Exploring Spatial Distribution and Interactions Toward SDG 11 Indicators at the Neighborhood Level: An Experimental Analysis

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Abstract. The current study analyzes the spatial distribution of SDG 11 targets across neighborhoods in Cagliari, Italy. Using aggregated indicators at the different SDG 11 targets and spatial autocorrelation techniques, the research identifies clusters and outliers across key dimensions such as housing, transport, disaster resilience, and green space access. Results reveal strong spatial structuring for targets like SDG 11.1 and SDG 11.4, while others show weaker patterns. Correlation analysis uncovers both synergies and trade-offs, notably between SDG 11.4, SDG 11.5 and SDG 11.6. The proposed methodology emphasizes the importance of neighborhood-scale analysis for targeted interventions and offers a replicable methodology for localizing SDG monitoring in urban contexts and identifying spatial correlations.

Keywords: Urban Sustainability Assessment Tools · 2030 Agenda · SDG 11 · Multicriteria Evaluation Framework

1 Introduction

Urbanization is one of the defining forces of the 21st century, profoundly reshaping economies, societies and ecosystems worldwide. According to the United Nations, by 2050, the global urban population is projected to surpass 6.6 billion, with near 68% of people living in cities [1]. While cities serve as engines of innovation and economic growth, they also present intricate challenges, functioning as interconnected systems where economic, social, and environmental factors continuously interact [2]. Consequently, urban planning and governance must evolve to address these complexities in a strategic and adaptive manner.

In response to these pressing challenges, the United Nations' 2030 Agenda has become increasingly pivotal. The 17 Sustainable Development Goals (SDGs) outlined in this framework provide a roadmap for fostering social, economic, and environmental progress. Among them, SDG 11, "Sustainable Cities and Communities", underscores the importance of interrelated actions, including several targets related to key issues such as housing, transportation, cultural heritage, disaster resilience, environmental sustainability, green and public spaces.

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A growing body of research has examined the implementation of SDG 11, with various studies proposing urban indices and analytical frameworks to measure progress [2–4]. However, significant gaps persist in the assessment and quantification of SDG 11 targets. Most evaluations have been conducted at national or regional levels, with relatively few studies focusing on the neighborhood scale [1, 3]. However, evaluating sustainability at the neighborhood level is essential, as urban phenomena are highly localized and context dependent. Without a localized understanding of sustainability performance, policymakers risk implementing broad-stroke policies that fail to address the unique needs of different urban districts.

A neighborhood-scale assessment enables a finer resolution for identifying disparities in sustainability performance within a city, allowing for targeted interventions that maximize impact. This localized approach not only improves decision-making but also facilitates the identification of spatial patterns that shape urban sustainability. By mapping SDG 11 performance at finer resolutions, planners can uncover synergies and tensions among different urban sectors, leading to more strategic resource allocation and policy design. Previous studies have investigated cross-boundary interactions in relation to one or several aspects of sustainable development, such as climate change, economic development, or health [5–8]. However, only a few have addressed these interactions specifically for the SDGs, and SDG 11 targets in particular, and mostly at the regional level. Feng *et al.* [9] computed an integrated index for SDG 11 at the prefecture level in Chinese cities and assessed spatial correlations across areas. They found that most cities with a higher integrated index also had neighbors with similarly high index values, and vice versa. Xiao *et al.* [10] used spatial econometric models to examine transboundary impacts on SDG progress across Chinese cities, concluding that the SDG performance of adjacent cities positively influences the performance of focal cities.

Moreover, understanding the interrelationships among SDG 11 targets is critical. Cities operate as dynamic, interconnected ecosystems where improvements in one domain can either enhance or undermine progress in another [9, 11]. Some targets exhibit strong synergies, where progress in one target promotes progress in another, or trade-offs, when progress in one target hinders another. For instance, advancements in public transportation or green spaces contribute to improved air quality and social inclusion. Conversely, trade-offs may arise, such as when rapid housing development leads to the loss of green infrastructure. Ignoring these interconnections can result in counterproductive policies. Thus, a systemic approach that anticipates these dynamics is essential for achieving balanced and sustainable urban development.

