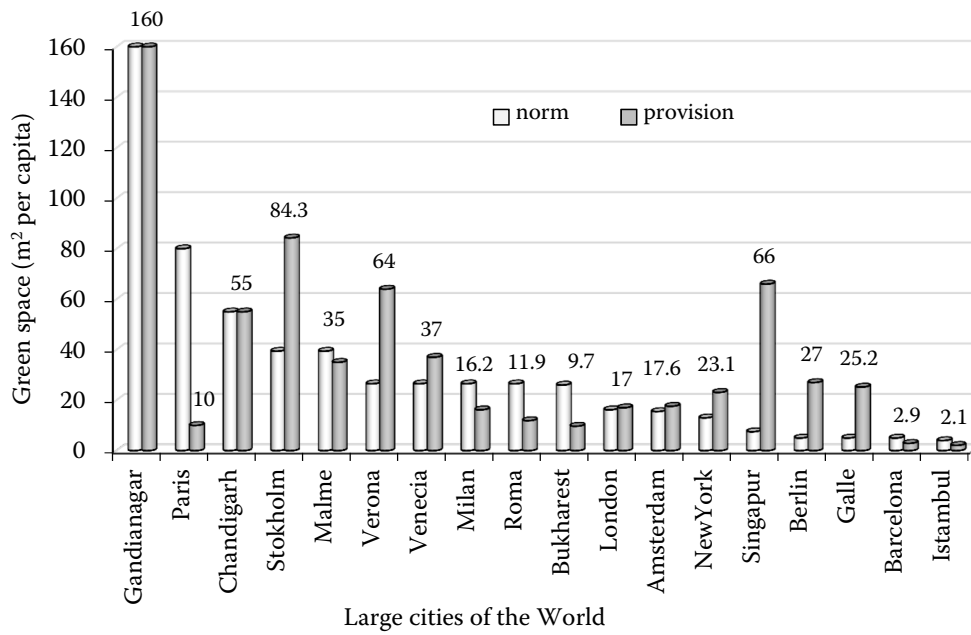


Fig. 2. Correlation of norm and provision of green space in cities according to the data of used literary sources

tors, and parameters regulating the development and implementation of documentation on land management in Ukraine.

The first problematic issue of the field of greening in Ukraine is the lack of exhaustive systematized information on indicators of the state of the field of greening with the justification of the causes and trends of change (BURAK 2014). Territories of cities remain the most attractive for developers, which led to a steady tendency to reduce the number of green spaces, especially for general use (BURAK 2014). According to official data, only 39% of the city’s facilities were surveyed. It is noted that in the period of 2000–2007 there

was no statistical reporting on the quantitative indices of green plantings, and at present the formation of statistical data on landscaping indicators remains imperfect, there are no substantiated explanations for the reasons for their changes. In addition to official reporting by the ministry, generalized information on green spaces is contained in the main socio-economic indicators of cities collected by the association of Ukrainian cities. According to them, the number of green plantations in 2008 and 2010 was respectively: in Lutsk – 6,6 and 8,6 m² per capita, in Khmelnytskyi – 7,6 and 75,6; in Zhytomyr – 7.6 and 82.1, in Kharkiv 104.8 and 51.7 m² per capita (Fig. 3).

