

ENVIRONMENTAL INDICATORS OF THE BALANCE OF THE TERRITORIES OF SMALL TOWNS IN KYIV REGION

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Abstract

Based on the data of the StateGeoCadastre of Ukraine and the General development plans of towns, a comparative analysis of the structure of the land fund of small towns of Kyiv region has been carried out with the following ecological indicators: ratio of different types of land use, level of greening, population/green plantings ratio. Data analysis of the level of greening of towns and the availability of green public landscapes for general population has been conducted and it revealed that the current state of land use of small towns, as well as other urbanized territories, does not meet the requirements of environment management. Results of the analysis suggest that small towns are characterized by an excessive proportion of property development areas and suboptimal areas of natural territories, as well as insufficient greenery plantings, which require further balancing. In most of the studied small towns ecological situation can be considered satisfactory. Due to the extraordinary diversity of ecological and geographical conditions, individual approach to the development and improvement of greenery systems of small towns has been deemed feasible.

Key words: built-up land, green space provision, greening level, urban landscape.

Introduction

Historical human development of the territories, growth of the built-up area caused the violation of natural systems in such limits, which made the world community to develop a concept of sustainable development of the territories for the possibility of preserving it for descendants (Gerasimchuk 2009). Land use in the world will undergo dramatic changes and will be accompanied by conflicts of land demand, which will require a coherent integrated policy on the ground to promote responsible land use and limit the negative ef-

fects of land use. Towns need scientifically-based solutions to urban development, such as the creation of green spaces (Eionet 2017). A European Environment Agency report published today says that the continent's land use increasingly sees striking changes and conflicts over land demand, which will require reconciling place-based management and macro policies to foster responsible land use.

Landscape-ecological optimization of the territory assumes to reach optimal relations between economic and natural lands (Pozniak and Tsaryk 2013). According to the UN recommendations, forests in

the land should occupy 50 %, agricultural land – 45 %, built-up land – 5 %. More than 42 % of the territory of Europe are covered with forests, which makes the continent one of the world's regions richest in forests (Cvejić et al. 2015). The optimal correlation between land use types in Ukraine includes forests 25–30 %, arable land 30–35 %, hayfields and pastures 20 %, about 6 % of built-up land, over 10 % of protected areas. Currently, anthropogenic landscapes in the territory of Ukraine occupy 58 %, anthropogenic-natural – 35 %, natural – only 7 % (Shashula 2009), and anthropogenic load on the environment exceeds several times the corresponding indicators of developed countries of the world.

Urban ecosystems can play a positive role in providing sustainable development despite the fact that towns worsen the natural environment (McHale et al. 2015). The review and improvement of the methodology of urban planning in the conditions of decentralization of investment activity, changes in land use, the character of the urban development process, and the strengthening of the role of the ecological component in urban development in Ukraine are relevant (Yegorov 2010). The unprecedented rate of residential development makes the study of green plantations against the background of a rapidly changing urban environment extremely relevant. The results of research on a single town cannot currently be interpreted to characterize another one (Narbut and Mirzekhanova 2016). The conceptual framework for comparative research in different towns must be developed (McPhearson et al. 2016).

Green spaces, known as green infrastructure or urban vegetation, are vital to urban dwellers, as they play an important role in eliminating the effects of urban