Within this context, the present study aims to compute integrated indices of SDG 11 targets at the neighborhood level and assess their spatial distribution. The context of the study is the municipality of Cagliari, a middle-size city in Italy. Cagliari's urban landscape is highly diverse, encompassing densely built historic districts alongside more fragmented suburban developments. This variability makes it an ideal testbed for evaluating sustainability performance across different urban typologies. By advancing granular sustainability evaluations, this research contributes to more informed, context-sensitive urban policies, ultimately fostering cities that are both more equitable and resilient in the face of contemporary urbanization challenges.

The structure of the paper is as follows: in Sect. 2 we outline the methodology used in the study, while in Sect. 3 we introduce the contextual background of the research. In Sect. 4 we present the main results of the analysis, and in Sect. 5 we provide some of the key findings of the study.

2 Methodology

The methodology employed in the current work included different steps:

1. Indicator identification and selection.
2. Computation of indicator values.
3. Standardization of indicator values.
4. Calculation of composite SDG 11 targets.
5. Comparison of SDG scores, autocorrelation spatial analysis, correlation analysis.

2.1 Indicator Identification and Selection

We selected indicators based on a combination of past research studies, national and international sustainability protocols, and national and regional sustainable development strategies. For each SDG target, we included as many indicators as feasible, considering data availability at the neighborhood level, complexity, and relevance. This approach aligns with previous studies [3, 12]. Our final list consists of 19 indicators, as reported in Table 1.

2.2 Computation of Composite SDG 11 Targets

Once we computed all the indicators listed in Table 1 for each neighborhood, we standardized them to a scale from 0 to 1 to facilitate comparison. We distinguish between negative indicators, which hinder the achievement of SDG 11 targets, and positive indicators, which contribute to their achievement. The following formulas were used for standardization:

$$\text{For negative indicators} : Ind' = \frac{Max(Ind) - Ind}{Max(Ind) - Min(Ind)} \tag{1}$$

$$\text{For positive indicators} : Ind' = \frac{Ind - Min(Ind)}{Max(Ind) - Min(Ind)} \tag{2}$$

Here, Ind' represents the standardized value of an indicator at the neighborhood level, while Ind denotes its original (non-standardized) value. After standardization, we constructed a composite index for each SDG 11 target by calculating the arithmetic mean of all standardized indicators associated with the specific SDG 11 target, as expressed in the following formula:

$$SDG_k = \frac{1}{M} \sum_{m=1}^{M} Ind'_m \tag{3}$$

where M represents the total number of indicators linked to the specific SDG.

Table 1. Description of SG11 indicators

Target	Indicator	Unit measure
11.1	Accommodation space per inhabitant	[m^2/inhabitant]
11.1	Diversity of building types	[N]
11.1	Percentage of buildings equipped with photovoltaic systems	[%]
11.1	Number of energy communities	[N]
11.1	Percentage of residential buildings with 5G internet connection	[%]
11.2	Percentage of road surface dedicated to pedestrian areas	[%]
11.2	Number of pedestrian crossings per 100 m	[N/100 m]
11.2	Percentage of streets with bike lanes	[%]
11.2	Percentage of streets with the presence of public transport	[%]
11.2	Percentage of population that can reach a bus stop within 150 m	[%]
11.3	Percentage of unused buildings	[%]
11.4	Number of historical-cultural heritage sites and landscape assets	[N]
11.4	Number of cultural associations per inhabitant	[N/inhabitant]
11.5	Percentage of the population exposed to flood risk	[%]
11.5	Percentage of the population exposed to landslide risk	[%]
11.6	Percentage of high-traffic roads	[%]
11.7	Public green space per inhabitant	[m^2/inhabitant]
11.7	Percentage of neighborhood area covered by green spaces	[%]
11.7	Percentage of population that can reach a green area within 300 m	[%]