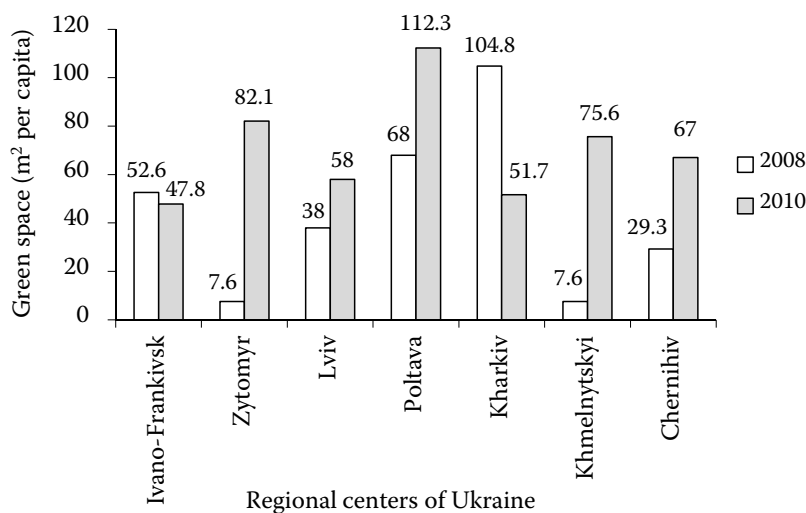


Fig. 3. Dynamics of provision of green plantations of seven regional centers in 2008 and 2010 (BURAK 2014)

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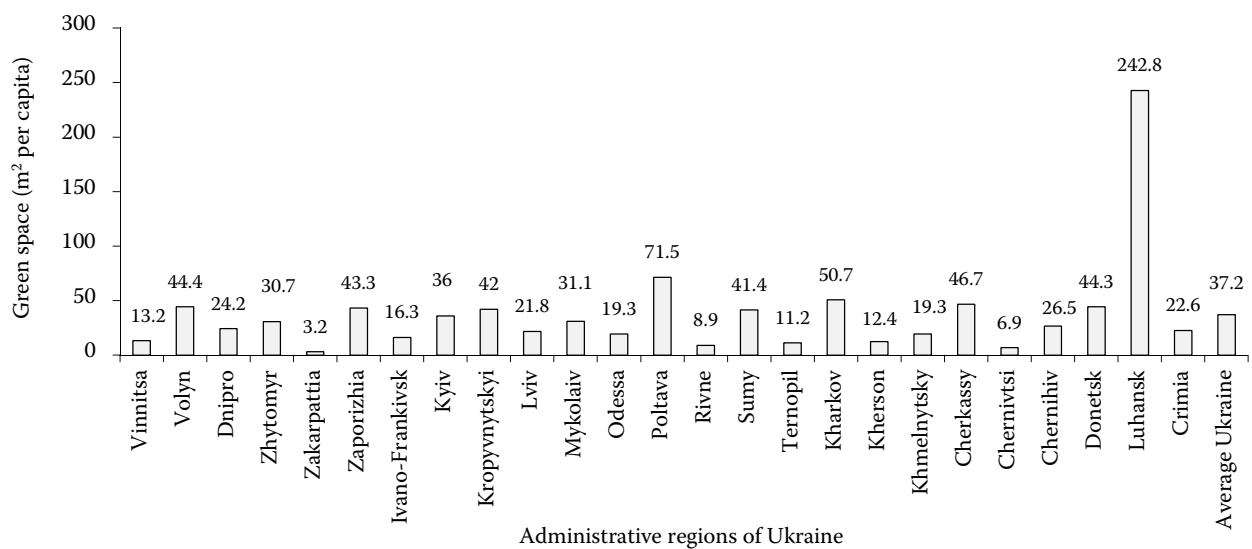


Fig. 4. Provision of green plantations within the administrative regions of Ukraine

According to BURAK (2014), it is clear that 14 (more than half) regional centres of Ukraine do not meet the WHO minimum (9 m² per capita). Number of green spaces in Lutsk alone (7% of cities). In addition to Lutsk, below the US standard (18 m²) the number of green plantations in Kherson and Chernivtsi (21% of cities); EU standard (26 m²) and UN requirements (30 m² per capita) are not provided also in Rivne, Sumy, Zaporizhia (in 43% of cities).

In our opinion, such inadequate dynamics over a two-year period can be explained by the lack of proper accounting of green spaces, unreliability of statistical reporting indicators, land use change changes (expanding the area of settlements due to adjacent green zones) and gaps in regulatory and legislative acts.