thermal sources, climate change, and the provision of ecosystem and aesthetic services (Ramos-Gonzalez 2014). Optimization of the ecological situation of urban areas presupposes, first of all, an analysis of their condition, including planting of greenery. Environmental indicators of sustainable development of territories characterize the quality of life of people, the state of the environment, and the impact of human activities on natural ecosystems. As indicators of sustainable urban development, it was proposed to consider quantitative indices of the existing areas of protected and nature-recreational territories and forest lands, the level of greening of cities and the provision of population with landscape and recreational areas (Valeto and Ulasik 2013). According to Vagin et al. (2015), one of the disadvantages of the existing basic system of indicators of sustainable development is that it does not take into account the percentage of greenery in urban areas, the proportion of urban and natural areas and other important aspects of the ecological state of the town. It is believed that the best correlation in urban practice is between 60 % and 40 % of natural areas, which are stabilizing the potential of the urban landscape (Barmin and Nikulina 2011). According to Gerasimchuk (2009), a favourable ratio of built-up area and greenery, which, according to urban planning requirements, should be 50:50, is currently not met even in most regional centres of Ukraine, where the share of the territory under buildings varies from 36.1 % (Chernivtsi) to 95.6 % (Vinnytsya), and agricultural land development exceeds the ecologically acceptable level in most regions. The trend towards the development of free areas by reducing the green area of towns leads to the loss of land, ecologically important urban reserves and environmental priority in the

process of urban development.

According to the norms, the level of greening of settlements in Belarus should be at least 40 %, and within the limits of development – not less than 25 % (Valeto and Ulasik 2013). According to the data of the Department of Ecology and Natural Resources of the Kyiv Regional State Administration (Regional report ... 2014), green areas in Ukrainian towns occupy 38.4 % of urban areas (at least 40 % of the norm), with general use only 13.4 %. In the city of Berlin, the cover of green space is 46 % of the city (Cvejić et al. 2015), the city of San Juan (Puerto Rico), Boston and Miami (United States) – over 42 %. One resident of San Juan has 122.2 m² of green space (Ramos-Gonzalez 2014), while a resident of Ukraine has 16.3 m² of greenery (Regional report ... 2014). At the same time, EU standards require 26 m² of green space per inhabitant, and according to the requirements of the World Health Organization – 50 m²/capita (Chiriac et al. 2009). Naturally, the minimum standards depend on the geographical location of the cities. According to Khalil (2014) and Thaiutsa et al. (2008), the standards of living in green spaces for USA and UN include 18 and 30 m²/capita, respectively. WHO recommends at least 9 m²/capita to provide environmental stability and other benefits.

This research is carried out in the framework of the development of conceptual foundations of the system of green plantations in small towns of Kyiv region in the context of ecologically balanced development. Small towns are the most widespread category of Ukrainian cities, and their number is over 75 % of the total. About 20 % of the urban population of the country lives there. Small towns are an intermediate link between big cities and rural settlements and the most degrad-

ed link in the urban process. At the same time, a small city can be considered a psychologically comfortable stereotype of an urbanized environment (Petryshyn 2008). Compared to large cities, small towns are characterized by a simplified system of landscaping, often lacking or neglecting out-of-town landscaping, lower normative indicators. Currently, the study of the environmental situation of the urban environment concerned, as a rule, large cities. This precisely led to the consideration of the situation in small towns and, first of all, in the Kyiv agglomeration, where small towns can serve as a recreation area for the capital's inhabitants. Intensive urbanization (especially in the metropolitan region) and the strategic course on sustainable eco-balanced development make research on the current state of small towns extremely relevant.

Kyiv region is one of the leading regions of Ukraine, the area of which (excluding Kyiv) is 4.7 % of the territory of Ukraine, and the population is 4.1 % of the total population of the country, 61.8 % of which is urban. Kiev region is one of the most developed industrial and agrarian regions of Ukraine. For the period from 2008 to 2014, the area of agricultural land in the region decreased by 7600 ha (up to 63.6 % of the total), forests – by 300 ha (up to 23.0 %), areas with surface water – by 300 ha (up to 6.2 %). Instead, built-up land increased by 12,600 ha (up to 4.8 %). The reduction of land potential of the region adversely affects the quality and quantity of other natural resources, including water, forest, and vegetation (Shevchenko 2015).

The purpose of the study is to determine the eco-balance of small towns in the Kyiv region based on an analysis of the structure of their land fund and such indicators as the ratio of land use types,

the level of landscaping and the number of green spaces per capita, and to compare the value of these indicators with European cities.

