Evaluation of green space systems in small towns of Kyiv region

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Abstract. We analysed the current state of greening of small towns in the Kyiv region; small towns constitute 80% of all towns and cities in the region. A difference is shown to exist between the classification of green plantings that is used in Ukraine and the world-wide approach of green infrastructure. This makes it incorrect to compare the indicators of landscaping of towns in Ukraine against those of other countries. Based on the data of *Master Plans* of towns, the generally accepted indicators of landscaping of urban areas were calculated: provision of greenery per capita and level of landscaping. These indicators of landscaping for small towns were analysed according to different approaches. It is found that, according to the traditional calculation, the provision of green plantations exceeds 300 m² *per capita* for only 5% of small towns of the region, but for 70% according to the approach of green infrastructure. The provision of green areas for public use meets the established state standards (8–11 m² *per capita*) for only 35% of small towns in the region. Small towns are grouped into four clusters according to the similarity of landscaping indicators, where only the difference in the availability of green plantings of public use was unreliable among the clusters.

Contents:

1. Introduction

There are 364 small towns in Ukraine. Of these, 52 are located in the areas of influence of large cities and have stronger dynamics of development. Due to the large number of small towns and the typicality of their socio-environmental problems, these have primarily attracted the attention of economists. It was noted that with the change of economy and structure of activity, small towns found themselves in the greatest stagnation (Sosnova and Tupis, 2015). The majority of attention has been paid to the problems of their development in the socio-economic transformation of Ukrainian society and the economic principles of their revival. Currently, the state priority is to create conditions to ensure their sustainable development.

Small towns are the most degraded part of the urban process (Topilko, 2011) and the most dynamic sector of the country, especially those located in close proximity to large cities (Mayer and Knox, 2009). At the same time, a small town is considered a psychologically comfortable stereotype of an urban environment (Petryshyn, 2008). The global trend to limit the growth of large cities encourages the need to create comfortable living conditions and a favourable landscape environment precisely in small towns (Samoshkin and Anisova, 2008). However, the socio-ecological situation in small towns has not been fundamentally studied (Yukhnovskyi and Zibtseva, 2018; 2019a; 2019b; 2020).

Problems of the sustainable urban development of small towns are among the most important issues discussed in recent decades by the global and European communities (Bilokon, 2008). However, Ukraine has developed relatively few small-town *Master Plans*, which are not only the legal basis for the territorial development of towns, but which also regulate economic activities in their territory and changes in functional use of the territory. Most small towns require that the natural and historical landscape be revived, sustainability and attractiveness for business and tourism be increased

and, at the same time, that the sources of eco-manmade hazards be severely reduced (Bilokon, 2008). Only in this case can small towns further become the basis for the harmonisation of public life, social stability and cultural revival of society (Petryshyn, 2008).

Urban ecosystem planning involves taking into account the current state of the green space system, its features and development trends. An important mechanism of territorial land use planning is the creation of a coherent system of national standards, norms and rules to ensure sustainable land use (Dorosh and Dorosh, 2015). The quantification of dynamic urban green space is the first basic step in its planning (Beiranvand et al., 2013), and the standard approach is clear and easy to apply and is used by local authorities as a guide (Jim and Chan, 2016).

According to studies of small towns in South African Republic (McConnachie et al., 2008), the most informative indicators of the state of the urban environment are population density and the quantity of green spaces *per capita*. According to WHO recommendations, to ensure the environmental impact and achieve other benefits, each town should provide at least 9 m² *per capita* of accessible, safe and functional urban green space (Russo and Cirella, 2018; World Health Organisation, 2012). The ideal number is considered to be 50 m² *per capita* by the WHO (Morar et al., 2014), 18 m² according to US standards, 26 m² by EU standards (Chiriac et al., 2009), and 30 m² by the UN (Khalil, 2014; Thaiutsa et al., 2008).

According to Elmqvist et al. (2013), the provision of green space to residents of European cities increases with increasing population and for cities with a population of up to 200,000 is characterised by the provision of up to 10 m² *per capita*. For most small towns of the Russian Federation, data on the inventory of plantations are missing or outdated (Bolshova and Bukharina, 2012), and the provision of public plantations in small towns ranges from 3.6 to 9.7 m² *per capita*.