Estimates of ZIBTSEVA (2017) on the basis of the data of the statistical yearbook for 2014 allowed obtaining a picture of the provision of green areas of settlements (Fig. 4). Provision of green plantings is provided for all administrative regions of Ukraine with the exception of Luhansk, Donetsk oblasts and the Autonomous Republic of Crimea.

Among of the 22 regions of Ukraine, the number of green spaces per capita in Zaporizhzhia, Rivne and Chernivtsi does not meet the WHO (9 m² per capita) minimum indicator. In addition, below the US standard (18 m² per capita) the number of green plantations in Vinnitsa, Ivano-Frankivsk, Ternopil, Kherson regions (31.8% of the regions); The EU norm (26 m²) is not yet provided in Dnipro, Lviv, Odesa, Khmelnytskyi regions (50% of the regions),

and the UN requirements (30 m² per capita) have not yet been met in the Chernihiv region (a total of 12 or 54.5% areas). That is, all listed standards are observed on average only in ten regions – Volyn, Zhytomyr, Zaporizhzhia, Kyiv, Kropyvnytskyi, Mykolaiv, Poltava, Sumy, Kharkiv and Cherkasy (45.5% that less than half of Ukraine's regions). The average for areas of value (28.2 m² per capita) also does not meet the UN requirements.

This indicator would be much more informative given the equal density of population in all settlements and regions. In reality, however, it must be supplemented by another indicator – the level of greening the territory of the city. An objective picture of the number of green areas can only be obtained if they are integrated, as is customary in most countries. Unfortunately, the comparability of data on Ukrainian cities is complicated by the categorization of green spaces adopted by us, rather than the green spaces and direct normalization of only green spaces of general use. It is not clear and not strictly adhering to the normalization of the level of greenery in the territories where the green plantations of limited use, and even more so for special purposes, are difficult to assess according to international standards, the total number of green spaces (green plantations) in our cities, not to mention the lack of green inventories plantations and doubtful statistics that can be verified using GIS technology. The introduction of clear European standards in Ukraine, for example, an example of German cities, with a minimum per capita

population of gaming, sports and free playgrounds, would clearly affect the culture and way of life, and would remove a whole set of problems.

From the data provided by Ukrainian sources of information, the picture of the provision of green areas of the population of domestic cities is not as idyllic as one would like to consider. Despite the relatively low density of settlements, the provision of green space per capita in the cities often does not meet the requirements of EU and UN.

We consider it expedient to borrow Chinese practices on the clarity and versatility of regulations and regulations on green space planning.

We believe that it would be advisable to take in the United States some of the hierarchical system of green space valuation. The normalization of the green space should be conditioned by a holistic urban landscape and a lifestyle culture (the latter could be trained as a derivative through the system of green spaces). It would be desirable to direct the norms to fulfil at least three short-term goals, namely: protection of natural sources; protection of historical and geographical values; preventing private ownership and, like in the United States, attaching green space to normative accessibility to school grounds.

The system of norms of green spaces introduced in the USA, which decreases with increasing population, seems quite logical in the territorial boundaries of cities. Standards are generally offset by a well thought-out hierarchical system that is being developed to a regional level. Such a well thought-out system is also needed in Ukraine, and its development is possible only with the introduction of landscape planning at the national level.

CONCLUSION

The analysis of the population's green space showed that the existing direct valuation of the provision of green plantations of general use is not enough. Nowadays the practice still exists in Ukraine, is just too primitive for the recreational function of greenery: in the modern planning of cities, all ecosystem services provided by green plantations should be taken into account. An urgent need is the primary orientation (as a limiting factor) for the ecological function of green spaces and the provision of sustainable and ecologically balanced urban development. Therefore, in addition to the existing greening standards for green public spaces, it necessary to introduce a mini-

um ecological standard for all green spaces within the city territory, regardless of the form of ownership and other amenities that must meet international standards. Only in such a case will the correct comparison of green space systems of Ukrainian cities with European and other world cities.

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Received for publication July 28, 2019

Accepted after corrections November 13, 2019