Material and Methods

There are 20 small towns in the Kyiv region. The main comparative studies were carried out for the territories of small towns: Boiarka, Bucha, Vyshhorod, Vyshneve, Fastiv, for which there are more detailed data on the distribution of urban territories by types of land use. The towns

of Vasylkiv, Kaharlyk, Ukrainka were connected to separate analyzes (if available data). The comparisons of greening indicators were carried out for 9 small cities of the region, which provided with actual master plans developed after 2000, including Yagotyn.

Studied towns of Kyiv region belong to small towns (with a population of 10–50 thousand inhabitants) located in the zone of influence of Kyiv at a distance of 2 km (Vyshneve) to 38 km (Vasylkiv and Ukrainka) and only Kaharlyk is at a distance of 77 km (Fig. 1). The choice of towns was justified by the availability of

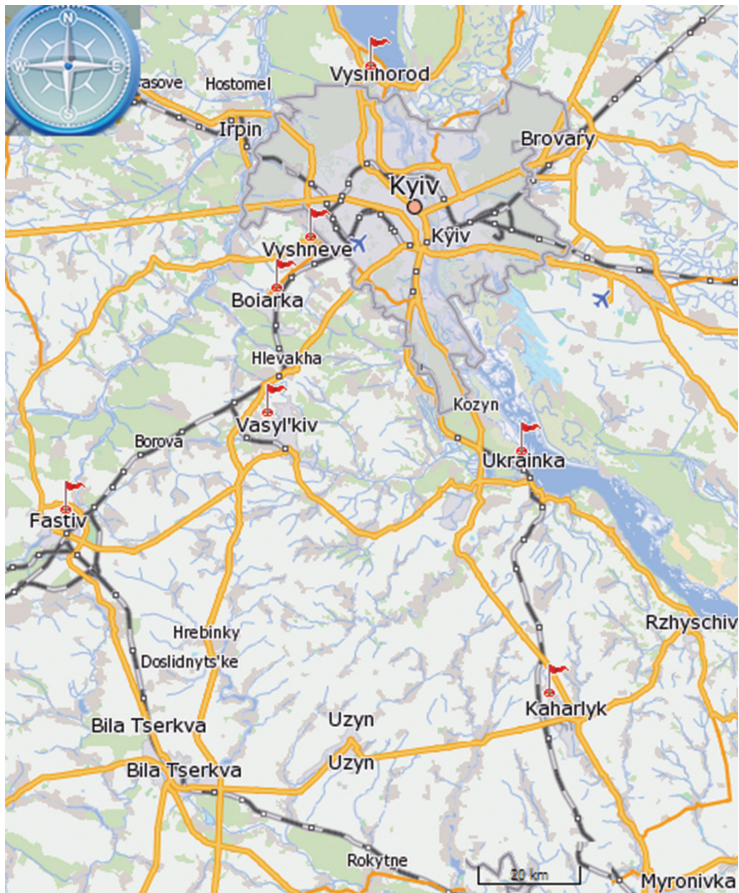


Fig. 1. Scheme of the location of pilot small towns relative to Kyiv.

publicly available fund material for analytical research.

The towns are located on the Kyiv Plateau, in the mixed forest zone, in the Kyiv Polissya (Boiarka, Bucha, Vyshhorod) and in the Forest-Steppe zone, the Kyiv highland area (Vyshneve, Kaharlyk, Vasytkiv, Ukrainka and Fastiv). Pine forests (Polissya) or agrocoenoses on oak forests site(s) (Forest-Steppe) dominate around the city. The ecological situation, where for estimating the living conditions of the population were taken into account the natural conditions of the territory, the pollution of the natural environment, anthropogenic loading on the territory is assessed as moderately favourable for Bucha, Vasytkiv and Fastiv and satisfactory

for Boiarka, Vyshhorod, Vyshneve, Kaharlyk and Ukrainka (Shevchenko 2015).

