STUDIES

Is the rival city always greener? An analysis of the indicators for European Green Capital Award shortlisted and applicant cities, 2010–2024

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The European Green Capital Award (EGCA) has been given to cities that can serve as role models for other cities in responding to environmental challenges with innovative solutions and contributing to the development of more sustainable and healthier cities. This study examines 100 of the 110 cities that applied for the award by the round of 2024 based on quantitative data that could measure the environmental awareness of those cities. The variables were selected in line with the topics of the EGCA call for proposals. Exploratory data analysis (EDA) was used to reveal the differences between the two groups, finalists and applicants who were nonshortlisted. Based on Mann–Whitney U tests and chi-square tests, the values of the finalists were convincingly more favorable for only 10 variables. To identify the variables with the strongest relationship with the outcome of the application, a logistic regression was performed after a dimension reduction carried out with multiple factor analysis (MFA). The model can be applied with high accuracy mainly in the category of nonshortlisted candidates (there are several erroneous estimates for the winners), which suggests that other, nonmeasurable criteria are also influencing factors. The model, with some limitations, can also be used by cities that also want to compete in the future to assess their chances before submitting their application.

Keywords:
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Introduction

Currently, 70-75% of Europe's population lives in cities, and this figure is projected to reach 80% by 2050 (Kotzeva 2016, UN 2014). Some of the environmental problems are concentrated in these areas: the negative effects of climate change may be more pronounced, such as heat waves and droughts (e.g., Beretta 2014, Carter 2011, Stone et al. 2012, Mi et al. 2019). Due to their growth, cities are occupying larger areas (Szirmai 2012), and the proportion of built-up and paved areas is increasing, which may increase the frequency of the urban heat island effect and flash floods and reduce biodiversity; distances within the city increase, intensive land use develops, environmental pressures (noise and air pollution) increase, and cities eventually will get completely separated from the natural environment around them (Kahn 2006, Stone et al. 2012). The situation is further exacerbated by alienation from society and from nature (e.g., Alberti et al. 2008, Beatley 2011). The livability of cities may arise as a key topic to manage those issues, as the quality of life of residents of a healthier, more sustainable (and attractive) city may also be higher (Gehl 2013).

Addressing these challenges can trigger new urban development trends and initiatives, making the pursuit of sustainability increasingly popular at both the urban development and urban planning levels (Busch–Anderberg 2015, Kohán et al. 2011, Mi et al. 2019). There are several indicators available to measure the "performance" of liveable, green and sustainable cities that look at cities from an environmental, social and economic perspective. Examples include the European Green City Index (Watson et al. 2009), Global Liveability Index (The Economist Intelligence Unit 2019), Sustainable Cities Index (Arcadis 2016), SDEWES index (Kilkiş 2018), Sustainability Scores (Zoeteman et al. 2015), and City Resilience Index (Arup 2014). There are also sets of indicators and frameworks that measure individual elements of cities, such as the City Blueprint (van Leeuwen et al. 2012), The Urban Metabolism Framework (Minx et al. 2011), the European Green Leaf Award (EC 2015a), Urban Ecosystem Europe (Berrini–Bono 2007), and the Urban Sustainability Indicator Framework (Mega–Pedersen 1998).

As a new initiative, the European Green Capital Award (EGCA) was launched in 2008, focusing on addressing urban ecological and environmental challenges and helping cities become green, liveable and sustainable. The award emphasizes the statements of the UN Habitat (1976, 1996) that everyone has the right to live in a healthy urban environment, and city management should strive to improve the quality of life and reduce negative impacts on the urban environment. In "The 2030 Agenda for Sustainable Development" (UN 2015), 17 development target areas (sustainable development goals – SDGs) have been identified, all of which directly or indirectly affect cities. The EGCA acts as a kind of liaison (and mediator) for the local realization of global goals and can act as a catalyst for cities to become more sustainable. Long-term (monitoring) studies can also help the development of cities, which can serve as feedback to local governments or act as an incentive for other cities.

The majority of studies on the EGCA focus on one of its key sustainability criteria. For example, Ruiz del Portal Sanz (2015) focused on the sustainable land use criterion; he focused on urban historical development and the resulting endowments, with historical development as a factor influencing the sustainability of cities today. Among the studies analyzing specific criteria of the EGCA, it is worth highlighting the work of Gudmundsson (2015), in which he presented the process of evaluating and assessing applications through the topic of local transport. Müller–Reutter (2020) examined the winning cities between 2010 and 2020 in terms of climate protection and sustainable local transport. Cömertler (2017) compared the green space characteristics of winning cities. Ratas–Mäeltsemees (2013) conducted the first study including all criteria and used them to compare cities. Their publication highlights the role of the environment in strengthening the competitiveness of cities, using the examples of the EGCA and the city of Tallinn. They compared Tallinn's values with those of the winning cities, based on the EGCA criteria and the data from the applications submitted, to see whether Tallinn had a chance of winning. This paper is also of particular relevance to the topic of this study, as it has shown that the environmental values of EGCA-winning cities are not always the best. The work of Pantic–Milijic (2021) has a similar theme, comparing Belgrade's current environmental status with the EGCA criteria and the values of Grenoble (the winner in 2022).

The EGCA has been repeatedly referred to in the literature as an environmental indicator set since 2014. Meijering et al. (2014) aimed to measure environmental sustainability as a tool to help develop environmental policies in European cities. In their study, they used tools and indicators from the European Energy Award, the EGCA, the European Green City Index, the European Soot-free City Ranking, the RES Champions League and Urban Ecosystem Europe. In addition, Zoeteman et al. (2014, 2015) assessed 64 EGCA candidate cities based on nearly 100 indicators. In the publication, 20 cities were selected and analyzed in detail on the basis of 57 environmental, social and sustainability indicators and then were provided with sustainability scores. Their results show that low-scoring settlements are typically shrinking or agricultural cities, while high-scoring municipalities are rich, growing cities. In their study, Sarubbi and Schmidt Bueno de Moraes (2016) used environmental indicator sets (Blue Green City, Sustainable Cities Programme and the EGCA) to monitor municipalities and measure the change in sustainability indicators. In their work, they used the examples of three specific cities: Bertioga, Campinas and Essen. Feleki et al. (2018) studied urban indicators and metrics at the global level, including the EGCA as a set of purely environmental indicators. The essence of their study was to bridge the diversity of global urban indices in an attempt to create an integrated, unified index.

According to a study by Zoeteman et al. (2015), the cities competing for the EGCA vary considerably in terms of the value of their sustainability indicators. This is due to urban typology, population size and geography. However, previous research on the EGCA has not shown which indicators differ substantially between the winners and the cities that have just applied. These variables may be the ones for which targeted investment in their development (without ignoring other indicators) could increase the chances of becoming a green capital. As the cities that have applied for the EGCA already represent a unique group of cities motivated for sustainability (Zoeteman et al. 2015), this analysis highlights the environmental indicators that can be associated with the variation even within this elite group. In this study, exploratory data analysis (EDA) is used to identify the differences between the finalists[1] and the nonshortlisted applicants on the basis of the 33 indicators examined. The analysis does not include hypothesis testing[2]. Although, as would be expected and logical, finalists would be significantly more favorable in terms of sustainability in most categories, this cannot be claimed from the effect sizes obtained.