2.3 Spatial Autocorrelation Analysis

To investigate the presence of spatial clustering of similar SDG 11 target values at the neighborhood level, where high target values might be concentrated in specific neighborhoods of a city, we conduct a spatial autocorrelation analysis. One of the most commonly used methods for this is the computation of Moran's Index, which is defined as:

$$I_k = \frac{N \sum_{i=1}^{N} \sum_{j=1}^{N} w_{i,j} z_{i,j} z_{j,k}}{\sum_{i=1}^{N} \sum_{j=1}^{N} w_{i,j} \sum_{i=1}^{N} z_{i,k}^2} \tag{4}$$

where I_k is the Global Moran'sindex for SDG 11 target k, $z_{i,k}$ and $z_{j,k}$ represent the deviations of the integrated SDG 11 target k for the neighborhoods i and j from its means, N is the number of neighborhoods, $w_{i,j}$ is the spatial weight between neighborhood i and j. In this study, the weight matrix used is the Queen Contiguity Matrix.

The Global Moran's Index provides an overall measure of spatial autocorrelation for the entire city, assuming homogeneity among neighborhoods. However, to identify local spatial clusters, where certain neighborhoods exhibit high or low values of SDG

11 targets, we compute Local Moran's I, expressed as:

$$I_{i,k} = z_{i,k} \sum_{i=N, j \neq i}^{N} w_{i,j} z_{j,k} \tag{5}$$

When the local Moran's value is positive, the area under study has similarly high or low values as its neighbors, resulting in High-High or Low-Low clusters. Conversely, when the local Moran's I is negative, the area in question may be a potential outlier, as its value differs from that of its neighbors. In this case, we observe either a High-Low cluster (an outlier with a higher value) or a Low-High cluster (an outlier with a lower value).

2.4 Correlation Analysis

To measure the correlation between SDG 11 targets, Pearson's and Spearman's correlation coefficients are the most commonly used in literature. Pearson's coefficient is employed when the variables are continuous and normally distributed, while Spearman's coefficient is used when the analyzed variables do not meet these criteria. In the specific case of our study, where not all variables are normally distributed, we apply Spearman's correlation coefficient. Following the work of Liu *et al.* [13], we considered a correlation coefficient greater than 0.5 as indicative of synergy between SDG 11 targets, while a coefficient smaller than −0.5 was considered a trade-off.Case study

3 Study Area

The study area chosen for our case study is the city of Cagliari. Cagliari is the capital and largest city of the Sardinia region, with a population of about 155,000 inhabitants and an area of 85.45 km2. Geographically, the city is located in the southern part of Sardinia, on the Gulf of Cagliari, which overlooks the Mediterranean Sea.

Cagliari has 31 neighborhoods (Fig. 1), four of which constitute the historic city center. Beginning in the first half of the 20th century, other neighborhoods developed around this core. The city's current urban configuration is the result of transformations from 1943 to 1980, driven by war damage and rapid urbanization [14]. Three main trends shaped its growth: the development of social housing districts, the depopulation and decline of historic areas like Marina and Castello, and the consolidation of Via Roma and surrounding streets as the city's economic and political hub. Since 1994, various urban regeneration interventions have revitalized the historic districts and seafront.

3.1 Data Acquisition

To compute the indicators reported in Table 1 and conduct spatial and correlation analysis, we developed a GIS database. For its construction, we utilized various sources:

- Open data provided by national, regional, and municipal administrations (ISTAT census dataset, RUNTS Registry of Associations, Regional Geotopographic Database, Regional Landscape Plan, Regional Hydrogeological Management Plan, GTFS transit service data, Revenue Agency data, Ministry of Education data).