The analysis of the structural distribution of the land funds of towns was carried out on the basis of the data of their Master plans, which often did not coincide, and plans of perspective development were not developed for all towns. Before 2011 inventory of green spaces has not been carried out in small towns, just like the census because of expense of local budgets. Therefore, for objective reasons, for some towns there is no data for comparisons.

The data obtained from studied small towns was compared with data about a number of major European cities (Table 1).

Table 1. Per capita values for European cities (Cvejić et al. 2015).

Indicator	Berlin	Malmö	Ljubljana	Edinburgh	Bari	Łódź
Green space, m ² /capita	16.35	32.86	8.85	31.39	5.81	12.50
Green+forest, m ² /capita	60.84	36.28	422.30	59.97	6.04	60.03
Water area, m ² /capita	14.50	5.87	9.72	5.38	0.15	0.82

According to the obtained data about the ecological indicators of small towns of Kyiv region, a comparison of the actual and normative relations of agricultural, natural and built-up areas of cities was made (Zibtseva 2015) and the level of greening of towns with provision by green public space, all green space and green infrastructure was analyzed.

Results and Discussion

The main indicators of the territory of small towns are shown in Figure 2. There is proportion of residential space (multi-apartment buildings and manor houses), urban forests, and greenery (all categories of greenery are included in this category: general use, gardens, meadows, cem-

eteries, gardens, other open spaces). The share of green public spaces (parks, parks, gardens, boulevards) is set separately – the only indicator of urban planning, which is accurately calibrated in terms of green spaces, as well as the percentage of water surface.

The relative size of living space in all five studied small towns varies from 9.1 % (Fastiv) to 41.9 % (Boiarka) and averages 26.6 %, while in the indicated European cities ranges from 11.3 % (Ljubljana) to 32.3 % (Berlin) and averages 20.8 %. That is, residential development in small towns also fluctuates widely and occupies an average 6.1 % higher share in urban areas. The relative area of development in Boyarka is twice the average in European countries. As a rule, this is due to the predominance of the private building

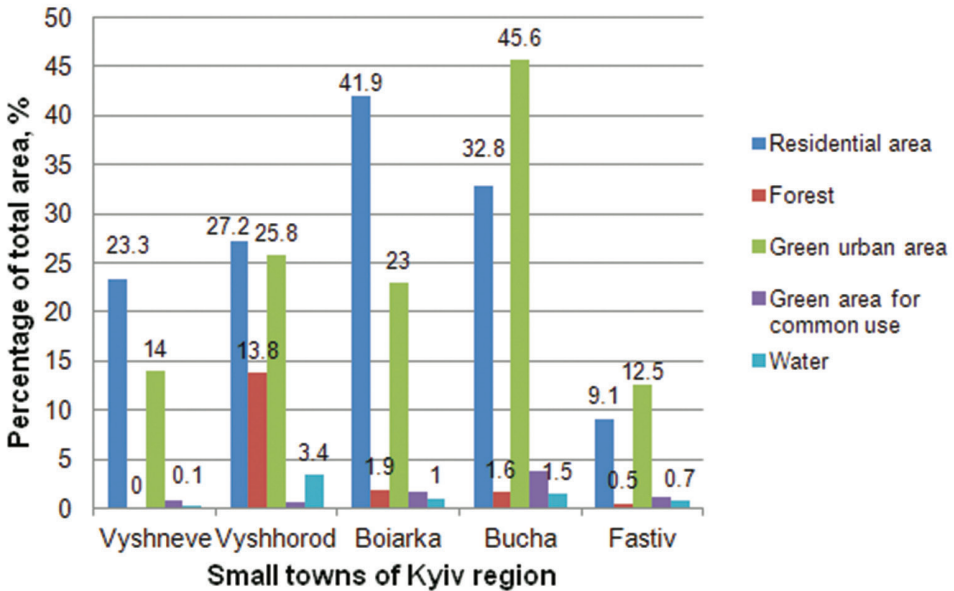


Fig. 2. Ecological indicators of small towns.

in the small town area.