Although the 12 categories are equally weighted in the EGCA application, there are obvious links between the indicators (e.g., transport and air quality), which may make certain indicators more closely connected with the outcome. The analysis presents an explanatory logistic regression after applying dimension reduction, where it is distinguished which dimensions show the strongest association with the finalist outcome. In summary, the research seeks to answer two main questions: Which indicators show substantial differences between the scores of finalist and nonshortlisted applicant cities, and which indicators are related to the success of the application?

The European Green Capital Award

The EGCA is based on an initiative launched by Jüri Ratas in 2006, which was joined by 15 European cities and the Association of Estonian Cities (Berrini–Bono 2010, Lönegren 2009, Sareen–Grandin 2019). A statement on the fundamentals of the award was issued, which was also supported by the European Commission, and they even acknowledged the need for the award. It was finally launched by the European Commission in 2008, and the first winning city, Stockholm (2010), was announced later that year.

The main purpose of the award was to reward and recognize the response of cities to environmental challenges, their long-term development, their innovative solutions

[1] This study categorized finalists and winners into one group. This is because the winners are ultimately selected from the shortlisted finalists. This process is also influenced by other factors that are difficult to measure, such as the ability to lead by example or the quality of the presentation in the second round. Furthermore, since the number of winners is negligible compared to the other groups, having separate groups would violate the assumption of parallel lines in the proportional odds logistic regression.

[2] Due to a large number of variables, multiple comparisons would have considerably reduced the number of significant differences. Furthermore, the primary purpose of this study is to show the difference between the values of the finalists and the other candidates, not to prove that the finalist cities are indeed greener.

and the creation of sustainable, healthy, liveable cities. It is also important for candidate cities to be able to inspire other cities and to serve as a good example after winning the award, thus ensuring a dynamic, collaborative system (Diverde 2016, Gulsrud et al. 2017, Nurse–North 2020).

The application is open to any country that has joined or is about to join the European Union, as well as to cities with a population of more than 100,000[3] in Iceland, Norway, Liechtenstein (European Economic Area) and Switzerland. Cities can enter the "competition" in any year, but winning cities cannot reapply (EC 2020). Cities applying for the award are assessed on the basis of 12 indicators (Gudmundsson 2015, Meijering et al. 2014). The criteria are usually changed slightly every 2-3 years, so sustainable land use and soil are included in the 2023 and 2024 calls (EC 2020). This study examines cities based on the environmental indicators of the 2022 call for proposals[4]. The criteria for the 2022 call were as follows:

1. Climate change: mitigation,
2. Climate change: adaptation,
3. Sustainable urban mobility,
4. Sustainable land use,
5. Nature and biodiversity,
6. Air quality,
7. Noise,
8. Waste,
9. Water,
10. Green growth and eco-innovation,
11. Energy performance,
12. Governance.

The application must include three sections: Cities must present the present situation and the measures taken over the last five to ten years and describe their short- and long-term goals. For the governance indicator, commitments, management arrangements, partnerships and public engagement should be presented (EC 2019). Applications are assessed on the basis of the 12 criteria by a panel of internationally recognized experts who evaluate the application documents received and rank the cities according to the scores obtained. The shortlist of finalist cities is decided by the European Commission on the basis of the expert panel's assessment (Gudmundsson 2015). In the second, participatory (presentation) round, a new panel is formed, consisting of representatives from the European Commission's Directorate-General

[3] If the population of the city with the largest population does not reach this limit, the municipality with the highest population may apply.

[4] Soil indicators are difficult to quantify and consist of specific data (e.g., soil sealing), and the vast majority of the cities applying for the award participated in rounds without soil as specified criteria, so if the authors were to include this criterion, most of the cities in the study would be judged on an indicator that was not even included in their application.

for Environment, the European Parliament, the European Committee of the Regions and/or the European Economic and Social Committee, the European Environment Agency and other environmental (nongovernmental) organizations. The jury will also assess whether the city is able to serve as a good example and encourage other cities with their best practices. Cities that do not make it to the finals will be notified of their results in relation to the 12 indicators, their overall ranking, and the suggestions and comments made by the judges. This evaluation is not public; only the municipality of the applied city will receive it. The finalists will also receive a public evaluation document (e.g., Expert Panel Technical Assessment Reports, Good Practice & Benchmarking Reports, Jury Reports).

Winning the Green Capital Award can bring many benefits to cities in addition to the cash prize: Exposure in the international media and events in the winning year can contribute to the growth of tourism in the municipality, new contacts and cooperation can be established, the municipality can become more attractive to investors and can serve as a good example for other cities. In addition, the involvement of the population in the projects can further strengthen their commitment to their town, their sense of pride, their sense of identity and ultimately their attachment to the place. The EGCA is also ideal for city marketing, as it promotes the image of a green city. Green city branding focuses on the green elements of a municipality, i.e., green spaces and environmental activities (Gulsrud et al. 2013). A number of studies on the city marketing activities of some EGCA cities have highlighted that the award helps to raise awareness and promote the reconciliation of environmental policy and green city marketing (Demaziere 2020) and that urban green spaces, which are not prioritized in city marketing, provide a significant competitive advantage (Gulsrud et al. 2013).

Between 2010 and 2024, a total of 110 cities competed from almost every country in Europe. To date, 15 winners have been announced, the vast majority of which are Western and Northern European cities. In the case of the winners, an axis can be observed that runs through Lisbon–Vitoria-Gasteiz–Essen–Hamburg–Copenhagen–Stockholm–Lahti. In terms of the finalist cities, there is an observable density in the Netherlands, Belgium, Germany, France and Italy. The easternmost (and the northernmost) winning city is Lahti, and there are only two winners[5] with a socialist past (Ljubljana and Tallinn). Most applicant cities from the Eastern Bloc have not yet been finalists (Appendix Figure A1).

Methodology

This research uses the tools of EDA and explanatory modeling. EDA is associated with John Tukey, who described it as a kind of detective work aimed at finding patterns in a large dataset (Tukey 1977). In such analyses, the patterns found are

[5] At least in the timeframe of our study. The winner of the EGCA round 2025 is Vilnius.

typically presented using graphical representations. EDA also uses statistical methods, but only as an indicator of the strength of the relationship, not for hypothesis testing (Velleman–Hoaglin 2012).

Although controversial, the p value also carries limited meaning in exploratory data analyses (Rubin 2017); therefore, these values are reported in the results section of this study alongside the effect sizes proposed by the literature (Fife–Rodgers 2021). Furthermore, for p values, there is only a risk of increasing the chance of type I error from multiple comparisons if the variables under investigation are indeed closely related (testing the same hypothesis) (Matsunaga 2007). This would obviously be a problem for some transport indicators, whereas unrelated indicators (e.g., noise pollution and water consumption) would not affect the alpha level. Although EDA research has long been neglected by regional science, it is now proving useful, as it allows the scope of regional science to be broadened (Rey 2014).