The lack of comprehensive systematic information justifying the causes and trends is the primary

problem of landscaping in Ukraine (Burak, 2014), and for the period 2000–2007, statistical reporting on the quantitative indicators of greenery in Ukraine is absent. Currently, the formation of statistical data on landscaping remains imperfect, and there is a lack of justified explanations for the reasons for the dynamics (Burak, 2014). As a rule, there are no schemes of urban landscaping, which in the case of intensive chaotic and poorly controlled building makes the green space completely unprotected. In addition, unfortunately, forestry services have nothing to do with landscaping small towns: this issue is traditionally taken care of only by housing and communal services.

Extremely little attention has been paid to the study of green space systems in small towns in Ukraine. Data on the eco-balance of areas or green space systems of small towns are currently limited mostly due to the economic situation. An inventory of greenery in these towns has never been conducted. *Master Plans* are almost the only source of information about landscaping systems in Ukrainian small towns.

The purpose of the work is to assess the green space systems of small towns in the capital region according to the main indicators of landscaping using different approaches: both traditional ones for Ukraine (those introduced in Soviet times) and those generally accepted in developed countries, in order to portray the real situation and correct comparative analysis of green infrastructure of Ukrainian towns and towns of other countries in the future.

2. Materials and methods

Small towns tend to vary in population, although this criterion varies considerably from country to country, and many countries do not have such a legal distribution at all. The small towns category in Ukraine includes towns with a population of 10,000 to 50,000. There are 20 such towns in the Kyiv region, which were founded in the years 907–1899. They are located at a distance of 2 to 144 km from Kyiv city.

Urban green space systems were evaluated on the basis of technical and economic indicators of their *Master Plans*. The main indicators of urban landscaping were calculated according to the generally accepted methods in Ukraine: the level of landscaping, provision of green areas (by all) and provision by public green areas *per capita*. It should be noted that in Ukraine the term "green planting" is generally accepted (Rules for the maintenance of green areas…, 2006), and not "green space" or "green infrastructure". Green plantings are divided into three categories: green plantings for public use, green plantings of limited use (on the principle of recreational use) and green plantings for special purpose (not for recreational use). There are only standards of provision of public green plantings for public use, which have to be not lower than the state established for different towns' "landscaping norms". For comparison, similar indicators of landscaping were calculated according to the approach adopted in developed European countries: level of landscaping, which takes into account all the green infrastructure of the town; and the provision of green space *per capita*, i.e. the area of green infrastructure *per capita*.

The thoughtless combination of different classification functional categories of green space under one name "green space" (Taylor and Hochuli, 2017) in general, in our opinion, is meaningless and even harmful, but in this study it is quite appropriate for use. Davies et al. (2006) identified a typology of multi-functional open spaces (Green Infrastructure), which when taken together comprised an "environmental resource" which contributes toward sustainable resource management.

The concept of green infrastructure (GI) is the most modern view on the urban landscaping system (Mansor et al., 2012). The GI approach is a notable contribution to the planning of ecological connections at many scales which meld with urban form to offer the prospect of a more sustainable landscape for well-being and biodiversity (Lafortezza et al., 2013).

When calculating the provision of public green spaces per person, all public green plantings were taken into account. Their areas are clearly indicated in the *Master Plans* of cities. When calculating the provision by all green plantings *per capita*, in addition to green plantings for public use, the green areas for limited use and for special purposes

specified in the materials of the *Master Plans* were also taken into account. It must be noted that the calculation did not include informal (unaccounted for) plots, green spaces of homesteads, areas for agricultural use, water surfaces and some others. By contrast, however, according to the generally accepted approach, the GI combined all undeveloped and uncovered areas, i.e., all areas covered with vegetation, including agricultural land, gardens, as well as swamps and water surfaces. The difficulty was that specific data on limited and special purpose greenery were usually missing in the *Master Plans* developed over the last 30 years. To remedy this gap in the data, we included half the total area of homesteads in the green spaces for limited use in the calculations.

The procedures for determining the level of urban landscaping and the provision by all green spaces are identical except for differences in the inclusion of different categories of land. The functional category of "green plantings for public use" is typical of the post-Soviet space, but has significant differences in the classifications of different post-Soviet countries. Public green plantings in Ukraine (Rules for the maintenance of green areas…, 2006) include green areas intended for recreational purposes for all segments of the population without restrictions.

