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Mechanisms of Change in Urban Green Infrastructure—Evidence from Romania and Poland

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Abstract: The extent and continuity of green infrastructure can be adjusted by planning. Depending on the sense of the adjustment, the process can lead to a vicious cycle, resulting in poorer urban quality, or to a virtuous planning, thus leading to psychological wellbeing and sustainability. However, socioeconomic circumstances also play an important role in managing green infrastructure. Starting from these premises, the current study aims to take an in-depth look at the mechanisms of change in urban green infrastructure and provide concrete planning recommendations for dealing with the green infrastructure. It is based on a complex approach, combining an ecological design, including geo-statistical analyses of the structure and dynamics of different categories of green infrastructure in all Romanian and Polish cities covered by the Urban Atlas data during 2006–2018, with selected case studies for analyzing the deeper mechanisms and drivers of change in green infrastructure, and focusing on the role of different planning actors. The results indicate that green infrastructure was lost in all the cities analyzed, regardless of the different planning systems of the two countries. Based on this, specific recommendations can be phrased for all stakeholders of the planning process, including planners, local administrations, policy makers, and scientists.

Keywords: transitional dynamic; post-socialist countries; urban sprawl; derogatory planning; urban greenery

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1. Introduction

The problems of urban green infrastructure (GI), in particular those related to its loss and fragmentation, have been widely discussed in the literature, thereby giving us the opportunity to review numerous titles covering the past 30 years. In summary, the review emphasized that the previous studies:

1. Justify the importance of any green infrastructure by the ecosystem services provided to the human population [1–3];
2. Show that fragmentation of the green infrastructure reduces the level of ecosystem services [4–6];
3. Indicate a significant influence of urban sprawl on fragmentation [3];
4. Reduce the planning problem to the choice between compact and dispersed cities [3,7].

However, despite the large number of studies, planning implications have not been addressed too much, and there seems to be a large gap between scientific approaches and planning practice. Where do we stand at present, from a scientific viewpoint? A quick glance at the literature reveals the following:

1. The literature kicks off sometime during the late 1990s and early 2000s, when it tries to establish an academically respectable position. Early papers touch upon the urban growth process, thereby linking to an older research strand, with an already established tradition. Once integrated, the research strand on GI substantiates its role within the urban growth tradition via the ecosystem services (ES) approach. The ecosystem approach GI research seems to gain initial momentum within the late 2000s, with a substantial increase in written output over the past few years [8].
2. We can therefore infer that GI is a rewarding research topic, especially in recent times. We are therefore entitled to conduct an appraisal of the agreed body of knowledge. The rationale behind such an assessment is simple: planners need actionable information within their planning practices.
3. Unfortunately, after nearly two decades of a relatively intensive research effort, the agreed body of knowledge looks surprisingly thin. One is bound to ask why the situation presents itself bleakly. The answers seem to be manifold, and we shall turn to them throughout this article.

The main focus of this study is the relationship between urbanization, planning, and GI, because planning can sometimes turn the vicious circle around, thereby preventing the loss of GI and consequences derived from losing its ES on urban welfare and sustainability [3,9]. The detailed mechanisms of urbanization dynamics are still debated by the existing literature. Hence, Puşcaşu [10] describes a cycle consisting of: (1) expansion of housing (second/vacation house) following the abandonment of agriculture; (2) tourism; (3) changes in large cities due to socio-economic drivers; and (4) loss of traditional rural space and consequent dissolution of borders between urban and rural areas. Díaz-Palacios-Sisternes et al. [11] present a simpler process: (1) "urbanization": transformation of agricultural land into urban land, (2) "agrarianization": development of agriculture and transformation of urban land into agricultural land, and (3) "renaturalization": colonization of urban and agricultural land by nature. A similar mechanism is presented by Grădinaru et al. [12]: (1) expansion of cities over agricultural areas; (2) abandonment of agricultural land which becomes unprofitable due to size, shape, and accessibility; and (3) transformation of agricultural land into built-up areas. Accounting for the change of political regime in Romania, Ianoş et al. [13] distinguish two drivers: (1) tourism, commercial, and residential amenities during 1990–2000; and (2) metropolitan urban sprawl after. Finally, in Eastern Europe, urbanization occurs around large cities, which add natural or agricultural land to their territory and turn it into urbanized land [14–16]. A different mechanism is underlined by other studies [17,18], namely the "derogatory planning". Hence, if the previous mechanisms accounted mostly for an "urbanization by sprawl" [19,20], "derogatory planning" is responsible for urbanization within city limits, including fragmentation and transformation of GI. In summary, the mechanism consists of real estate development occurring through a series of exemptions from planning provisions (either national or municipal), favored by local authorities for different interests (usually economic). As a result, urban development causes a densification of built-up area at the expense of nature, and in most cases in worsening the living conditions of inhabitants [21,22]. Such mechanisms can generate concrete recommendations: Our previous study [3] partially filled in the gap, but it was based on general analyses that were unable to look at the changes of particular types of GI. We therefore indicated the study of these changes as a possible continuation of research.

Therefore, our aim originates in the need for correlating "ecological studies" in their epidemiological meaning [23], i.e., carried out at the level of population units (in this case, different cities or urban areas considered each one as a whole), with an in-depth analysis of individual cases, in order to discern the mechanisms affecting the urban GI. Consequently, the study plans to combine analyses looking at land cover and use changes with analyses of individual cities, to derive some concrete planning recommendations.

2. Materials and Methods

The study covers the period of 2006–2018, but focuses on the interval 2006–2012, for the following reasons: First, the start and end years were dictated by the availability of data, collected by the Urban Atlas this way. Second, the period was selected to reflect two important socio-economic trends: the real estate boom peaking in 2008, and subsequent economic decline and partial recovery. This choice correlates with the finding that socio-economic drivers are those affecting the environment [24,25].

To overcome the effects of "ecological fallacy" that usually accompany an ecological design, i.e., meaning that conclusions obtained at population level do not necessarily hold true at the individual one [26], we used two type of methods: quantitative, applied for looking at trends of transitional dynamics affecting the GI in all analyzed cities, and qualitative, for in-depth analyses of drivers determining these dynamics in selected cities. An outline of the methodology is presented in Figure 1.

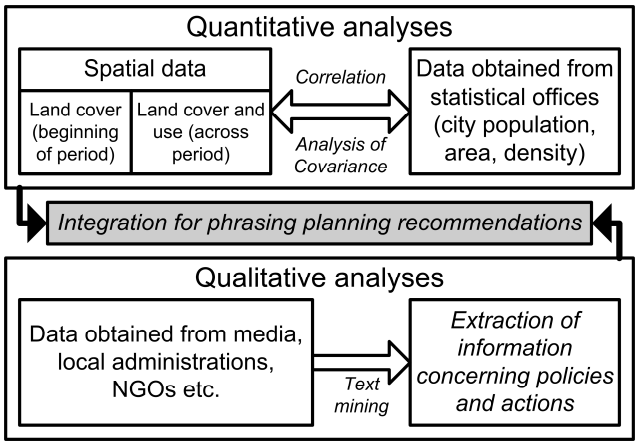

Figure 1. Outline of the study methodology, integrating quantitative and qualitative approaches to phrase planning recommendations.