Of the 110 cities applying for EGCA, 100[6] were included in the database. The analysis is based on the EGCA criteria system, with a focus on quantitative variables that are easily accessible from pan-European databases and official municipal documents (Table 1). A limitation was that some EGCA topics were less measurable with quantifiable indicators, but even for these, at least one indicator was included. Most of these variables are included in the European Green City Index and in the research of Zoeteman et al. (2015).

The cities that applied for the EGCA are classified as finalists and nonfinalists (nonshortlisted applicants). In the EDA analysis, these are the two groups under consideration, while the outcome of the application is included as a dependent variable in the logistic regression.

[6] For ten cities, there was a serious data shortage. Those cities are: Belgrade, Bursa, Gaziantep, Istanbul, Izmir, Kamëz, Kütahya, Skopje, Tirana, Trabzon.

Table 1

Descriptive statistics of the selected indicators between 2010 and 2024

Criteria	Indicators	Mean value	Standard deviation	Data source
1. Climate change: mitigation	CO_2 emission (ton/capita/year)	4.850	4.621	[4], [5]
	CO_2 emission – cities' value compared to the national average (%)	80.022	55.017	Calculated based on [24]
3. Sustainable urban mobility	Length of bicycle paths (m/capita)	0.772	0.859	[5], [21], [22]
	Number of cars per 1000 inhabitants	429.155	110.688	[5], [14], [22]
	Number of cars per 1000 inhabitants – cities' value compared to the national average (%)	82.03	18.15	Calculated based on [15]
	Percentage of people traveling to work by car (%)	45.366	13.659	[3], [5], [12], [14]
	Percentage of people traveling to work by public transport (%)	22.877	11.867	[5], [3], [12], [14]
	Percentage of people traveling to work by foot (%)	23.685	10.893	[3], [5], [12], [14]
	Percentage of people traveling to work by bicycle (%)	8.051	8.750	[3], [5], [12], [14]
4. Sustainable land use	Size of urban green areas (m^2/capita)	26.884	25.150	[5], [14], [21]
	Population density (capita/km^2)	3,096.433	2,745.192	[5], [14]
5. Nature and biodiversity	Proportion of Natura 2000 sites in relation to the area of the municipality[a)] (%)	7.350	9.339	Calculated based on [23]
6. Air quality	NO_2 annual average (μg/m^3)	26.667	7.795	[5], [10], [14]
	PM_{10} annual average (μg/m^3)	21.494	6.015	[5], [10], [14]
	$PM_{2.5}$ annual average (μg/m^3)	12.548	4.964	[5], [10], [14]
7. Noise	Percentage of people living in areas with noise pollution above L_{den}65 dB (%)	15.197	12.426	[5], [11], [25]
	Percentage of people living in areas with noise pollution above L_n55 dB (%)	16.869	14.057	[5], [11], [25]
8. Waste	Municipal waste (kg/capita/year)	431.364	105.899	Assessment of separate collection schemes in the 28 capitals of the EU (European Commission, Final Report 2015), [5], [14], [21]
	Municipal waste – cities' value compared to the national average (%)	89.879	21.090	Calculated based on [17]
	Recycling rate (%) – city	40.560	15.276	Assessment of separate collection schemes in the 28 capitals of the EU (European Commission, Final Report 2015), [5], [21]
	Recycling rate – cities' value compared to the national average (%)	100.903	44.690	Calculated based on [9]

(Table continues on the next page.)

(Continued.)

Criteria	Indicators	Mean value	Standard deviation	Data source
9. Water	Drinking water consumption (l/capita/day)	132.388	31.479	[5], [14]
	Drinking water consumption – cities' value compared to the national average (%)	106.602	33.289	Calculated based on [26]
	Wastewater generation load (p.e./year)	781,383.361	687,804.175	[27]
10. Green growth and eco-innovation	Number of electric car charging stations per 1000 inhabitants	0.156	0.94	[1], [5], [6]
11. Energy	Final energy consumption (MWh/capita/year)	19.304	6.665	[5], [4], [7], [8], [14]
	Final energy consumption – cities' value compared to the national average (%)	322.781	138.349	Calculated based on [16]
		Median	Mode	
2. Climate change: adaptation	Existence of Climate Strategy	1	1	[20]
11. Energy	Existence of Sustainable Energy Action Plan (SEAP)/Sustainable Energy and Climate Action Plan (SECAP)	1	1	[20]
12. Governance	Members of the Covenant of Mayors	1	1	[4]
	Signatories of the Aalborg Charter	1	1	[13]
	Signatories of the Circular Economy Declaration	0	0	[2]
	Members of the International Council for Local Environmental Initiatives (ICLEI)	0	0	[18]

a) The EGCA criteria also include Natura 2000 sites within 10 km of the municipal boundary.

The winners' application documents are publicly available, unlike those of the other applicants. In addition to the small number of application documents (e.g., Perugia, Nuremberg, Pécs, Logrono, Guimarães), the evaluations issued by the jury are also available (Benchmarking Reports), but they do not contain data for all indicators. An additional problem is that since the 2018 round, these reports have not included all cities that applied in the given year. To ensure the consistency of the data, the authors worked primarily with data from pan-European databases (e.g., Eurostat, European Environment Agency); if a value was missing, then the documents of the municipalities had to be used (e.g., SEAP or SECAP, Climate Strategy, Municipal Waste Management Plan, Sustainable Urban Mobility Plan). However, there were also cases where data could not be extracted in any way. In these cases, national and regional statistical databases, documents and, finally, materials published by the local media were used.

It was important to obtain the most recent data available for each indicator, so most of the data are from 2019 or a few years earlier. The problematic nature of the fact that in the case of some variables the data were from different years was also reported in the research of Zoeteman et al. (2015). Using just one timestamp for each city, the study is not able to take into account the sustainability developments that occurred in the recent past and the future plans, both of which, as mentioned in the EGCA section, are important factors in the evaluation of the EGCA application.

In the database created in this way, each city is listed once, with the most recent data available, regardless of how many times it competed. Similarly, if a city has competed more than once, the outcome value is the most recent result. For this reason, the model created does not take into account how strong the competition was in a given year. However, it takes into account how many times a city has applied for the European Green Capital Award. This is an indicator of commitment and progressive improvement in sustainability. Looking at the variables for each city at a nearly uniform point in time may, however, introduce a bias in the sense that the values of the earliest cities to apply for the EGCA may have changed since the EGCA application. So if they have improved since then, we analyze them on the basis of values they did not have back then at the time of the application. In addition to this limitation, however, there is a potential advantage to be gained from sampling the data in this way. According to research by Pace et al. (2016), a major drawback of green city measures, including the EGCA, is that they do not monitor cities after evaluation. As they write, the fate of these cities after the competition is unknown ("They may flourish or deteriorate" p. 4, 2016).

In the exploratory part of the research, the finalists and the nonshortlisted applicant groups were compared. In addition to the graphical representation, Mann–Whitney *U* tests or independent samples *t* tests were used depending on the normality of the scale variables, and chi-square tests were applied for binary variables. In simple terms, the Mann–Whitney *U* test and the independent-samples *t* test are used to see whether the means of two groups (in the case of the Mann–Whitney *U*, the mean ranks) are significantly different.