During the analysis of green space systems in small towns, the level of landscaping was assessed in comparison with the current Ukrainian standard, according to which the landscaping level must be at least 40% and the provision by public greenery should meet the landscaping norm, which for small towns is at least 8 m^2 *per capita*, and for towns surrounded by forests, in coastal areas of large rivers and reservoirs, it is permissible to reduce the area of green areas by 20%.

The calculations must show the difference in the assessment of landscaping systems in small towns, performed on the basis of different approaches to traditional and green infrastructure. The results of the study must also confirm or refute the main hypothesis: whether it is legitimate to compare the cities landscaping in different countries based on a comparison of landscaping indicators calculated according to different approaches.

The next stage was the clustering of small towns according to the calculated five indicators of landscaping. Clustering was carried out using the

STATISTICA 10 program by the *k*-means method. *K*-means is a method of cluster analysis that groups observations by similarities across rows. *K*-means by default aims to minimise within-group sum of squared error as measured by Euclidean distances (Everitt et al., 2011). This allowed the reliability of the difference in landscaping between clusters of towns to be assessed and in future may help to develop strategies for the development of landscaping systems and the formation of ecologically balanced towns.

3. Results

The analysis of official statistics revealed negative dynamics in the areas of all categories of green plantings and their total area in Ukraine. Provision of the population with green plantings in the regions is uneven and varies dozens of times. Among the 22 considered regions, Kyiv region ranks eighth in terms of providing residents with public green plantings and 14th in terms of providing all green plantings among the 22 considered regions. The average provision of green plantings in Ukraine is 701 m^2 *per capita*, in Kyiv region it is 482 m^2 *per capita* (Zibtseva, 2017). The average provision of green plantings for public use is 28.2 and 36 m^2 *per capita*, respectively.

The location of green areas is determined not only by landscape resources, but also by the historically composed planning structure of cities and their current economic development. The combined structure of green plantings systems with the presence of water-green diameter, which is one of the main forming factors, is widespread among small towns of Kyiv region. In the *Master Plans* of small towns, not all areas of green plantings are included in the overall calculation, which makes them "non-existent" and unprotected and contributes to the actual disappearance due to the expansion of building. The *Master Plans* of Ukrainian small towns (as well as land management documents) do not take into account the area of greenery on the territory of private estates and some others that should be taken into account in green infrastructure. Only methodologically uniform consideration of all areas of green infrastructure

will allow the landscaping systems of Ukrainian cities to be correctly compared against European cities and others.

According to the *Master Plans*, the territorial resources of small towns close to the capital within the existing boundaries are very limited: free areas for building are almost non-existent; the existing buildings are very dense. As a rule, the proposals set out in the developed *Master Plans* for the promising boundaries of small towns provide for the inclusion of additional areas at the expense of the adjacent lands of villages, which contradicts the ideals of a compact city. At the same time, the *Master Plans*

declare clearer zoning of urban areas and rational land use.

The average correlation between distance from Kyiv and population density (*r=-0.693*) was revealed, as well as the inverse correlation between population density and provision of green plantings (*r=-0.459*) and green infrastructure (*r=-0.516*) (Table 1).

The level of landscaping of the urban area is one of the indicators of urban environment quality, as well as an important indicator of ecologically balanced urban development. The obtained data show that the results of the approach used in Ukraine to calculate the indicators of landscaping

Table 1. The main indicators of landscaping of small towns of Kyiv region

Town	Population density, persons / km^2	Public green plantings, m^2 *per capita*	Level of landscaping, %		Provision, m^2 *per capita*	
			green plantings	green infrastructure	green plantings	green infrastructure
Kaharlyk	648	73.0	18.3	77	283	1,188
Pereyaslav	850	42.5	30.5	51.7	313	530
Yahotyn	350	30.7	13.1	70.8	365	1,968
Bucha	1,072	25.9	27.8	47.2	192	326
Fastiv	1,081	17.8	18.4	48.3	166	436
Ukrainka	2,622	16.3	5.4	17.0	32	99
Berezan	504	12.9	27.8	45.8	314	517
Uzyn	181	7.3	27.3	49.6	220	400
Tarashcha	295	6.7	10.9	20.2	127	236
Boiarka	2,879	5.4	36.4	44.9	118	145
Vasyl'kiv	1,267	4.6	28.9	53.4	177	328
Skvyra	258	4.3	29.6	45.2	200	305
Myronivka	1,043	3.8	24.8	44.4	151	285
Irpin	2,310	3.5	40.0	59.5	257	173
Boguslav	1,050	3.4	30.7	51.0	174	288
Tetiiv	1,012	3.2	10.2	48.3	102	483
Obukhiv	1,397	2.8	26.1	45.6	285	500
Rzyshchiv	208	2.8	8.4	83.3	836	1,530
Vyshhorod	3,180	1.8	53.1	59.2	128	167
Vyshneve	1,552	1.0	14.0	14.0	21	21