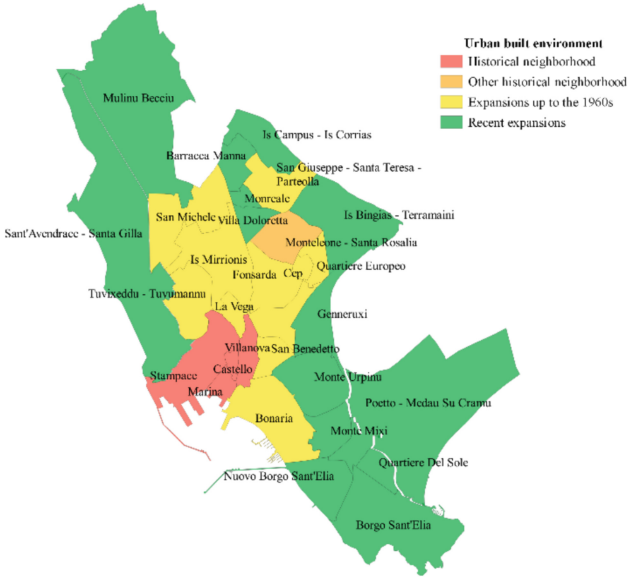

Fig. 1. Neighborhoods in Cagliari

- Open data from services such as OpenStreetMap and Google Maps.
- Manually digitalized data.

4 Results

4.1 Spatial Distribution of SDG 11 Targets

The first analysis examined the performance of Cagliari's various neighborhoods across the seven SDG 11 targets. Table 2 presents a statistical overview of the SDG 11 targets, including averages, variances, and value distributions, while Fig. 2 illustrates their spatial distribution across the different areas of the city.

Regarding SDG 11.1 (safe and affordable housing), the average score is 0.362, with most neighborhoods in the city scoring below 0.5. From a spatial standpoint, there are limited variations among different areas. The generally low score for this SDG target can be attributed to poor performance in terms of sustainable energy efficiency, as only a small percentage of buildings are equipped with photovoltaic systems or are part of an energy community. In some areas, such as the southern and northern parts of the city, the low score may also be due to a lack of diverse building types, which limits housing options for different population groups, or to limited living space per inhabitant.

We now turn our attention to SDG 11.2 (affordable and sustainable transport systems). The average score is 0.440, indicating a moderate level of achievement toward this target. Approximately 67.7% of neighborhoods have a score between 0.25 and 0.50, while 29.0% score above 0.5. From the map in Fig. 2, it is possible to identify the areas that emerge as high performers. These are mainly concentrated in the central part of

Cagliari, due to the presence of high-quality public transport services, and in the eastern areas, thanks to well-developed walkability infrastructure.

SDG 11.3 (inclusive and sustainable urbanization) shows a relatively high average score of 0.651, with 80% of areas scoring above 0.50. From the analysis of the maps, the two lowest-scoring neighborhoods are the peripheral area of Monreale and the historic district of Castello, located in the city center. In the Monreale neighborhood, several buildings are under construction but remain unfinished. In Castello, by contrast, many historic buildings are abandoned and in poor condition.

As for SDG 11.4 (Protect the World's Cultural and Natural Heritage), this target records the lowest average score (0.241) among all the SDG 11 indicators, with over 60% of areas falling into the lowest bracket (0–0.25), and an additional 16% scoring zero. Nevertheless, disparities between areas are evident. Neighborhoods located in the city center of Cagliari tend to feature cultural assets and active cultural associations, whereas neighborhoods, particularly those in the city's periphery, lack heritage resources and community-driven cultural initiatives.

In contrast, SDG 11.5 (Reduce the Adverse Effects of Natural Disasters) emerges as the best-performing target, with a high average score of 0.860 and a low variance (0.038), indicating consistent progress in reducing the exposure of urban populations to flood and landslide risks. More than three-quarters (77.4%) of observations fall within the top performance bracket (0.75–1.00). The main problem areas are in the northern part of the city, particularly the neighborhood of Terramaini, which has historically been prone to flooding, and in the southern neighborhoods of Stampace and Tuvixeddu, where landslides represent the primary risk.