Before running the logistic regression, the data needed to be cleaned, and the reduction of the number of variables was also necessary. As a first step, due to the outliers and the lack of normality, each scale variable was transformed using a rank scale transformation (Conover–Iman 1981). This method ranked the values from lowest to highest and assigned them a number between 1 and 100[7]. The dimension reduction had to take into account that some variables are binary, while others are scalar. Additionally, the 12 categories of the EGCA are unevenly represented by the indicators. Taking these considerations into account, the principal components were determined using multiple factor analysis (MFA) (Pagès 2002), which can address

[7] In the case of a tie, the average method was used for ranking.

both problems. The eigenvalue of 1 was taken as the cutoff value for the analysis, resulting in seven[8] principal components (Appendix Table A1). These seven variables and the number of applications were included as independent variables in the binary logistic regression, while the outcome of the application was the dependent variable. With the help of this explanatory model, it becomes clear which dimensions have the strongest relationship with the outcome of the application and whether the higher or lower value is more beneficial for these dimensions.

Results

Two of the normally distributed variables had at least small effect size values (Table 2). Among the 22 nonnormally distributed scale indicators included in the analysis, 15 of the rank biserial correlation (r_{rb}) absolute values were higher than 0.11 (Table 3), which is above the level corresponding to a small effect size according to Peng–Chen (2014)[9]. None of the indicators reaches the large effect size (threshold 0.48). In the following, the variables with moderate and large effect sizes are presented (Appendix Figure A2).

Table 2

Results of the independent samples t tests between 2010 and 2024

Indicator	Mean (non-shortlisted applicants)	Mean (finalists)	t	Cohen's d	Interpretation of effect size
NO_2 annual average (μg/m³)	26.763	26.473	0.174	0.037	–
Percentage of people living in areas with noise pollution above L_n55 dB (%)	16.221	18.185	–0.654	–0.139	–
Municipal waste (kg/capita/year)	420.149	454.132	–1.518	–0.323	Small
Municipal waste – cities' value compared to the national average (%)	90.649	88.316	0.518	0.110	–
Recycling rate (%)	37.788	46.187	–2.663**	–0.566	Moderate

Note: **: p<0.01.

[8] It accounts for 60.2% of the total variance.

[9] The authors' study defined these values for the Cliff's delta effect size. However, in the case when analyzing only two groups, the Cliff's delta and biserial rank correlation values are the same (Ben-Shachar et al. 2021).

Table 3

Results of the Mann–Whitney *U* tests between 2010 and 2024

Indicator	Mean (non–shortlisted applicants)	Mean (finalists)	Mann–Whitney U	Biserial rank correlation	Inter–pretation of effect size
CO_2 emission (ton/capita/year)	5.016	4.511	1,116	0.009	–
CO_2 emission – cities' value compared to the national average (%)	82.834	74.315	1112	0.005	–
Length of bicycle paths (m/capita)	0.581	1.159	631***	–0.429	Large
Number of cars per 1000 inhabitants	446.182	394.584	1,397.5*	0.264	Small
Number of cars per 1000 inhabitants - cities' value compared to the national average (%)	85.228	75.537	1,453.5*	0.314	Moderate
Percentage of people traveling to work by car (%)	45.899	44.284	1101	–0.004	–
Percentage of people traveling to work by public transport (%)	25.027	18.512	1,429*	0.292	Moderate
Percentage of people traveling to work by foot (%)	23.418	24.227	1,031	–0.067	–
Percentage of people traveling to work by bicycle (%)	5.670	12.884	702**	–0.364	Moderate
Size of urban green areas (m^2/capita)	26.764	27.127	966.5	–0.125	Small
Population density (capita/km^2)	2,727.641	3,845.194	738**	–0.332	Moderate
Proportion of Natura 2000 sites in relation to the area of the municipality (%)	6.754	8.560	991.5	–0.103	–
PM_{10} annual average (μg/m^3)	22.595	19.258	1452*	0.313	Moderate
$PM_{2.5}$ annual average (μg/m^3)	13.388	10.843	1434*	0.297	Moderate
Percentage of people living in areas with noise pollution above L_{den}65 dB (%)	14.842	15.919	983	–0.110	Small
Recycling rate – cities' value compared to the national average (%)	102.795	97.062	1,093.5	–0.010	–
Drinking water consumption (l/capita/day)	132.028	133.118	1,085	–0.018	–
Drinking water consumption – cities' value compared to the national average (%)	112.167	95.304	1,411*	0.276	Small
Wastewater generation load (p.e./year)	730,526.013	884,639.189	908	–0.178	Small
Number of electric car charging stations per 1000 inhabitants	0.112	0.244	714**	–0.354	Moderate
Final energy consumption (MWh/capita/year)	18.507	20.924	822*	–0.256	Small
Final energy consumption – cities' value compared to the national average (%)	340.001	287.820	1,311	0.185	Small

Note: *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$.

The biggest difference between the finalist and the nonshortlisted applicant group is in the length of cycle paths per capita. For this variable, there are significant geographical differences, as the indicator is lower in cities in Southern and Eastern Europe than in cities in Northern or Western Europe (Appendix Figure A3). Transport culture, urban structure, settlement morphology and infrastructure development may be factors behind these geographic differences. It can be assumed that more cycle paths generate higher cycling-to-work rates, but there are discrepancies in this alleged relationship, for example, in some Finnish and French cities where the cycle path network is well developed but the share of cyclists is below 10% (Schmeller 2022). The top ten cities in terms of length of cycle paths per capita include two winners (Lahti, Grenoble), six finalists and two nonshortlisted applicants. The cities with the highest percentage of inhabitants who cycle to work are Nijmegen (37%), Freiburg (34%), Münster (33%), Amsterdam (32%) and Copenhagen (30%). In Freiburg, Amsterdam and Copenhagen, the modal split in favor of sustainable urban transport seems to be realized. Essen (winner of the round of 2017) introduced the "4x25% principle" for the modal share; i.e. car, cycling, walking and public transport all account for 25%, which is favorable for sustainable transport (Müller–Reutter 2022).

Of the nine variables with moderate effect size, only the share of people traveling to work by public transport is the variable for which the cities in the nonshortlisted applicants group have a more favorable value than the finalists. This is because, for historical reasons (Pucher 1990), the use of public transport in the Eastern European region is among the highest in the world (Kenworthy 2003), and the cities from this region were mostly not finalists.

A significant part of the urban transport challenge is linked to the popularity of car transport, which is also a barrier to sustainability goals (May 2013). However, the results show that neither the number of cars per 1000 inhabitants nor the share of inhabitants using cars reaches a moderate effect size. This is because car use and car ownership are influenced by a number of country-specific factors, such as individuals' wealth, perceptions, urban structure or transport culture (Schwanen 2002, Orru et al. 2019). The difference between finalists and nonshortlisted applicants is more significantly reflected in the number of cars relative to the national average, an indicator that can better reflect a city's sustainability ambitions than the raw value of the number of cars. The overall commitment of the cities applying to the EGCA is also well illustrated by the fact that 87 municipalities have fewer cars per 1000 inhabitants than the country as a whole.