The quantitative methods rely on using Urban Atlas data, appropriate for understanding phenomena specific to urban areas [27,28]. The data are freely provided in a shape file format projected to the ETRS 1989 Lambert Azimuthal Equal Area L52 M10 system [27] by the Copernicus Land Monitoring Service (https://land.copernicus.eu/ (accessed on 14 December 2020). We used the three datasets available for 2006, 2012, and 2018 land cover and use, with a resolution of a minimum mapping unit of 25 hectares and a minimum 100 m width of linear elements [29], as well as two datasets on the changes (2006–2012 and 2012–2018), with a 0.25 ha resolution for artificial surfaces and 1 ha for others [30].

The study used only Romanian and Polish cities present in the Urban Atlas datasets in 2006, 2012, and 2018, thus totaling 32 in Poland and 14 in Romania (Figure 2). As the image shows, the spatial distribution is relatively balanced from a spatial perspective in both countries. Although the Urban Atlas dataset was designed to include cities over 100,000 inhabitants, it included smaller cities, and excluded larger ones in both countries. However, our dataset was limited by the Urban Atlas selection criteria and availability of data. Moreover, since Urban Atlas data cover cities and their functional urban areas, we limited our analyses to the administrative limits of cities, such that the GI analyzed corresponds to the urban GI.

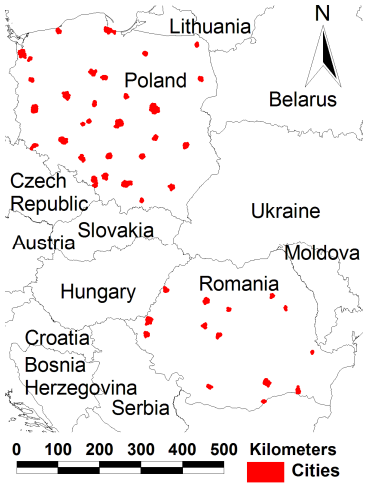

Figure 2. Cities included in the study. The sizes of the cities were enlarged for a better visualization of their position.

The methodology consisted of analyses performed using ArcView GIS 3.X and its spatial analysis extensions. First, data were converted to the Stereo 70 format and were clipped to the boundaries of administrative units. Data were recoded matching Urban Atlas categories to those of the GI [3,9,25], more specifically: 14,100—green urban areas, 14,200—sports and leisure facilities, 20,000—agricultural areas, and 30,000—natural and (semi-)natural areas. The changes for each category were coded as "loss", if land parcels labeled as GI in the beginning year had a different use in the end one, "gain" if land parcels with a different use in the beginning year became GI in the end one, or "transformation" if parcels preserved their GI label but changed their land use during the period. In addition, we reclassified the newer data, which include a more detailed classification of agricultural areas, and natural and (semi-)natural areas, to match the previous ones, in order to permit comparisons. Recoded polygons were dissolved for each city, computing the total area affected by each process, using the X-Tools extension of ArcView GIS 3. To overcome the differences due to city size, the area occupied by each category or the changes affecting it were expressed as a share of the GI or as a share of the area affected by changes of the GI, respectively.

Additional data from the statistical yearbooks were collected for each city, especially concerning its population. The administrative boundaries were used to compute the city area using the X-Tools extension of ArcView GIS 3. The additional data, including the city population, area, and density (computed based on the others) were used in analysis of co-variance (ANCOVA) looking at the dependence of the status parameters (area of each category of GI) and process ones (gain or loss of each category and transformation) on the additional variables. In addition, we tested whether the loss for each category depended on the total area covered by that category in the first year of each period. The choice of ANCOVA over multiple linear regression was justified by the fact that in addition to the numerical variables, differences were also sought by country and period, which are categorical variables. In addition to ANCOVA, correlation analyses were performed for all variables.

All statistical analyses were run at two levels of significance: 0.05, characteristic to all disciplines, and 0.1, used in environmental sciences and occasionally in other fields. The latest corresponds to an "uncertainty area" due to a reduced sample size. Hence, if significant results are detected at this level, it is likely that additional analyses, performed on larger samples, would yield results significant at the 0.05 threshold.

Provided that the statistical analyses revealed significant differences between the two countries, separate analyses were run for each country apart and overall.

Qualitative analyses compared representative case studies selected from each country, relying on information from official sources (public administrations, official statistics, and scientific literature) and mass media, in terms of their performance. Media sources included both "official" versions (i.e., pure media—newspapers, radio, or television, or official media releases of local administrations) and sources reflecting the perspective of different civil society stakeholders, especially NGOs. All sources are cited as references. We have selected two case studies from Poland (Konin and Lublin) and four from Romania (Bucureşti, Cluj Napoca, Giurgiu, and Oradea). The reason is that Polish cities were found to be on average twice as large than the Romanian ones [3], and Polish planning conditions are identical for all cities. Thus, we felt the need to include smaller cities, which were found only in Romania. Moreover, we attempted to select "well doers" and "poor performers" from among Romanian cities.

3. Results

3.1. Quantitative Analysis

Tables 1 and 2 and Figure 3 depict analyses of the structure of GI, and Table 3 shows its dynamics. The analyses describe the influence of potential drivers, based on the results of the analysis of co-variance. The Annex found in the Supplementary Materials includes two tables showing the correlation of all variables, i.e., Tables S1 and S2. In addition to the statistical analyses. In addition to the statistical analyses, Table 4 displays an overall comparison of the loss of different categories of the GI across the two periods and counties.

Table 1. Variables influencing the structure of GI categories in Romanian and Polish cities covered by Urban Atlas data. The table displays the p value associated with each relationship, using the following notations: **Bold**—significant, $p \leq 0.05$; *Italic*—significant, $p \leq 0.1$; Regular—not significant, $p > 0.1$.