Source: authors' elaboration

differ significantly from those used in developed European countries. The calculated level of the town landscaping and the provision of greenery according to the method adopted in Ukraine is much lower than when the area of green infrastructure is taken into account. According to traditional calculations, the level of urban landscaping exceeds the normative 40% for only two objects of observation (Irpin and Vyshhorod) but when green infrastructure is taken into account (i.e., the area of agricultural land, swamps and water surfaces are added in) almost all exceed 40%. Similarly, in relation to the provision of all green plantings (precisely, green space), while the provision exceeds 300 m² *per capita* for only four objects of observation according to traditional calculations for green infrastructure, 12 exceed that figure.

Provision of green plantings for public use in the small towns in descending order of the value of the indicator is shown in Figure 1.

Figure 2 shows the dendrogram of similarity of small towns of Kyiv region according to the main indicators of landscaping of their territories, and Figure 3 – location marks of town clusters, determined by *k*-means using the program STATISTICA 10.

The first cluster included 11 (55%) towns with average values of landscaping indicators: Obukhiv, Uzyn, Berezan, Skvyra, Myronivka, Boguslav, Fastiv, Pereyaslav, Bucha, Vasyl'kiv (Fig. 4).

The second cluster (15%) was formed by three towns with the highest level of landscaping and the lowest provision by green plantings for public use: Vyshhorod, Boiarka, Irpin. The third cluster also includes three towns with relatively higher rates of all green plantings and green plantings for public use and low levels of landscaping: Rzhyshchiv, Yahotyn (with a significant water surface area within both towns) and Kaharlyk (with a large area of green areas and a relatively small population). The fourth cluster includes the towns of Tarashcha, Ukrainka and Vyshneve, which are characterised by lower values for certain indicators of landscaping, in particular the level of green infrastructure.

Only the difference in the provision of green plantings of public use per capita between urban clusters turned out to be insignificant (Table 2).

It is known that the provision of green plantings of public use is largely determined not only by historical and natural conditions, but also by the local politics, culture, social demands and economic opportunities of the town.
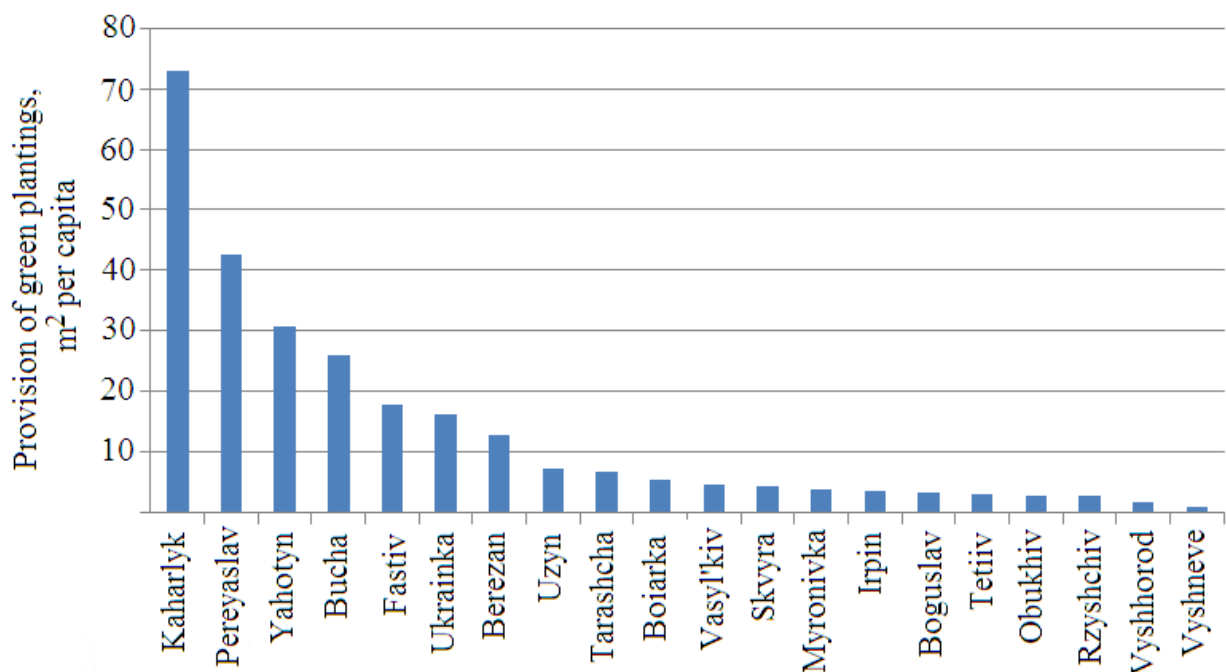