SDG 11.6 (Reduce the Environmental Impact of Cities) has an average score of 0.559, with a variance of 0.05, indicating a moderate degree of inequality in this target. In some parts of the city, the presence of high-traffic roads leads to poorer air quality compared to other areas.

Finally, we analyze SDG 11.7 (Provide Access to Safe and Inclusive Green and Public Spaces). On average, this target scores 0.378, indicating that access to public green and open spaces remains limited. Most observations (61.3%) fall within the 0.25–0.50 range. From this perspective, the least-performing areas in Cagliari are the historical neighborhoods, which, due to their urban development and layout, were not designed to include green spaces and are often located far from accessible parks or open areas within walking distance.

4.2 Spatial Autocorrelation Analysis

To assess the presence of spatial autocorrelation among different neighborhoods, we computed the global Moran's I. The results are presented in Table 2, where we report on the Moran's I value and corresponding p-value for each SDG 11 target.

We found statistically significant Moran's I values for nearly all SDG 11 targets, except for SDG 11.3, SDG 11.6, and SDG 11.7. For SDG 11.1, we observed a Moran's I of 0.444, indicating a high degree of positive spatial clustering for this target. This can be attributed to the low variability in the target across neighborhoods, as discussed in Sect. 4.1. Another target with a relatively high global Moran's I is SDG 11.4, with a value of 0.462. This is likely to reflect historical urban development patterns, where

Table 2. Values of SDG 11 Targets

	SDG 11.1	SDG 11.2	SDG 11.3	SDG 11.4	SDG 11.5	SDG 11.6	SDG 11.7
Average	0.362	0.440	0.651	0.241	0.860	0.559	0.378
Variance	0.010	0.019	0.054	0.051	0.038	0.050	0.027
0	0.0%	0.0%	3.2%	3.2%	0.0%	3.2%	3.2%
0 – 0.25	9.7%	3.2%	3.2%	61.3%	0.0%	3.2%	16.1%
0.25 – 0.50	83.9%	67.7%	12.9%	16.1%	9.7%	19.4%	61.3%
0.50 – 0.75	6.5%	25.8%	41.9%	16.1%	12.9%	58.1%	16.1%
0.75 – 1.00	0.0%	3.2%	38.7%	3.2%	77.4%	16.1%	3.2%

Table 3. Global Moran I values for different SDG 11 targets

	SDG 11.1	SDG 11.2	SDG 11.3	SDG 11.4	SDG 11.5	SDG 11.6	SDG 11.7
Global Moran I	0.444	0.179	0.039	0.462	0.309	0.047	0.127
P value	0.001	0.041	0.230	0.001	0.003	0.237	0.086