A further indicator of the gap in sustainable urban transport is the number of electric car charging stations per 1000 inhabitants. While there have been significant expansions in the number of electric vehicle charging stations across Europe, sharp spatial differences (including within countries) in the extent and accessibility of the network can still be observed (Falchetta–Noussan 2021). This geographical pattern is also found for the cities that have applied for EGCA, with municipalities in Southern and Eastern Europe typically at the bottom of the ranking.

On the topic of sustainable land use, the difference in population density values (Appendix Figure A4) was of moderate effect. Population density values can be used to infer the extent and type of built-up areas and the character of residential areas. Higher population densities and vertical expansion are ideal for the sustainability of settlements, which is one of the basic conditions for a compact city (Carl 2000, Gaigné et al. 2012, Hajnal 2006).

Two of the three air pollution data used as indicators show a discrepancy. The WHO (2021) recommends that the annual average value of PM_{10} should not exceed 15 $\mu g/m^3$, while the annual average value of $PM_{2.5}$ should not exceed 5 $\mu g/m^3$. The data show that the majority of cities that applied for the EGCA exceed these thresholds. Anthropogenic particulate matter is mostly generated from solid fuels (coal, wood) and transport (fuel combustion) (Fehérné Baranyai 2015). The amount of PM_{10} and $PM_{2.5}$ in the air may therefore be related to the number of cars and the modal distribution of transport.

The average recycling rate of the finalist cities is almost 10% higher than the average of the nonshortlisted applicants. However, there is no difference in the amount of waste generated and its value compared to the national average.

The chi-square test for the six binary variables shows that all variables have a moderate effect size.

Table 4 shows that all the finalist cities have a climate strategy and SEAP or SECAP document, as well as membership in the Covenant of Mayors, while these are missing in several of the nonshortlisted candidate cities. The preparation and practical application of a climate strategy and SEAP or SECAP documents is a prerequisite for membership in the Covenant of Mayors; i.e., those who are members will have both documents at the time of application or within a few years of application. Both in the EGCA application documents and in the Jury Reports, the importance of climate strategy is stressed as a long-term commitment and as a basis for climate change mitigation and adaptation. All of the EGCA winning cities currently have a climate strategy and were likely to have had one at the time of application, while 18 of the nonshortlisted applicants do not (a number that was probably even higher in the years of application). The existence of a climate strategy is particularly important for two EGCA criteria (climate change: mitigation; climate change: adaptation), although there is no meaningful difference in CO_2 values between cities with and without a climate strategy.

According to the data, all finalist cities are currently members of the Covenant of Mayors, but this was not the case for all winners and finalists at the time of application (e.g., Ghent was not a member at the time of application and hence became a finalist). Among the other signatories of the declarations, the finalist cities are much less represented (ICLEI membership is the least frequent) but are still overrepresented in percentage terms compared to the nonshortlisted applicants.

Table 4

Crosstable of the EGCA application outcome and the binary variables and chi-square results between 2010 and 2024

Indicators	A	B	C	D	Chi-square	Cramer's V	Effect size
Existence of Climate Strategy	33	0	49	18	9.068**	0.328	Medium
Existence of SEAP/SECAP	33	0	59	8	2.814	0.207	Medium
Covenant of Mayors membership	33	0	58	9	3.369	0.220	Medium
Aalborg Charter's signatories	26	7	35	32	5.482*	0.255	Medium
Circular Economy Declaration's signatories	10	23	9	58	3.066	0.202	Medium
ICLEI membership	20	13	24	43	4.552	0.234	Medium

Note: *: $p<0.05$, **: $p<0.01$, ***: $p<0.001$. A: Number of finalists that have that membership or document; B: Number of finalists that don't have that membership or document; C: Nonshortlisted applicants that have that membership or document; D: Nonshortlisted applicants that don't have that membership or document.

Explanatory Logistic Regression

By using logistic regression, the authors sought to determine which dimensions (7 dimensions generated from the 33 variables, using MFA) have the strongest relationship with the outcome of the application and how accurately the EGCA results can be modeled. The classification matrix based on the logistic regression model is shown in Table 5. The model has an accuracy of 77%, a sensitivity of 66.7%, a specificity of 82% and a Nagelkerke R^2 of 0.515. These results suggest that the model is better suited to correctly categorize nonfinalists than finalists. This is also evident from the fact that Valencia, Nantes and Vitoria-Gasteiz, which already have the EGCA title, are also included in the category of nonshortlisted applicant cities according to the categorization based on the model. Regarding the number of applications for the award, it is striking that Tallinn and Lahti have entered the competition five and four times, respectively, so the model includes them among the finalists, while the three cities that actually won but were not finalists according to the model have only one (Nantes) or two (Valencia, Vitoria-Gasteiz) applications.

Oslo (96.2%), Ljubljana (92.6%) and Copenhagen (90.2%) have the highest propensity scores, so they are the most likely to make it the final according to the model. In fact, they were not only finalists but also winners in real life. Of the cities that are finalists or winners based on the real results, Cagliari (24.7%), 's-Hertogenbosch (17.6%) and Frankfurt (12%) have the lowest probability of being a finalist based on the model. However, it should be noted that while Frankfurt has a low probability of making it the final according to the model, the probability is still higher than that for 37 nonshortlisted cities that applied. According to the model, Polish and Romanian cities have the lowest probability of making the final.

Table 5

Classification table based on the logistic regression model between 2010 and 2024

Threshold above 50%	Was a real winner or finalist	Was not a real winner or finalist
The city will qualify for the final based on the model	22	12
The city will not qualify for the final based on the model	11	55

Binary logistic regression showed that the first, second and fourth MFA dimension components had a significant connection with the outcome of the application (Table 6). These variables that constitute to the three mentioned dimensions are therefore the most helpful in predicting the outcome of the application, i.e., whether or not a city is selected as a finalist.

Table 6

Results of the logistic regression model between 2010 and 2024

Variable	β coefficient
MFA dimension 1	–1.017*** (0.280)
MFA dimension 2	0.789** (0.347)
MFA dimension 3	–0.279 (0.244)
MFA dimension 4	0.493** (0.244)
MFA dimension 5	0.192 (0.252)
MFA dimension 6	0.407 (0.365)
MFA dimension 7	0.351 (0.308)
Number of applications	0.676** (0.296)
Constant	–2.696*** (0.727)
Observations	100
Log likelihood	–40.286
Akaike Inf. Crit.	98.573

Note: Standard errors in parentheses. *p<0.05, **p<0.001, ***p<0.001.

According to the results, MFA dimension 1 has the strongest relationship with the outcome. If the value of this dimension is lower by one for a given city, there is an association with the increased odds of the city being a finalist by a factor of 2.7

(OR=0.36 [CI: 0.19; 0.58]). The lowest-ranked cities based on the first dimension have low annual average PM_{10} and $PM_{2.5}$ values and low daily drinking water consumption. These cities also have high green space and cycle path length (in addition to a large percentage of residents who choose to bike to work) per capita values and are among the leaders in recycling and electric car charging station availability. However, these cities have high final energy consumption. It should be stressed that high annual energy consumption is obviously not ideal from an environmental point of view, but the vast majority of the 20 lowest-ranking cities in this dimension are in northern Europe, where heating may increase the energy use of municipalities.