Specific forest area in small towns ranges from 0 (Vyshneve) to 1.9% (Boiarka) and only in Vyshhorod it is 13.8%, the average value for the towns is 3.6%. A similar situation is observed in European cities, where the forest area ranges from 0.06% (Bari) to 17.5% (Berlin) and only in Ljubljana is 42.1% and the average value is 12.8%, which is 3.6 times higher than the average value for the studied Ukrainian small towns. Unfortunately, at present, forests in small Ukrainian towns are not considered as a recreational or eco-stabilizing facility, but only as a reserve for expansion.

The relative area under green space in small towns ranges from 12.5% (Fastiv) to 45.6% (Bucha) with an average of 24.2%, whereas in European cities – from 0.5% (Ljubljana) to 6.8% (Edinburgh) with an average of 4.2%. The area of green public spaces (the indicator not applicable for European cities) in small towns varies

from 0.68% (Vyshhorod) to 3.8% (Bucha) and an average of 1.6%. The value of this indicator is 2.7 times lower than the previous one for European cities.

Green public use according to the norms for small towns of Ukraine should make up 22–25% of the total area of green plantations on the territory of development. In fact, in the pilot towns, their percentage in the total area of the green plantations of the towns range from 2.2% (Vyshhorod) to 8.7% (Fastiv), this is 2.5–11 times lower than the normative indicator.

Water surfaces in small towns occupy from 0.1% (Vyshneve) to 1.5% (Bucha) and only in Vyshgorod (at the expense of the Dnieper and hydraulic structures) reach 3.4%. In European cities, there is a similar situation: the surface area of water surfaces ranges from 0.1% (Bari) to 1.2% (Malmö) and only in Berlin is 5.7%.

The structure of land resources of small towns in the order of growth of built-

up areas is illustrated by Figure 3. If on the whole in the Kyiv region the area of development is 4.5 %, then on the territory of small towns it varies from 10.3 % (Kaharlyk) to 84.6 % (Vyshneve). The optimal value (not exceeding 50 % of the town's territory) is constructed in only half of the research towns – Kaharlyk, Fastiv and Bucha.

The area of agricultural land varies from 5.5 % (Vyshneve) to 81.2 % (Kaharlyk) with an average of 29.6 %. The share of agricultural land in Fastiv is 59 %, which is equivalent to the average value in the Kyiv region (Fig. 3). In small towns, a fairly tight inverse correlation between the built-up area and the agricultural area can be traced: $r=-0.841 \pm 0.131$, $t=6.42$ ($P=0.99$).

There is no prospect of increasing agricultural land in small towns, and the priority for compacted multi-storey construc-

tion is still here. As a whole, agricultural lands in the region are twice more than it is recommended, and natural territories are twice less. There are very few natural areas in small towns. In the most secured in this regard, Kaharlyk town is 12.5 times less than the recommended value. At the same time, the number of built-up land is not critical and has a reserve for growth (4.5 % against 6.0 %).

The area of natural territories, to which all of the inbuilt territories with natural cover are attributed to us, are: landscaped territories, perennial plantations, water surfaces and other lands, are ranging from 8.5 and 9.9 % in small towns (respectively, Kaharlyk and Vyshneve) to 32.4 and 34.1 % (Vyshhorod and Bucha).

In general, the most optimistic aspect of the land is the Bucha area, where the maximum area of natural territories is pre-