Independent Variables	Dependent Variable			
	Green Urban Areas	Sports and Leisure	Agricultural Areas	Natural and (Semi-)Natural Areas
1. Overall				
Country	**<0.0001**	**<0.0001**	**<0.0001**	**0.0164**
Year	0.6389	0.7335	0.5020	0.5959
Area	**0.0301**	**0.0493**	*0.0813*	0.1875
Population	0.1617	0.3566	0.4706	0.4542
Density	**<0.0001**	**<0.0001**	0.2877	0.7733
2. Poland				
Year	0.9049	0.7772	0.6193	0.7028
Area	**0.0306**	*0.0564*	**0.0008**	**0.0039**
Population	0.7377	0.1531	**0.0169**	**0.0298**
Density	**<0.0001**	**<0.0001**	**0.0475**	0.3868
3. Romania				
Year	0.1316	0.8289	0.7811	0.8095
Area	0.4695	0.1739	**0.0005**	**0.0007**
Population	**0.0055**	0.3646	**0.0027**	**0.0059**
Density	**<0.0001**	**0.0141**	**0.0196**	**0.0018**

Table 2. Distribution of the GI across the different categories (14,100—green urban areas, 14,200—sports and leisure, 20,000—agricultural areas, and 30,000—natural and (semi-)natural areas) in Romanian and Polish cities covered by Urban Atlas data. The values represent the share of the area of each category from the total GI area per city.

	Green Urban Areas	Sports and Leisure	Agricultural Areas	Natural and (Semi-)Natural Areas
Poland				
Białystok	9.84	10.46	40.55	39.15
Bydgoszcz	3.64	5.50	34.78	56.09

Table 2. *Cont.*

	Green Urban Areas	Sports and Leisure	Agricultural Areas	Natural and (Semi-)Natural Areas
Poland				
Częstochowa	4.05	3.83	79.08	13.05
Gdańsk	5.84	7.62	51.61	34.92
Gorzów Wielkopolski	7.03	7.58	69.00	16.39
Jastrzębie-Zdrój	4.58	2.66	77.23	15.53
Jelenia Góra	1.65	3.54	46.24	48.57
Kalisz	2.96	3.48	85.89	7.67
Katowice	5.81	3.69	15.11	75.39
Kielce	3.81	5.80	51.38	39.01
Konin	3.28	4.22	79.02	13.48
Koszalin	3.74	4.52	42.16	49.58
Kraków	9.65	4.63	73.42	12.30
Łódź	7.19	6.53	62.56	23.72
Lublin	8.36	7.24	62.11	22.29
Nowy Sącz	1.74	3.87	62.92	31.47
Olsztyn	7.62	6.02	35.67	50.69
Opole	2.58	2.80	77.39	17.22
Ostrów Wielkopolski	3.44	8.93	63.92	23.71
Pabianice	4.77	4.49	73.46	17.28
Płock	4.30	6.25	64.59	24.86
Poznań	12.46	7.74	49.28	30.52
Radom	4.00	4.38	76.76	14.87
Rybnik	1.22	1.93	37.97	58.88
Rzeszów	3.51	4.88	80.74	10.87
Stargard	3.14	9.04	71.03	16.79
Suwałki	1.21	2.74	75.01	21.04
Szczecin	6.74	10.91	37.20	45.15
Toruń	8.03	7.32	30.45	54.20
Warszawa	12.50	9.11	38.51	39.88
Wrocław	7.08	12.28	63.98	16.66
Zielona Góra	0.86	2.17	28.20	68.78
All cities (average)	5.21	5.82	57.41	31.56
Romania				
Alba Iulia	0.78	0.24	69.33	29.65
Arad	1.19	0.34	91.98	6.49
Bacău	6.92	3.35	74.76	14.96
Brăila	9.36	2.34	78.14	10.16
Bucureşti	19.82	5.62	63.66	10.90
Călăraşi	0.48	0.22	89.85	9.45
Cluj Napoca	1.43	0.61	74.71	23.24
Craiova	6.45	2.33	80.44	10.79
Giurgiu	1.62	0.46	76.96	20.95
Oradea	2.53	0.62	91.89	4.96
Piatra Neamţ	0.43	0.63	34.99	63.95
Sibiu	1.41	0.97	68.47	29.15
Târgu Mureş	2.49	5.57	50.19	41.76
Timişoara	3.30	1.96	86.45	8.29
All cities (average)	4.16	1.80	73.70	20.34
All cities and countries (average)	4.89	4.60	62.37	28.15

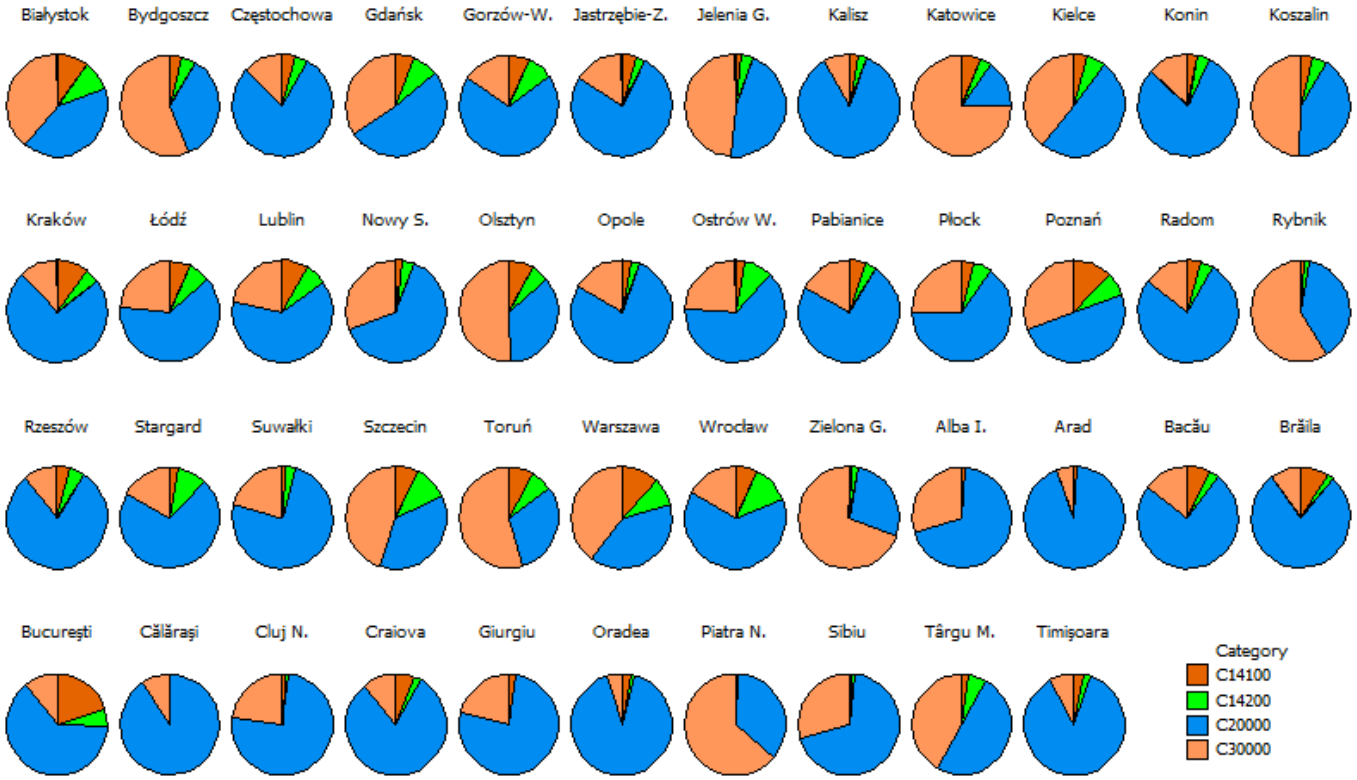

Figure 3. Distribution of the GI across the different categories (14100—green urban areas, 14200—sports and leisure, 20000—agricultural areas, and 30000—natural and (semi-)natural areas) in Romanian and Polish cities covered by Urban Atlas data. The graph is built based on the average values in 2006, 2012, and 2018, respectively.