For the second dimension, cities that are ranked higher have high noise pollution levels, high municipal waste per capita (even relative to the national average), high population density, and low green space per capita values. From an environmental point of view, except for population density, none of these indicators is particularly favorable. The top 20 cities with the highest scores are overwhelmingly southern European, including two winners, Valencia and Lisbon. The logistic regression results suggest that an increase in the value of this dimension by one is associated with a successful outcome (OR=2.2 [CI: 1.22; 4.74]). Although this is contradictory from a sustainability point of view, the model uses this dimension to calculate the fact that in reality, several Italian, Spanish, Portuguese and Southern French cities have already been selected as finalists.

For the fourth dimension, the cities that are ranked higher have high wastewater discharges, high population density, high commuter transport, high CO_2 emissions per capita and high green space per inhabitant values. However, recycling rates are low compared to the national average. It is important to emphasize that not all indicators with high values are associated with negative environmental impacts: For example, a high proportion of people using public transport and a high value of green spaces per capita are assumed to be linked with less air and noise pollution.

Among the winners, Hamburg has the highest MFA dimension four value, but Stockholm is also in the top ten. Increasing the value of this dimension by one, controlling for other variables, is connected to a 63.8% (OR=1.63 [CI: 1.05; 02.77]) increase in the odds of being a finalist. The number of applications to the EGCA was also found to be an important factor. Each new entry is related to nearly doubling (OR=1.996 [1.13; 3.67]) the chance of being a finalist when controlling for other variables. The city can learn from the critiques of the jury reports received and thus improve with a sense of purpose, and the number of entries is also an indicator of the city's commitment to sustainability. There are also several winning cities (Lahti, Lisbon, Ljubljana, Tallinn) that did not make it to the final the first time they applied. However, submitting multiple entries does not guarantee success if there has not been progress over time; the best example of this is Budapest, which has been an applicant five times but has never been a finalist.

Conclusions

When a city becomes a European Green Capital, it is a clear sign that it is liveable, pollution-free and sustainable (Ratas–Mäeltsemees 2013). As this research shows, even finalist cities in the EGCA competition can be generally considered greener than nonshortlisted applicant cities, but not according to all environmental indicators. This result suggests that for some indicators on their own, there is no serious lag in the nonshortlisted (typically Eastern European) cities and that their low chances of making the final and the uncompetitiveness are due to the combined effect of several variables. Those indicators where no difference was found, however, are far from unimportant. Since the analysis is based on current values, trends that can be attributed to recent developments or the quality of the future plans may already show a difference between the finalist and the candidate group.

Some of the indicators that show differences rely on the development undertaken by the municipality (e.g., length of cycle paths), while others depend on the attitude of the population toward sustainability (e.g., recycling) and/or a combination of these two factors (e.g., proportion of people who cycle to work). The largest differences were found for indicators related to or closely linked to the sustainable urban transport category. The establishment (and development) of sustainable urban mobility is always beneficial from an environmental point of view, which can also affect the quality of life and health of local residents (Beretta 2014, Buehler–Pucher 2011, Niţă et al. 2018). Appropriate promotion and public information, joining international initiatives (e.g., CIVITAS) and the resolve, determination and commitment of local decision-makers are essential to increase the rate of green transport (Pucher–Buehler 2017, Schwedes et al. 2016). Even if not all indicators are found to be substantially different for the two analyzed groups, it is important to note that to achieve success in the EGCA competition and to transform into a green city, applicants must strive for improvement in all criteria. The fact that there is no difference between the two groups for some indicators does not mean that the given indicator is negligible. Cities need to simultaneously focus, for example, on the extent and condition of green spaces, the development of environmentally friendly public transport, and the reduction of waste and noise pollution. A city's efforts to achieve sustainability can be captured in several different areas, and due to the interactions between these indicators and the spillover effects, their combined development will successfully improve the environmental status of the municipality (Ratas–Mäeltsemees 2013). Development for environmental sustainability also has an impact on economic and social sustainability, such as the creation of new parks that can create jobs, investments and events that can have a community building effect, and environmental measures that make progress towards achieving a clean living environment. As Zoeteman et al. (2015) argue, the pillars of sustainability are not independent of each other, and some environmental sustainability indicators (e.g., wastewater treatment, air quality) have a strong connection with social and economic sustainability variables.

The commitment to sustainability is another area where the finalist cities have proven to be better. The finalist cities are more likely to commit themselves to participating in international sustainability partnerships and thus to goals that focus on long-term sustainability. These memberships and document signatures coincide with one of the main objectives of the EGCA, to develop networks between cities (Diverde 2016, Gudmundsson 2015). The demands imposed by participation in these organizations, the experience of international cooperation and the guidelines of the strategies adopted are all factors that feed back positively into the environmental indicators.

Commitment to the application and gaining experience is associated with greater chances of reaching the final, according to the results of the logistic regression. The final model is able to categorize the cities studied with an accuracy of 77% and is particularly suitable for estimating the outcome of cities with a low chance of being a finalist. Due to the explanatory approach, the model might be overspecified due to the lack of training and testing decomposition and cross-validation. Taking this limitation and warning into account, the model might even be suitable for the estimation of the outcome of other cities that have not yet been applied. This study will help end users of green city rankings, city managers and urban planners, who are often not familiar with the methodology of these rankings and the variables that are closely linked to the results (Mayer 2008). The study will provide a new benchmark based on the mean values of the finalist cities, against which the candidate cities can compare their own scores and can better assess their own chances. In this way, they can identify indicators where lagging behind could be a constraint to EGCA success. It is important to note that, as each green city ranking uses a different methodology (Meijering et al. 2014), the claims made in this study apply only to the EGCA.

And why is it that not all variables showed large differences? Or why is it that, based on a regression model, some environmentally unfavorable values are associated with the increased probability of a city being a finalist? The reason is that cities that applied for the EGCA differ significantly in terms of settlement structure, geographical location, history and economic position within the country. As a result, the environmental and economic problems they face are also different (Ratas–Mäeltsemees 2013). Furthermore, the greenest city is not always the one that is awarded the prize. The aim of the competition is to make the municipality a role model for other cities. For this reason, improvements made toward achieving sustainability and the transition to a green city are more important than the provision of historically outstanding environmental qualities (Ruiz del Portal Sanz 2015).