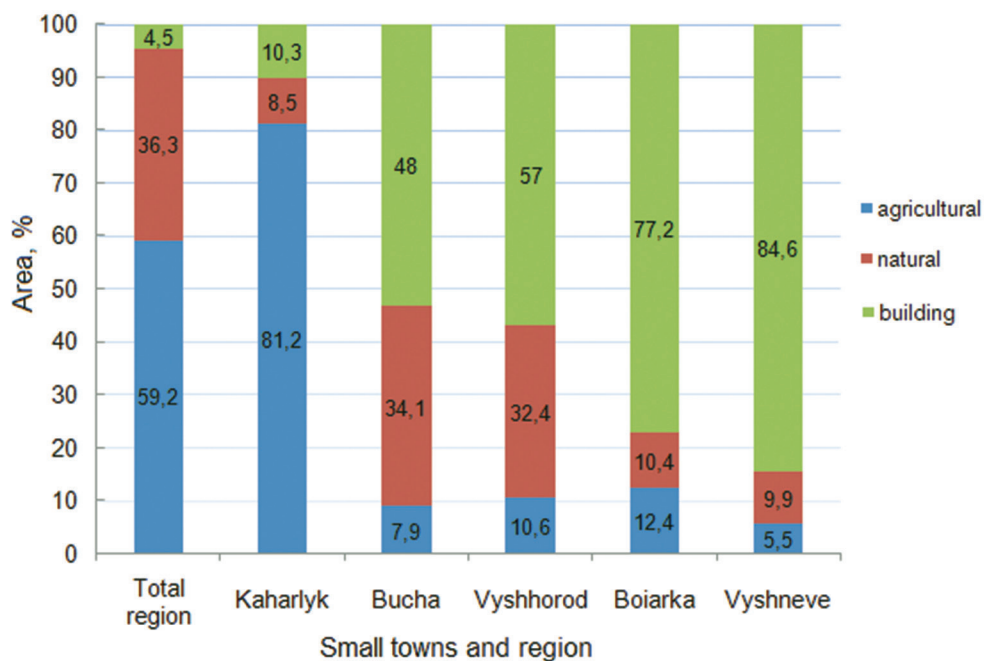


Fig. 3. Distribution of small towns by category of land use.

served and the area of development does not exceed the normative value. Second place in the balance of land belongs to Vyshgorod, where, despite the excess of built-up land (by 7 %), almost a third is natural territory. In the town of Vyshneve, the share of built-up areas is 8.2 times higher than in Kaharlyk. Natural areas are almost absent. According to the indicators, the situation is worse there. The ecological framework of the town is not formed.

The study of small towns in Belarus (Ministry ... 2010) revealed a large share of arable land, a significant proportion of meadow (47.4 %) and low-stem forest (5.3 %). The share of natural areas in the structure of the land fund of small towns of Belarus is 19 % (9 % are meadows, 4 % are bushy-vegetation, 3 % are water bodies, 2 % are marshes and 1 % is forests). Moreover, forest lands are only in 20 small towns of 74. Instead, there is no mire in only 13 towns, meadows – in 6. A characteristic feature of most small towns of Belarus (as well as small towns of Kyiv region) is the presence of water in the city and in suburban areas water objects. Forest areas are often found near small towns, but the introduction of them at the border of towns does not always correspond to the economic interests of the town economy, and the request for recreational use of forests in small towns is lower than in large, although in small towns there is a higher interest in the use of non-wood forest resources.

According to the recommendations of Luse (1978), developed in the Soviet times for small towns in Latvia, the greening rate for small towns should regulate the maximum permissible level of landscaping and be about 4 m² per capita. In our opinion, the introduction of such regulation for small Ukrainian cities would be extremely inappropriate and would lead

to an even more intensive reduction (development) of urban green spaces. According to the data of Srodnykh (2005), the number of common use plantings in most towns varies from 1.0 to 3.3 m²/capita, whereas according to norms should be 8 m²/capita. The provision of green public landscapes in studied small towns ranges from 1.2 m²/capita in Vyshneve to 17 m²/capita in Bucha (Fig. 4). Only two towns – Bucha and Ukrainka – have complied with this standard.

The disappointment dynamics of the provision of green public landscapes (parks, squares). Thus, at the time of the development of the past Master plan of Vyshhorod, the provision of green public landscapes was 6.7 m²/capita, while the Master plan provided for its increase to 13.0 m²/capita. Instead, the park in the centre of the town was built up with multi-storey buildings, and now the territory of common-use plantations has decreased by 2.7 times: from 13.7 to 5.1 ha, and their population's supply – by 3.4 times: from 6.7 to 2 m²/capita. The newly created park is a garden. A similar situation is observed in Vyshneve. In Bucha, however, 47.7 % of the greened areas constitute green public utilities, and 52.3 % are urban forests.