3.2. Qualitative Analysis

To explore the drivers of change in more depth, the analysis continued with several representative case studies from each country (Konin and Lublin in Poland, and Bucureşti, Cluj Napoca, Giurgiu, and Oradea in Romania), based on data from the media, official statistics, or scientific literature, which can explain the processes affecting local GI. Several characteristics of the cities are displayed in Table 5.

3.2.1. Romania

We attempted to select "well doers" and "poor performers" from among Romanian cities. Hence, we have chosen two typical examples of Romanian small cities, Giurgiu and Oradea, and two large ones, Bucharest and Cluj-Napoca. Nevertheless, the structure and dynamics of their GI differ, as well as other features. Giurgiu stands out as the only city where the GI did not suffer any transformations during 2006–2012; Bucharest has the smallest share of GI (dominated by green urban areas—highest share among all case studies), and Cluj-Napoca the largest, even compared to all case studies, including the Polish ones. Bucharest also has the highest density. Finally, the GI of Oradea and Giurgiu is dominated by agricultural areas.

Table 3. Variables influencing the gain and loss of GI categories in Romanian and Polish cities covered by Urban Atlas data. The table displays the *p* value associated with each relationship, using the following notations: **Bold**—significant, $p \leq 0.05$; *Italic*—significant, $p \leq 0.1$; Regular—not significant, $p > 0.1$.

1. Overall	**Dependent Variable**										
Independent Variables	**Green Urban Areas**		**Sports and Leisure**		**Agricultural Areas**		**Natural and (Semi-) Natural Areas**		**Transformation**	**Total Gain**	**Total Loss**
	Gain	**Loss**	**Gain**	**Loss**	**Gain**	**Loss**	**Gain**	**Loss**			
Country	0.8414	0.6825	*0.0628*	0.2250	0.4820	**0.0254**	0.3140	0.7181	*0.0941*	0.6837	0.1687
Year	0.6532	**0.0011**	0.2102	0.8518	0.4377	**<0.0001**	**<0.0001**	0.4206	0.1441	**<0.0001**	0.5066
Area	0.9995	0.8110	0.5498	0.9647	0.9741	0.3471	0.7064	0.4986	0.2371	*0.0543*	**<0.0001**
Population	0.7500	0.2653	0.2379	0.6296	0.4571	0.2506	0.4186	0.4788	0.9103	0.6661	0.9756
Density	0.4096	0.2726	0.1575	0.3812	0.8754	*0.0532*	0.3519	0.4828	0.4384	0.5339	0.4182
Initial total area	–	**0.0004**	–	**0.0001**	–	**0.0015**	–	**0.0350**	–	–	–
2. Poland	**Dependent Variable**										
Independent Variables	**Green urban Areas**		**Sports And Leisure**		**Agricultural Areas**		**Natural And (Semi-) Natural Areas**		**Transformation**	**Total Gain**	**Total Loss**
	Gain	**Loss**	**Gain**	**Loss**	**Gain**	**Loss**	**Gain**	**Loss**			
Year	0.5330	**0.0005**	0.3687	0.8864	0.4829	**<0.0001**	**0.0003**	0.5784	0.1637	**0.0005**	0.9834
Area	0.6921	0.8668	0.8849	0.7543	0.6828	0.3874	0.9952	0.3337	**0.0301**	*0.0934*	**0.0008**
Population	0.7451	0.5526	0.8068	0.5360	0.4936	0.2347	0.7810	0.3865	0.1490	0.7630	0.4698
Density	0.7001	0.6654	0.9734	0.3235	0.9975	0.2695	0.5118	0.7713	0.6297	0.3974	0.0537
Initial total area	–	**0.0044**	–	**0.0009**	–	**0.0050**	–	**0.0187**	–	–	–
3. Romania	**Dependent Variable**										
Independent Variables	**Green Urban Areas**		**Sports And Leisure**		**Agricultural Areas**		**Natural And (Semi-) Natural Areas**		**Transformation**	**Total Gain**	**Total Loss**
	Gain	**Loss**	**Gain**	**Loss**	**Gain**	**Loss**	**Gain**	**Loss**			
Year	0.9662	0.7782	0.3254	0.4380	0.7763	**<0.0001**	0.0397	*0.0606*	0.6268	**0.0138**	0.2157
Area	0.8202	0.9313	0.8749	0.8025	0.4396	0.2342	0.8730	0.3735	0.6867	0.1531	**0.0367**
Population	0.6677	0.3218	0.2686	0.2093	0.9208	*0.0912*	0.5502	0.5248	**0.0176**	0.8931	0.8408
Density	0.4138	0.5720	0.1279	0.7637	0.7300	**0.0303**	0.5380	0.6001	0.5778	0.5764	0.9159
Initial total area	–	0.1917	–	0.8992	–	0.7659	–	0.5430	–	–	–

Table 4. Overall loss of different categories of GI categories across the two periods and counties in Romanian and Polish cities covered by Urban Atlas data. The table displays the average share of each category in the total loss of GI.

Period	Category	Poland	Romania	Overall
2006–2012	Green urban areas	3.9474	1.5187	3.2083
	Sports and leisure	1.1086	0.1366	0.8128
	Agricultural areas	88.9037	97.4752	91.5124
	Natural and (semi-) natural areas	6.0402	0.8695	4.4665
2012–2018	Green urban areas	1.0691	1.6006	1.2308
	Sports and leisure	1.3190	0.2404	0.9908
	Agricultural areas	6.2796	19.4738	10.2952
	Natural and (semi-) natural areas	5.1993	9.8599	6.6177
2006–2018	Green urban areas	2.5082	1.5597	2.2196
	Sports and leisure	1.2138	0.1885	0.9018
	Agricultural areas	47.5917	58.4745	50.9038
	Natural and (semi-) natural areas	5.6197	5.3647	5.5421

Table 5. Data for the individual case studies included in the qualitative analyses. The table displays physical and demographical characteristics and the dynamics of GI.