Appendix

Figure A1

Cities that applied to the EGCA between 2010 and 2024

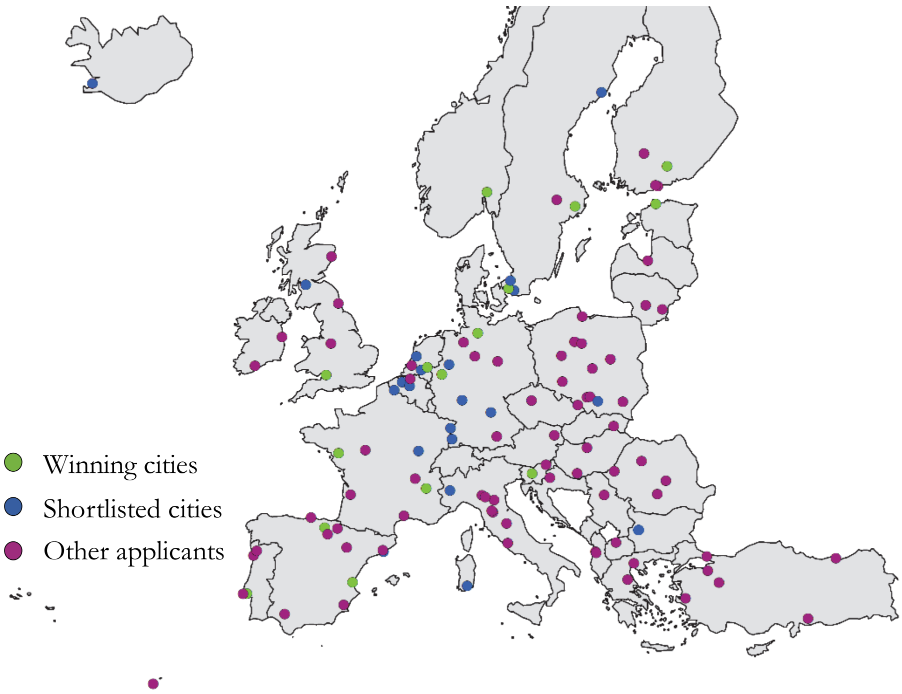

Table A1

MFA dimensions and its components between 2010 and 2024

Dimen-sions	Positive correlation	Negative correlation	Binary variables	Highest-value cities	Lowest-value cities
1	PM_{10} and $PM_{2,5}$ annual average, drinking water consumption–cities' value compared to the national average	Size of urban green areas per inhabitant, final energy consumption per inhabitant, length of bike paths per inhabitant; recycling rate, percentage of people traveling to work by bicycle, number of electric car charger stations per 1000 people	–	Cluj-Napoca, Lódz, Rzeszów, Brasov, Krakow	Umea, Tampere, Reykjavík, Malmö, Helsing-borg
2	Percentage of people living in areas with noise pollution above L_{den} 65 dB and L_n dB, amount of waste per inhabitant, amount of waste–cities' value compared to the national average, population density	Size of urban green areas per inhabitant	SEAP or SECAP, Covenant of Mayors	Barcelona, Turin, Prato, Florence, Thessa-loniki	Magdeburg, Kosice, Rzeszów, Gdansk, Poznan

(Table continues on the next page.)

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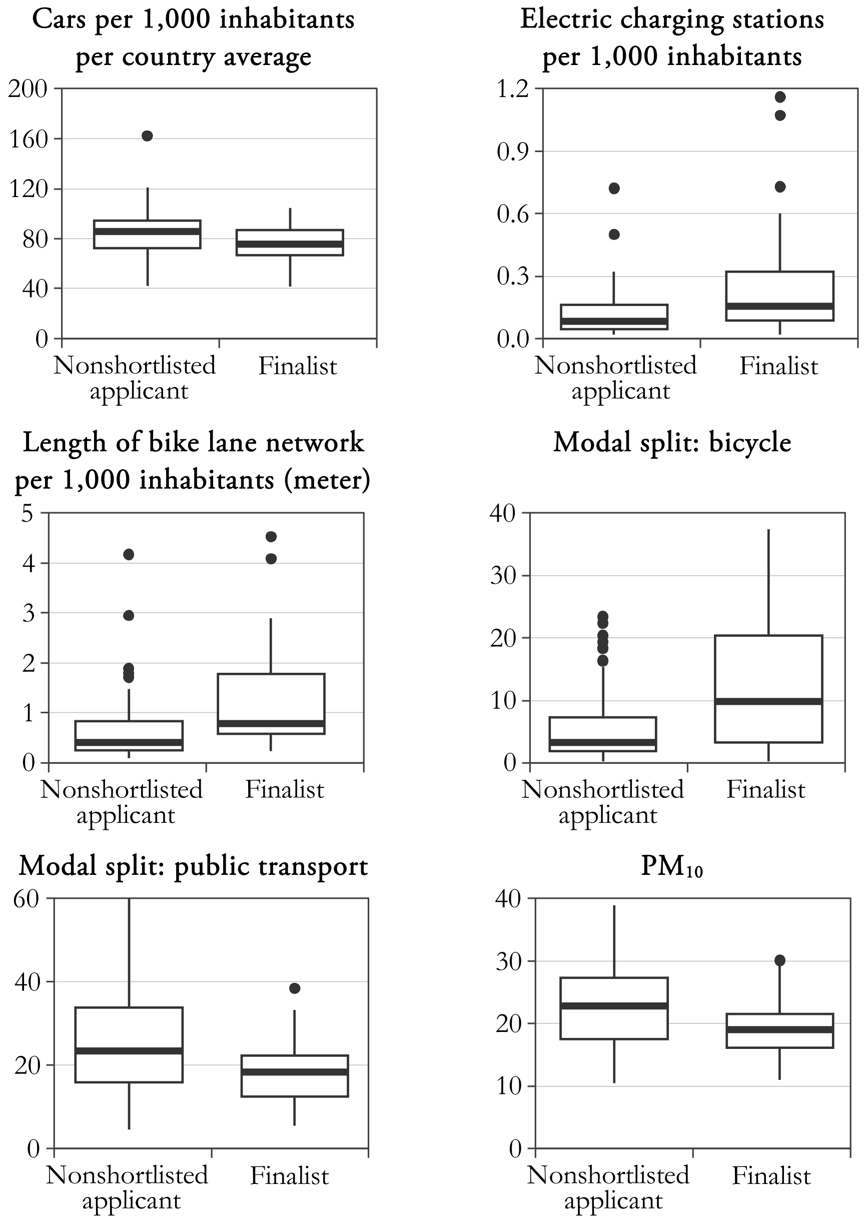
Dimensions	Positive correlation	Negative correlation	Binary variables	Highest-value cities	Lowest-value cities
3	CO_2 emission-cities' value compared to the national average, CO_2 emission per inhabitant, final energy consumption-cities' value compared to the national average, final energy consumption per inhabitant, recycling rate, percentage of people traveling to work by car	Proportion of Natura 2000 sites in relation to the area of the municipality, percentage of people traveling to work by foot	–	Reggio Emilia, Parma, Stoke-on-Trent, Florence, Turin	Zaragoza, Vilnius, Oslo, Vitoria-Gasteiz, Barcelona
4	Wastewater generation load, population density, percentage of people traveling to work by public transport, CO_2 emission per inhabitant, size of urban green areas per inhabitant	Recycling rate-cities' value compared to the national average	Climate Strategy	Glasgow, Lyon, Warsaw, Frankfurt, Dublin	Perugia, Prato, Pécs, Parma, Guimaraes
5	Proportion of Natura 2000 sites in relation to the area of the municipality, CO_2 emission per inhabitant, final energy consumption-cities' value compared to the national average, $PM_{2,5}$ annual average, number of electric car charger stations per 1000 people	Percentage of people traveling to work by car, drinking water consumption per inhabitant	–	Freiburg, Ljubljana, Bremen, Hamburg, Kaunas	Reykjavík, Porto, Sofia, Stoke-on-Trent, Dijon
6	Recycling rate-cities' value compared to the national average, recycling rate, percentage of people living in areas with noise pollution above L_n 55 dB, population density	Size of urban green areas per inhabitant, drinking water consumption-cities' value compared to the national average, drinking water consumption per inhabitant	SEAP or SECAP	Barcelona, Lódz, Copenhagen, Prague, Gdansk	Funchal, Kaunas, Torun, Arad, Tours
7	Recycling rate-cities' value compared to the national average, number of cars per 1000 people, final energy consumption, recycling rate, drinking water consumption per inhabitant, proportion of Natura 2000 sites in relation to the area of the municipality	Amount of waste per inhabitant, population density, amount of waste-cities' value compared to the national average	Climate Strategy	Bordeaux, Cascais, Zagreb, Cagliari, Turin	Rotterdam, Kosice, Amsterdam, Larissa, Arad

Figure A2

Boxplots of variables that have moderate or large effect sizes between 2010 and 2024



(Figures continue on the next page.)