Per capita green space index in European cities (Table 1) ranges from 5.8 (Bari) and 8.8 (Ljubljana) to 32.9 (Malmo) and 31.4 (Edinburgh), although in the total for Eastern Europe was 13.7 m²/capita. Comparing with these figures, the value of provision of green public landscapes, only among the Ukrainian small towns in Bucha, this indicator corresponds to the average for Eastern Europe. Counting all the green spaces, which included garden communities, recreation centres, cemeteries, meadows and other territories, in addition to the green spaces of gener-

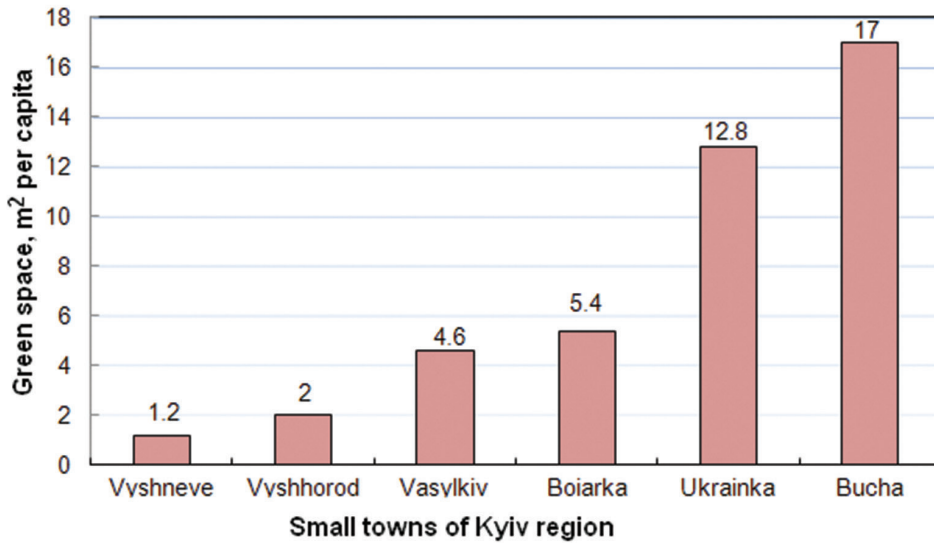


Fig. 4. Provision of small towns with green spaces of public use.

al use, allowed obtaining the results of the provision of greenery in cities within 25.7 m²/capita (Vyshneve) to 294.9 m²/capita (Bucha) that is comparable to European cities (Table 2).

The inclusion in the calculation of ur-

ban forests did not improve the figure for Vyshneve, where there are no forests. Table 3 shows the public availability of green public spaces, all green spaces and green infrastructure calculated according to the actual master plans of small cities.

Table 2. Per capita values for Kyiv's small towns.

Indicator	Vyshneve	Vyshhorod	Kaharlyk	Boiarka	Bucha
Per capita green space, m ²	25.7	40.3	73	73.8	294.9
Per capita green+forest, m ²	25.7	83.7	398.3	79.9	310.2
Per capita water area, m ²	0.1	10.6	76.4	3.1	14.4

Table 3. The provision of the population of small towns of Kyiv region with green space.

Town	Provision, m ² per capita		
	Green spaces of public use	Green areas	Green infrastructure
Vyshneve	1.2	25	25
Vyshhorod	1.8	128	167
Vasylkiv	4.6	177	328
Boiarka	5.4	118	145
Fastiv	17.8	166	436
Bucha	25.9	192	326
Yagotyn	30.7	365	1968
Pereyaslav	42.5	313	530
Kaharlyk	73	283	1188

The relatively high rates for Kaharlyk are explained by the small population (13.8 thousand) and the large area of the town, over 80 % of which is occupied by agricultural land, and for Yagotyn by the large area of reservoirs. In general, the data obtained indicate that the results of the approach to landscaping indicators used in Ukraine differ significantly from those used in developed European countries: the availability of green space (green plantations) differs significantly from the area of all green space and the area of green infrastructure. According to the traditional calculation for the post-Soviet space, the area of green space exceeds 300 m² per capita for only two towns, and for green infrastructure – for six towns.