City	Konin	Lublin	Bucureşti	Cluj Napoca	Giurgiu	Oradea
Country	Poland	Poland	Romania	Romania	Romania	Romania
Area (km^2) in 2006	82	147	162	88	22	77
Area (km^2) in 2012	82	147	238	93	30	79
Area (km^2) in 2018	82	293	240	105	30	82
Population in 2006	80,471	353,483	1,931,236	305,620	69,479	205,956
Population in 2012	77,847	347,678	1,883,425	324,576	61,353	196,367
Population in 2018	74,151	342,039	2,121,794	324,267	67,402	221,398
Density (per km^2) in 2006	981	2405	11,958	3467	3226	2668
Density (per km^2) in 2012	949	2365	7918	3483	2022	2483
Density (per km^2) in 2018	904	2339	8840	3091	2221	2706
Share of GI (%) in 2006	57	60	29	75	57	62
Share of GI (%) in 2012	56	54	27	73	56	58
Share of GI (%) in 2018	55	52	27	70	56	56
Fragmentation of GI during 2006–2012	No	No	Yes	Yes	Yes	Yes
Fragmentation of GI during 2012–2018	Yes	No	Yes	Yes	Yes	Yes
Gain of GI during 2006–2012	Yes	No	Yes	Yes	Yes	Yes
Gain of GI during 2012–2018	Yes	Yes	Yes	Yes	Yes	Yes
Loss of GI during 2006–2012	Yes	Yes	Yes	Yes	Yes	Yes
Loss of GI during 2012–2018	Yes	Yes	Yes	Yes	Yes	Yes
Balance (gain/loss) of GI during 2006–2012	Loss	Loss	Loss	Loss	Loss	Loss
Balance (gain/loss) of GI during 2012–2018	Loss	Loss	Loss	Loss	Loss	Loss
Transformation of GI during 2006–2012	Yes	Yes	Yes	Yes	No	Yes
Transformation of GI during 2012–2018	Yes	No	Yes	Yes	Yes	Yes
Average share of green urban areas (%)	3	8	20	1	2	3
Average share of sports and leisure (%)	4	7	6	1	0	1
Average share of agricultural areas (%)	79	62	64	75	77	92
Average share of natural and (semi-) natural areas (%)	13	22	11	23	21	5

Giurgiu and Oradea were former industrial cities, which experienced a marked decline in industrial activity between 2006 and 2012, and, along with it, a decrease in population, which was more dramatic in Giurgiu (from 69,479 to 61,353—12%), but also present in Oradea (from 205,956 to 196,367—5%). During the next period, both cities witnessed an increase in population (to 67,402—10% in Giurgiu, and 221,398—13% in Oradea). However, the fate of industry differs in each city. In Oradea, the first industrial parks were created in 2008; they are among the few ones created in Romania thus far, and according to the definition of GI, their creation corresponds to adding new GI to the existing one. This is not something created formally; the inner regulations of industrial parks (Eurobusiness II used as an example—[31]) has clear provisions on the creation and maintenance of

green spaces covering 25% of the park area. In addition to the industrial park, the public administration of Oradea has taken concrete actions, including and without limiting to, planting 23,207 trees during 2009–2019, to compensate for the 7475 cut off during the same period [32], and by the creation of 20 new landscaped green spaces in 2011 [33]. The trend continued with the creation of 8 hectares of new green spaces in 2015 [34] and another 10 in 2018, through conversion of degraded land, using European funding [35]. Giurgiu also witnessed some incentives of the local administration that consisted of creating five green spaces totaling 8000 m^2 in 2009 [36], but most likely, the changes are due to the abandonment of its industry and colonization of abandoned spaces by vegetation, as well as by landscaping the exit route to Bulgaria, which is situated on the administrative territory of Giurgiu. Apart from this, Giurgiu is referred to by the media as a city with poor green spaces [37,38].

On the opposite side, the case of Bucharest can serve as a good example of a city where planning does not seem to account for the GI. The latest Master Plan of Bucharest was approved in 2000, and its validity was extended to 2010 by the City Hall. The new Master Plan is still in the preparatory phase, although each city must renew its plan every 10 years, at most, according to the Romanian legislation. The provisions of the 2000 Master Plan included the creation of a "yellow-green belt", consisting of existing forests and agricultural areas of neighboring rural settlements. The green belt was never created; instead, small businesses built up their facilities around the belt line, and neighboring rural settlements lost their agriculture and rural functions, turning into residential areas for the citizens of Bucharest who, due to social and economic reasons, switched from living in large housing estates built in the socialist period to individual housing, bought and modified or built up from scratch. At the same time, the restitution of properties, a process formalized in 2005 by the creation of a specialized agency, resulted in accelerating this process, but also ended by transferring important portions of parks to former owners, who turned them into restaurants or other facilities. Another consequence was that the price of real estate increased. It is even hard to know the total area of green spaces. A study carried out under the framework of the Swiss–Romanian cooperation program points out that the area of green spaces per capita "increased" from 3 m^2 in 2007 to 23.21 m^2 in 2011 without creating any new green space, but accounting for the private ones [39]. Overall, the problem of Bucharest is that its Master Plan, initiated in 2013 and due in 2016, was not finalized; however, the previous (and obsolete) plan was modified by numerous plans for smaller areas, disregarding the requirements providing for green spaces, among others [40]. As a result, in the lack of clear-cut regulations, new developments are continuously shrinking the existing green spaces; numerous examples are presented by the media, which depict the situation as disastrous [41,42].

A somewhat different situation is found in Cluj. Here, during the first stage, the city began losing an increasing number of landscaped squares or green open spaces to the erection of filling stations, churches or bank offices, with land leases increasing throughout the 1990s. A second stage followed closely in the early 2000s, when relatively large swathes of parks were transformed into housing estates or large-scale shopping centers, thereby almost completely voiding the provisions of planning documents endorsed during the socialist period. This second stage resulted in an overall 30-hectare decrease in the total green area of the city. During the 2010s, a new generation of planning documents struggled to increase the green area ratio per capita, in an attempt to compensate for the losses experienced during previous decades. When artificial increases were sought out, such as declaring green spaces on private properties, litigations soon followed, and the practice was dropped. A third stage became manifest a few years ago, when the Municipality began organizing urban design competitions, a practice that has by now become customary. This latest period is by far the most interesting, as it tackled not only the overhaul of existing green open space network, but it tentatively began pursuing its gradual expansion. However, the status of the city in the media with respect to the GI is controversial; two articles published in 2018 stated that, based on the data from the statistical office, Cluj-Napoca

was well positioned with respect to the green space per capita, with 25.8 m^2/inhabitant, close to the European Union limit (26 m^2/inhabitant), surpassing Bucharest, with only 21 m^2/inhabitant, but continues to state the need for urban green spaces, as only two of them, landscaped in 2014, were functional [43]. The same lack of landscaped green spaces is pointed out in a second article, showing that some of the landscaping projects were not implemented, and the city lacks true and functional green spaces [44], and by a study carried out under the framework of the Swiss–Romanian cooperation program, which points out the lack of interest for the landscaped green spaces [45].