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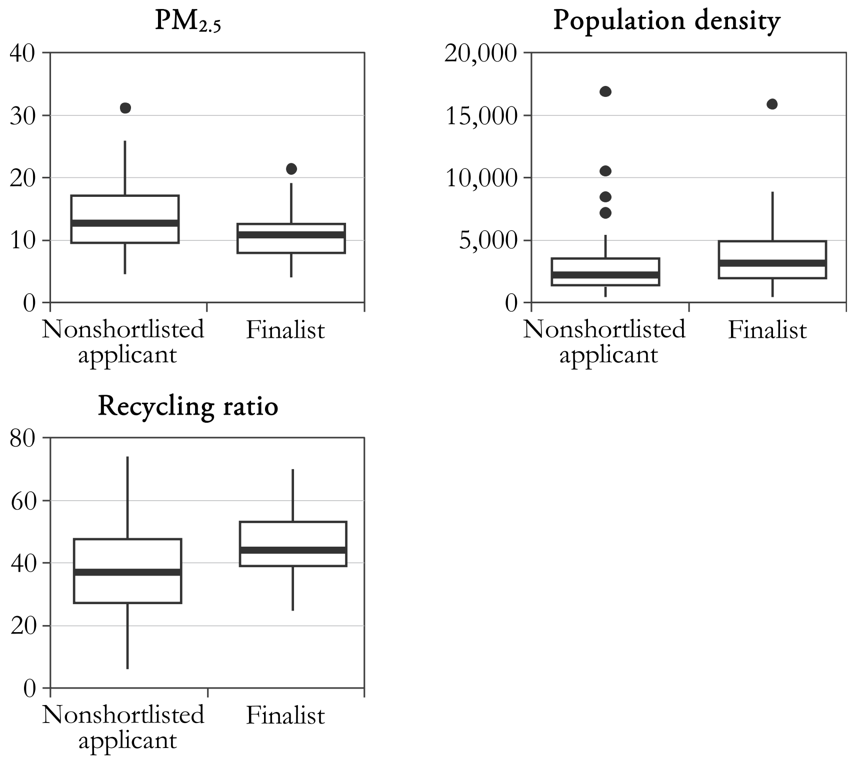

PM2.5
40
30
20
10
0
Nonshortlisted applicant
Finalist
Population density
20,000
15,000
10,000
5,000
0
Nonshortlisted applicant
Finalist
Recycling ratio
80
60
40
20
0
Nonshortlisted applicant
Finalist

Figure A3

Length of the bike paths per inhabitants in the analyzed EGCA applicant cities between 2010 and 2024

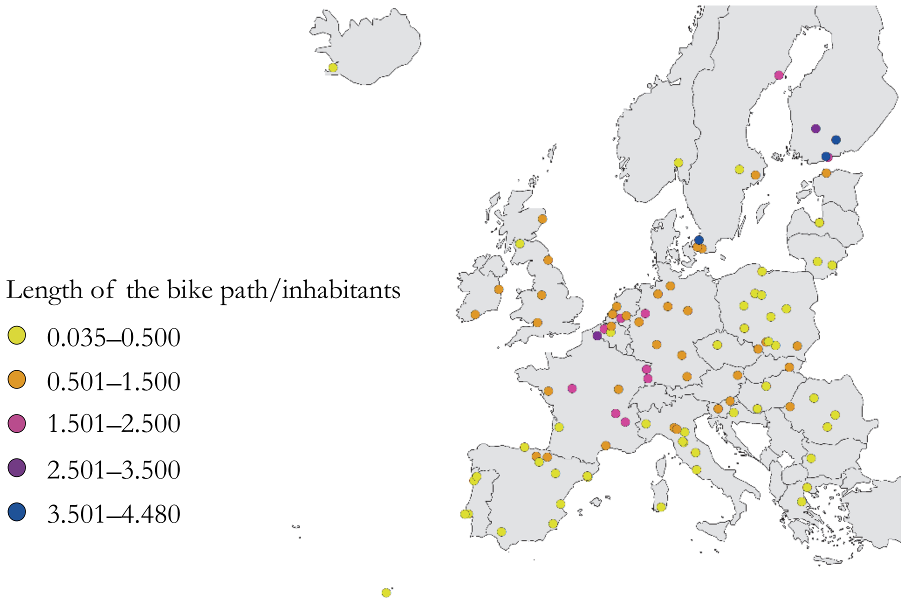
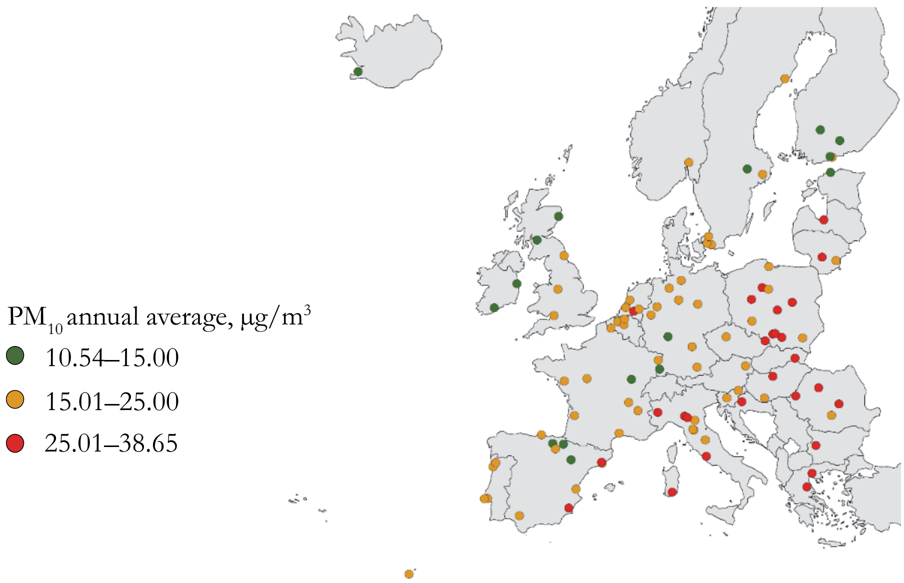


Figure A4

PM_{10} annual average values for the analyzed EGCA applicant cities between 2010 and 2024



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