The indicator of green space for public use meets the established standard (8–11 m² per capita) only for Kaharlyk, Pereyaslav, Yagotyn, Bucha, Fastiv (in order of decreasing its nominal value). Taking into account all green infrastructure (i.e. not all built-up areas covered by vegetation or water), it is 25 m² per capita only for Vyshneve, and for the rest towns it ranges from 167 to 196 m² per capita.

Figure 5 shows the dendrogram for 9 observations of small towns of Kyiv region by the similarity of the main indicators of landscaping of their territories.

The first cluster included towns with maximum green space and relatively low landscaping; to the second cluster – towns with higher levels of landscaping

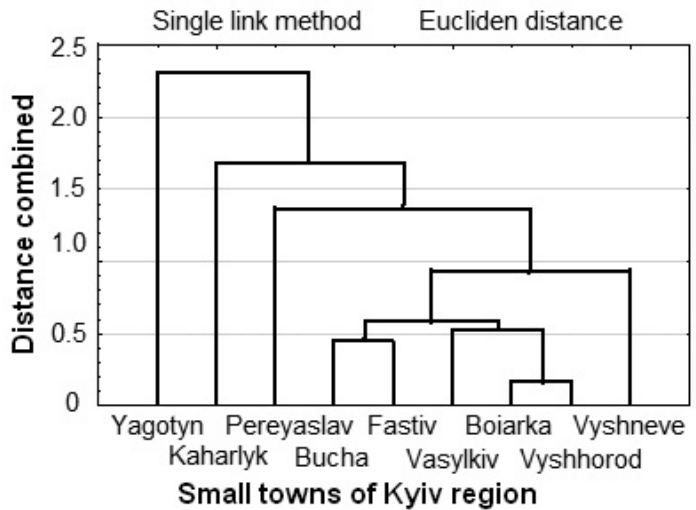


Fig. 5. Dendrogram of similarity of small towns of Kyiv region in terms of landscaping.

Note: Cluster 1: Yagotyn, Pereyaslav, Kaharlyk; cluster 2: Vyshhorod, Vasytkiv, Boiarka, Fastiv, Bucha; cluster 3: Vyshneve.

but low availability of green spaces for public use. The third cluster included the town with the worst greening values. The data obtained indicate a polarized situation in small towns of the region. Similar results were found for the balance of China's urban infrastructures, with only 40 % of cities achieving acceptable performance (Wang et al. 2019).

Conclusions

Results of the conducted analysis confirm the data available in literary sources on the current state of use of land resources of small towns, as well as other urban areas, therefore highlighting the fact that the norm and requirements of sustainable environment management are not adhered. Investigated small towns are characterized by excessive areas of property development and extremely low levels of natural areas, and often insufficient

areas of green space, especially those intended for public use (i.e., parklands, unrestricted recreational use), which requires further balancing. Such situation is typical for cities, where recreation areas are scarce due to the excessive property development. In small cities, there is a fairly dense inverse correlation between the built-up area and the agricultural area, which primarily results in the expansion of the building.

Compared to European cities, the relative size of living space in the structure of small towns is on average 6.1 % higher and the area of urban forests on average 3.6 times smaller. The relative area of green space in small towns is much higher than in European cities.

The analysis of small towns by arrangement of green spaces indicators as eco-performance of territories showed that, with the exception of Vyshneve, the ecological situation in the pilot small towns of the Kyiv region can be considered satisfactory.

Only 21 % of experimental small towns have relatively high landscaping rates. Provision of green space for residents of Ukrainian small towns is comparable to similar indicators of European cities.

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