The situation of these last two cities must be understood against the background of the general trend during the study period in Romania, especially in large cities. The year 2008 was the peak of a real estate bubble that had started earlier, followed by a drop in property prices. For example, based on real estate data, the price of a three-room apartment from the socialist period in Bucharest increased from 63,805 euros in 2006 to 146,678 in 2008 and then dropped down to 70,783 until the end of 2012 [46]. This increase has to be interpreted in the particular context of Romania, where 96% of people own the homes they live in, this being the highest share in Europe, and only 4% (compared to 30% EU average) live in a rented house or apartment [47], and prices in Bucharest are higher than the Romanian average (1413 euro/m^2 compared to 1341 euro/m^2 in 2019—[48]), with prices in central areas equaling those in Paris or London [49]. At the same time, prices in Cluj-Napoca are even higher on average (1900 euro/m^2 [48]). Because of the real estate boom, former owners turned the restituted property, usually a house with some green space or a parcel of land, into a larger unit, thereby using up almost the entire land.

3.2.2. Poland

In the case of Polish cities, Lublin and Konin were selected for a more detailed analysis. These two cities differ in the nature of the socio-economic processes taking place, including the level of involvement of the local community.

Lublin is one of the least green large Polish cities with a rather limited access of inhabitants to greenery and a relatively high level of GI fragmentation, mainly due to the small share of forests and tall greenery (about 11% of the city area) [50]. This is probably the reason why GI is perceived as one of the most valuable elements of the city's ecosystem. Shaping a coherent system of greenery and improving residents' access to it are goals included in the city's development strategy [51]. The city authorities yield a great importance not only to the protection of forests and revitalization and development of urban GI (in the last decade a total of 72 hectares of green areas have been created and revitalized, including, for example, the construction of Park Czuby), but also to the social participation in the process. Therefore, residents, supported by the activities of non-governmental organizations for the protection of trees and development of urban GI (e.g., the Lublin City Movement—City for People, fighting for the preservation of every tree in the city), play an extremely important role in shaping the urban GI [52]. Activating positive GI processes is not easy, as Lublin is currently the most rapidly developing metropolis in Eastern Poland and one of the most attractive places to live and do business in the whole country. However, at the beginning of the period of economic and social transformation initiated in Poland in 1989, the city was characterized by insufficient industrial development, which resulted in a comparatively low level of performance, as pointed out by economic indicators. However, this backwardness turned out to be an asset in the post-industrial transformation. Although in the period under study, similar to most Polish cities, Lublin lost population (population loss was 1.74% from 2006 to 2012 and 2.38% from 2012 to 2018) and had an average level of economic development; in 2006–2010, it became one of the fastest developing cities in Poland. Despite the global crisis, economy increased significantly in the city, and the growth of the number of businesses was one of the largest among major Polish cities [53]. The effect of economic changes was a gradual increase in the wealth of residents and in the accompanying investment pressure. This pressure, combined with weaknesses of the spatial planning legislation, caused a loss of GI. This loss was primarily related to the felling

of trees accompanying the implementation of different types of investments (e.g., road reconstruction, construction of roundabouts, new housing estates, shopping malls etc.) [54]. The loss of fallen trees was unfortunately not fully compensated by planting new ones. For this reason, Lublin lost green areas and stopped the fragmentation processes.

Konin, in turn, is a typically industrial town, which owes its development to the exploitation and processing of brown coal. The city has experienced a particular transformation of the political system, manifested by a progressive, dynamic decline in population (by 3.26% in 2006–2012 and 4.75% in 2006–2018), steady number of businesses, high unemployment, and a significant decrease in the average salary compared to the national average (from 96,3% in 2006 to 93% in 2012). The unfavorable trends during this period were caused by a progressive restructuring of its economy and group mass layoffs among the city's inhabitants. As a result of these demographic and economic processes, in Konin the development pressure was not too high (only slightly more than 500 new apartments were added between 2006 and 2012, and between 2012 and 2018—830). The attention of local authorities was primarily focused on the modernization and expansion of the road network and inclusion of new areas for economic activation in the communication system. These activities have been major contributors to the loss and progressive fragmentation of green spaces, which was not counteracted by the passive and poorly organized residents, connected only to a small extent with the inhabited city (largely immigrant population, recruited to work in industry). However, the positive side consists of the creation of new GI. As a result of reclamation and revitalization activities, operations parks (Park 700-lecia, Park Ojców), recreational amenities (tennis courts, playgrounds, playgrounds, and sport halls), allotments, arable fields and afforested areas were created in the regions of three former open-pit mines, which to some extent blurred the mining history of the city [55]. These activities resulted in an increase in forests (123%), street alignments (by 72 ha), and parks, greeneries, and private house green spaces (by 30 ha) [56].

Therefore, the processes taking place in Lublin and Konin are different, and conditioned by the specificity of economic development, but also, and perhaps most importantly, resulting from the characteristics of local communities. Everything seems to indicate that the positive example of Lublin is largely due to its inhabitants forming a community, and not just a collection of residents. Only a community was able to quickly "find itself" in new political conditions, aware of the role of GI in the city, capable to organize itself and take bottom-up initiatives to protect the GI, and to build up an important social capital in sustainable urban development. However, local authorities also played a role in this success, attaching great importance to both the protection of green spaces from fragmentation and the public participation processes. Conversely, the case of Konin, representing a center of traditional mining industry preferred during the socialist period, reveals a community passively waiting for the public authorities to provide them with jobs and a higher life quality. The inhabitants of Konin are largely characterized by the lack of activity and entrepreneurship, and an unwillingness to undertake bottom-up initiatives. In turn, local authorities, wanting to improve the image of the city and make it a more attractive place to live, focused their attention not only on job creation and the implementation of "hard" investments, but also on the rehabilitation and organization of new GI elements.