Fig. 1. Provision of green plantings for public use of small towns of Kyiv region
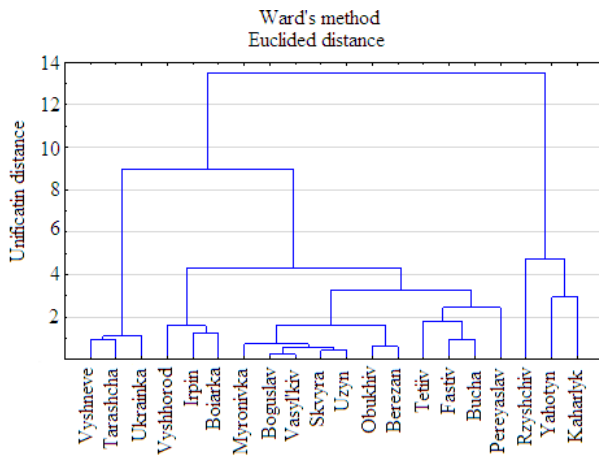
Fig. 2. Dendrogram of similarity of small towns of Kyiv region in terms of landscaping

4. Discussion

In Ukraine, as in Chinese or Polish cities (Wysmułek et al., 2020; Szymańska et al., 2015), there is no information on green space in backyards and these are practically not taken into account when determining citywide indicators of landscaping. Taking into account all the green space in small towns provided green space results that are comparable with the indicators of European and other towns. However, even in this case, the provision by green plantings in Vyshneve town does not meet the requirements of the WHO (50 m^2 *per capita*) and EU standards (26 m^2 *per capita*). In addition, calculations of the number of plantings required for stable development by Zhang et al. (2007) showed that, only in Vyshneve, green plantings do not meet the needs of the urban population for oxygen
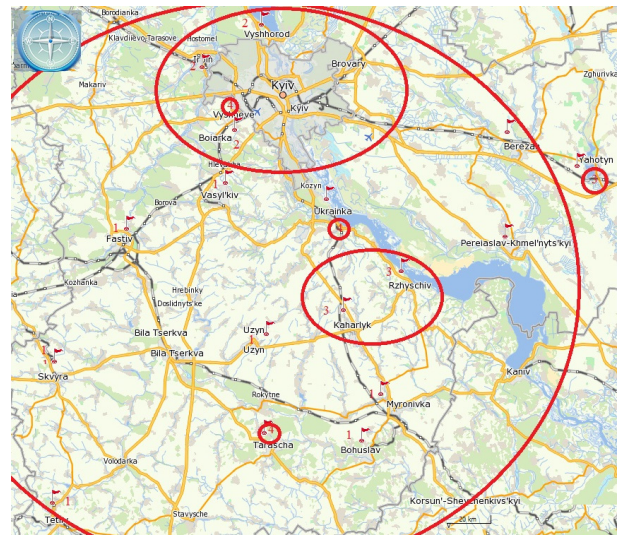