4. Discussion

4.1. Quantitative Analysis

Our findings indicate that agricultural and natural areas make up the largest share of urban GI (best seen in Figure 2). With several exceptions (mostly in Polish cities), one of them dominates the other, but the other landscaped areas (green urban areas and sports and leisure facilities) rarely sum up to 25% of the urban GI. The dynamics of GI seem to vary mostly by the country and year, at least with respect to the gain and loss of some categories, but also overall. In more detail (see Table 4), during 2006–2012, Polish cities lost more landscaped GI and natural areas, but Romanian cities lost more agricultural land, and during 2012–2018, the trends reverted. The city area seems to influence only the total gain

and loss, which is consistent with previous findings [3]. However, the loss of GI seems to be influenced to a great extent, for each category, by the share of this category in the beginning of the period. This means that the well-represented categories tend to lose more than the less-represented ones. In addition, the analyses did not reveal many significant predictors for the landscaped green spaces (green urban areas and sports and leisure facilities). We suspect that their reduced share makes it hard to distinguish the drivers of their loss or gain, compared to the dominant categories (agricultural and natural areas). On a similar note, the loss seems to depend on some of the predictors accounted for (population and density), while the gain seems to be less influenced by them. This might indicate that the urban social metabolism tends to consistently eliminate the GI, while its gain is mostly due to random causes.

Our analysis differentiates between large cities and small ones, the latter having a closer status to rural settlements. Large cities have a well-represented landscaped GI, corresponding to the third type of city nature described by Kowarik [57]. Small cities preserve in their structure agricultural areas [58], and these are the first to be lost when the city increases; some are compensated for by the newly created landscaped areas. However, the loss is proportional to the share of each category, suggesting that the process is irrespective to the type of GI.

Similar to our previous study [3], we also found many inconsistencies. To cite an example for each analysis, natural and (semi-) natural areas are influenced by the density of population in Romania, but not in Poland and overall; natural and (semi-) natural areas seem to be significantly inversely correlated with the total area of the city in Romania, marginally significantly positively correlated to it in Poland, and not correlated overall; the loss of agricultural areas is significantly influenced by density in Romania and marginally significantly overall, but not influenced in Poland; and the transformation of GI is significantly positively influenced by population in Romania and overall, but not in Poland. While it would be easy to blame the small sample size for such differences, all the examples above show significant values in Romania, where the sample size is the smallest (14 cities). Therefore, it is sounder to explain them by the variability of phenomena rather than considering them statistical fluctuations.

Similarly, there seem to be variables which correlate with almost all others (e.g., population, for the analysis of the structure of GI, and total gain of GI, least in Romania, for the analyses looking at its change), and variables that do not correlate with any others, in the case of analyses looking at the changes of GI, e.g., gain of green urban areas). Particularly in the case of the latest analyses, the predictors (area, population, and density) and overall transformation, gain and loss seem to be the most correlated (almost all possible pairwise correlations are significant). Again, these results indicate that it is easier to obtain the overall picture, similar to our previous study [3], but the detailed mechanisms of change are more contextual and harder to generalize.

In brief, despite the many variations, indicating the contextual nature of changes, we were able to show that natural and agricultural areas are the most represented components of the urban GI. The latest tends to diminish its size on a rural-urban gradient. The size, population, and density of cities can play an important role in explaining the loss of different GI categories, but the gain and transformation are less predictable. Most importantly, the loss of GI, regardless of the category, is a generalized phenomenon, and its intensity varies, for each category, with its share in the total urban GI.

4.2. Qualitative Analysis

4.2.1. Romania

Against the individual cases, we can distinguish some salient features of planning practices: in a first phase, socialist planning documents fall into disrepute and their provisions are either eroded gradually or voided completely, through a plethora of lower-rank planning documents explicitly geared toward exacting derogations from higher-ranking plans. In a second stage, planning documents aim at protecting the existing network of

open green spaces, while at the same time experimenting with various methods for increasing the overall surface of green areas. When litigations follow, experiments are halted. In a third stage, the provisions within planning documents become subject to national or international competition, thereby seeking a higher degree of validation from the general public. It is definitely too soon to tell, but the practice of organizing urban design and urban planning competitions might well engender a reform within the current architecture of the Romanian planning system.

It is also important to analyze another particular aspect of Romania. One could question the role of people, communities and organizations involved in the process. All these stakeholders do not play an important role in Romania, and our discussion focuses mainly on local administrations and business pressure. Citizens do not play an important role, and their reactions seem limited to protesting against trees being cut off by municipalities in Bucharest [59] or Iași [60], or initiating online petitions in Bucharest [61], with limited success. The reasons are a combination of the fact that, in Romania, citizens are less organized in making up one single voice for their issues, and authorities are generally less prone to listen to them. Nevertheless, if this is the case of population alone, NGOs were more successful; "Save Bucharest" (Salvaţi Bucureştiul in Romanian), an NGO founded in 2008, adopted the legal path and announced in 2020 winning its 166th lawsuit against Bucharest City Hall [62].

Three lessons can be learned from the Romanian case studies. One is that the "winning" cases for GI are those where public administrations got involved or the process occurred naturally, due to the lack of intervention; however, these are the exceptions. The second one shows that the general "rule" of greed for profit applies, especially when analyzing phenomena through the lens of land price, generated a spontaneous urbanization. The real estate crisis slowed down the process after 2008 [25], but overall effects could not be diminished in the least. The third is that planning documents adapt, as Municipalities face inherent weaknesses of the Romanian planning system and search for new ways of gaining legitimacy for their planning actions.

4.2.2. Poland

Unfortunately, in all analyzed Polish cities, the loss and, consequently, a negative balance of GI occurred, and the vast majority of cities also experienced its fragmentation. The functional and spatial conflicts between the needs of public interest (represented by the city) and those of individual interests (often including development companies interested only in short-term profit, and not the well-being of residents) were, among others, due to the expectation of destination for development, mainly residential, of all categories of areas in the city, including the agricultural and green ones. The main source of conflict was the lack of adequate coverage of the city with spatial development plans (their drafting is optional) and launch of further investment areas through non-planning tools, such as decisions on development conditions, often detrimental to the city (interference with land reserved for roads, green areas necessary to maintain a high quality of life, areas designated for conservation, etc.) [63–65]. From 1 January 2017, the difficult situation was significantly worsened by the amendment to the provisions of the Nature Conservation Act, which abolished, among other things, obligation to obtain a permit to cut trees on private real estate (the so-called "Lex Szyszko"—the name of the minister responsible at that time for environmental protection). The law was tightened again on June 17 of the same year, but for half a year, there was massive felling of trees, causing significant losses in tree cover in practically all Polish cities [66].

In Poland, planning conditions are identical for all cities. Therefore, changes in the scope of urban greenery are determined by actions of local authorities (first of all, they are responsible for deciding which areas will be covered by spatial development plans allowing for the protection of GI) and bottom-up actions taken by inhabitants. For this reason, all Polish cities need a substantial improvement of their spatial policy. Without it, they are at

risk of increasing spatial chaos [67], of a gradual loss of natural assets, and of fragmentation of ecological corridors under the pressure of short-term goals of the investors.