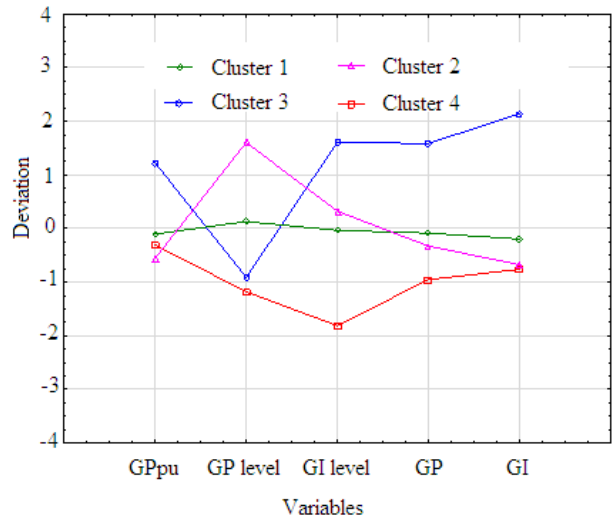**Fig. 3.** Labels of urban clusters on indicators of landscaping, determined by *k*-means

Fig. 4. Graph of average values of landscaping indicators for each cluster of small towns of Kyiv region: GP – green plantings; GPpu – green plantings of public use; GI – green infrastructure

Table 2. Variance analysis in the division of towns into clusters by indicators of landscaping

Indicator	Between SS	CC	Inside SS	CC	F	Significance P
GPpu *per capita*	5,844	3	13,156	16	2,369	0.10896
Level of landscaping (GP)	14,595	3	4,405	16	17,671	0.00003
Level of landscaping (GI)	17,950	3	1,050	16	91,152	0.00000
GP *per capita*	10,672	3	8,328	16	6,834	0.00355
GI *per capita*	17,285	3	1,715	16	53,741	0.00000

(taking into account physiological needs and energy consumption) and should be more than doubled.

The indicator of the provision by green plantings for public use indicates the recreational quality of urban green space, i.e. the presence or almost no landscaped green space for recreation of urban residents. This indicator meets the established standard (8–11 m² *per capita*) only for seven towns – namely, Kaharlyk, Pereyaslav, Yahotyn, Bucha, Fastiv, Ukrainka, Berez (in order of decreasing nominal value). Taking into account all the green infrastructure (i.e., all undeveloped, vegetation covered or water areas) it will be 21 m² *per capita* for Vyshneve only, 99 m² *per capita* for Ukrainka, and 145 m² *per capita* and above for other small towns.

According to Srodnykh (2005), the quantity of green plantings for public use in most small towns of Western Siberia (Russian Federation) ranges from 1.0 to 3.3 m² *per capita*, while the standards should be 8 m2 per capita. Provision by green plantings for public use in small towns of Kyiv region ranges from 1.0–1.2 m² *per capita* (Vyshneve) to 73 m² *per capita* in Kaharlyk. The standard was observed only in one third of the considered small towns. The dynamics of provision of green plantings for public use is also negative: compared to the previous *Master Plan*, the area of green plantings for public use in Vyshhorod has decreased by 2.7 times, and the population's supply by 3.4 times. A similar situation is observed in Vyshneve. The proposed maximum limit in 4 m² *per capita* for small towns in Latvia (Luse, 1978) would currently be extremely inappropriate for small Ukrainian towns and would only accelerate green plantings for public use (primarily in the centre of parks and squares) being replaced by buildings.

5. Conclusion

Ukrainian urban planning continues to be based on urban and sanitary standards, and urban landscaping on recreational standards, while ecosystem planning for sustainable cities is a recognised European strategic approach. The lack of a comprehensive systematised and reliable information base on quantitative and qualitative indicators of landscaping

is the main obstacle to successful urban landscaping planning of Ukrainian towns.

In contrast to developed countries, Ukraine does not practice the concept of green space and green infrastructure; there is no rationing of the total number of all types of green spaces, but widespread rationing of green plantings for public use (landscaping level), which is mostly not achieved. These differences cause mistakes when comparing the rates of town landscaping in different countries. In particular, it was found that the traditional approach to the classification of urban areas into the category of green spaces significantly underestimates the value of the obtained indicators of landscaping of urban areas. The indicators of landscaping of small towns will increase significantly if we take into account all green infrastructure elements such as the area of green space of private homesteads, water surfaces, swamps and agricultural plots.

Studies have shown the shortage of green plantings for public use in the territory of small towns and the predominance of green plantings for limited use and a generally satisfactory landscaping situation in most of them.

The application of cluster distribution of small towns will allow the development of somewhat related strategies for the development of their green space systems for providing further ecologically balanced development.

Acknowledgements

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