4.3. Lessons Learned from the Study

Before proceeding to sketching our recommendations, we need to pause for a moment and frame the limitations that have become prominent while conducting this research exercise. Generally speaking, the data and methodology produced significant results. Nevertheless, it is local variations and the failure to ascertain the exact degree of influence these driving forces have on GI that render these limitations explicit. In short, they are the following:

1. The methodology needs more fine tuning to improve statistical significance. This is, however, easier said than done. To illustrate this point, please consider the following data-related issue: the frequency of land cover and land use data are low. Hence, while the Urban Atlas demonstrated its suitability for performing comparative analyses of changes, its temporal span does not allow for highlighting the intrinsic mechanisms of these changes.
2. To complicate things even further, there are some additional limitations that affect the methodological exercise proper. They are the following:
    - Mathematical constraints apply to modeling complex processes describing the dynamics of the GI. Hence, it is difficult to achieve both intuitive clarity and statistical power.
    - The ecological fallacy characterizing ecological studies could cast a doubt on the validity of results. More precisely, even if local influence of the driving forces could be determined if available data were available, there will be always a doubt that aggregated data reflect appropriately each particular case of fragmenting, losing, or changing of the GI.

5. Conclusions and Recommendations

In summary, we found out that the loss of GI is a generalized phenomenon, but its intensity varies with the different categories. Large cities have a GI dominated by natural areas, which are parts of the surrounding natural areas incorporated by them as they grow. Smaller, rural-like towns are dominated by agricultural areas, which tend to shrink as the towns evolve into large and complex cities. Consequently, most urban areas have an infrastructure consisting mainly of agricultural or natural areas, while the landscaped spaces make up only a small share. The loss of GI is uniform and generalized to all investigated cities, and most likely common to other cities not included in our study, but the loss is proportional with the share of each category. While the most important drivers seem to be the city population and its density, the process is influenced, as the case studies indicate, by a local "culture" of administration or citizens in terms of dealing with the GI. The main actors seem to be public administrations in Romania and city dwellers in Poland. However, civil society and city dwellers seem to be more organized in Romania in recent years too, while adopting legal tools in order to make public authorities listen to their voice. Finally, plan coverage seems to play an important role in Poland too, namely, the insufficient level of coverage of cities by plans. Overall, the study confirmed previous results in terms of the overall findings (generalized loss of the GI) but revealed the fact that inner mechanisms are contextual and therefore hard to generalize, as indicated by the statistically significant fluctuations by country and period, although we were able to reveal that most losses account for natural and agricultural areas.

Against the background defined by our findings, we can now venture to make a series of recommendations for planning practitioners. We have conceived these recommendations in a generalized way, as they are applicable to other countries experiencing similar planning issues, such as the central-eastern European ones. However, they apply first to Poland and Romania, and, due to this reason, we have phrased specific recommendations for these countries wherever appropriate. In short, in both Romanian and Polish planning systems,

GI elements are not adequately protected. All planning studies should introduce provisions and solutions for protecting and restoring the environment.

However, the two countries fare differently: In Poland, there is no national document defining directions for spatial planning, at least for the time being. Hence, there is no framework for buttressing spatial policies relevant to GI. In addition, plan coverage at the local level is low, with only about one- third of the country covered by plans. At the time of writing, plans remain optional. Against this background, urban development is managed via administrative decisions, which tend to encourage circumvention. Hence, with plans remaining optional, there are both substantive and procedural barriers to successful GI implementation in the planning practice. Any recommendation will therefore require either a structural change within the Polish planning system, or an incremental improvement in the performance of administrative decisions.

In Romania, the legal framework is there, but the problem is practical: There are no dedicated and precise planning instruments, aimed at ensuring GI critical mass and continuity in real estate development. Simply put, planners and developers do not have readymade prescriptions for creating viable and scalable GI. In addition, there is no comprehensive analysis of Romanian zoning and building regulations aimed at highlighting provisions that work against the creation of GI. Hence, the problem here is merely procedural and could easily be solved by producing scientifically and legally informed planning and design manuals.

Consequently, we propose the following preliminary recommendations, which require a considerable amount of good will from planning practitioners:

1. Consistent formation of the urban GI system, which would ensure the maximum area and compactness (compact shape) of its elements, their spatial continuity, and connection with suburban green areas. The process is possible in Romania, where guidelines for drafting plans exist, but they are outdated; updating them is the easiest solution. However, Poland lacks such tools; the study revealed their need, and they can be developed accounting for the GI from the beginning.
2. Preserving the system's continuity by integrating remnants of natural environment in the urban structure, usually including the water system, and preserving adjacent natural and semi-natural areas. This can also be achieved via the guidelines for developing plans described above.
3. Protecting the remnants of natural and semi-natural urban green areas (meadows, wetlands, etc.). Again, spatial plans are a solution, but this measure needs the cooperation of environmentally aware local communities, and their stronger participation in the process of drafting the plans.
4. Developing properly landscaped green areas of the estates and accompanying greenery which should reduce the pressure on compact alignments of GI. Similarly, this recommendation depends on the cooperation of environmentally aware local communities.
5. Appropriate local and regional spatial policies, considering public participation. Against this background, we would like to highlight the lack of a Polish national document defining directions for spatial planning. Without such a document, spatial policies are bound to remain patchy.
6. Adopting spatial development plans that are not only growth-oriented, but also have a protection component, maintaining the spatial continuity of GI. Again, we face a procedural issue in Poland, as there is no legal obligation to adopt urban plans. Hence, without such obligations, relevant spatial policies are rendered moot. What is left to tend to for Polish GI are development decisions of the public administrations, which usually foster bypassing. An incremental improvement in these decisions seems possible, but it rests on public pressure.
7. Eliminating the instruments (i.e., building conditions) leading to the fragmentation of GI. This requires an in-depth analysis of both zoning and building regulations in both countries. Depending on the results, some legal provisions might need updating.

8. Building developments allowed only in areas already equipped with a technical infrastructure. Unfortunately, enforcement requires a separate discussion, via "derogatory planning", but can be addressed while revising planning provisions in both countries.
9. Educational and awareness activities focused on the importance of GI for a city and its residents. Several other points stressed the need for cooperation of environmentally aware local communities. However, public involvement needs to be responsible, efficient, and positive. For that, both countries need to expand environmental education, even by informative means, enabling it to reach not only city managers and planners, but also local actors.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/land11050592/s1: Annex S1. Additional tables analyzing the correlations between variables describing and influ-encing the structure and dynamics of GI categories in Romanian and Polish cities covered by Urban Atlas data, containing: Table S1—Correlations between variables describing and influenc-ing the structure of GI categories in Romanian and Polish cities covered by Urban Atlas data, and Table S2— Correlations between variables describing and influencing the dynamics of GI catego-ries in Romanian and Polish cities covered by Urban Atlas data.

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