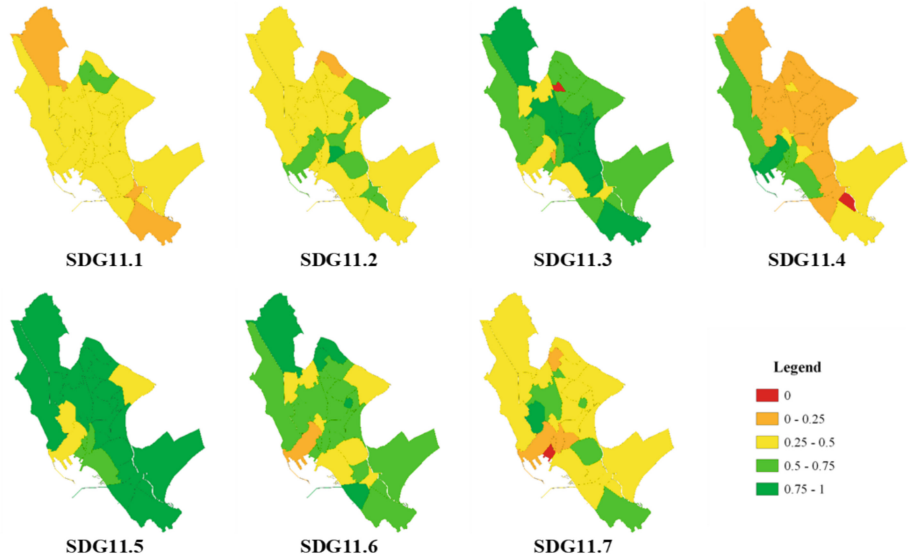

Fig. 2. Spatial distribution of SDG 11 targets across neighborhoods in Cagliari

cultural sites are concentrated in the city's most ancient neighborhoods. Other SDG 11 targets, while statistically significant, show only moderate levels of spatial clustering.

As discussed in the methodology section, global Moran's I only provides a metrics of spatial autocorrelation at the city level. To assess the presence of spatial cluster at the neighborhood level, we compute for each neighborhood local Moran's I. Results are reported in Fig. 3, from which emerged that different neighborhoods display statistically significant spatial clusters.

In terms of SDG 11.1, we observe the presence of low-low clusters in the southern peripheral areas of the city, specifically in neighborhoods like Borgo Sant'Elia and Nuovo Borgo Sant'Elia, which are currently considered slums. Within this context, Quartiere del Sole and Monte Mixi emerge as high-low clusters, meaning they stand out as outliers with significantly higher SDG 11.1 values compared to the surrounding areas. This is consistent with their status as affluent residential neighborhoods. In the northern part of the city, we see the presence of high-high clusters, although there are also low-high outliers within this zone, specifically the neighborhoods of Monreale (previously discussed) and Terramaini. To the west, Sant'Avendrace forms part of a low-low cluster, sharing similar challenges related to SDG 11.1 with the neighboring districts of San Michele, Is Mirrionis, and Mulinu Becciu.

Regarding sustainable mobility (SDG 11.2), a high-high cluster is observed in the central area of Cagliari, specifically the neighborhoods of La Vega, Villanova, and Sant'Alenixedda. Within this cluster, the neighborhood of Genneruxi stands out as a low-high outlier due to its relatively limited public transport connectivity compared to the other neighborhoods in the same cluster. The map also reveals a high-low cluster in the northern periphery, represented by the neighborhood of San Michele, which distinguishes itself from nearby areas through better public transport coverage and more pedestrian-friendly infrastructure. In contrast, other northern peripheral neighborhoods form a low-low cluster. These areas generally lack sidewalks and are served by a limited number of public transport lines, which contributes to their poor performance in sustainable mobility.

For SDG 11.3, it is interesting to observe that neighborhoods such as Cep, Fonsarda, and Sant'Alenixedda form High-High clusters, suggesting a commonly low share of unused buildings in these areas. In the north, the neighborhoods of Is Mirrionis and Mulinu Becciu form a High-Low cluster, likely due to their proximity to the Monreale neighborhood, which has a high level of unused buildings.

SDG 11.4 and SDG 11.5 also exhibit noteworthy spatial dynamics. Stampace and Castello are clear High-High clusters for SDG 11.4 indicators, consistent with their historical significance and central location, which makes them attractive locations for cultural associations. Disaster resilience (SDG 11.5) shows fewer clusters overall, though the northern neighborhoods of the city once again emerge as High-High clusters.

As for SDG 11.6, some spatial patterns can also be detected. High-High clusters appear in the peripheral northern neighborhoods of the city, due to the lack of dense road infrastructure. On the other hand, Mirrionis and Villanova are identified as High-Low outliers, as their share of high-intensity traffic roads is lower compared to that of adjacent neighborhoods.

Finally, SDG 11.7 highlights the presence of Low-Low clusters in the historical neighborhoods of Marina, Castello, and Villanova, located in the southern part of the city. This is due to limited accessibility to green and open spaces, as explained in the

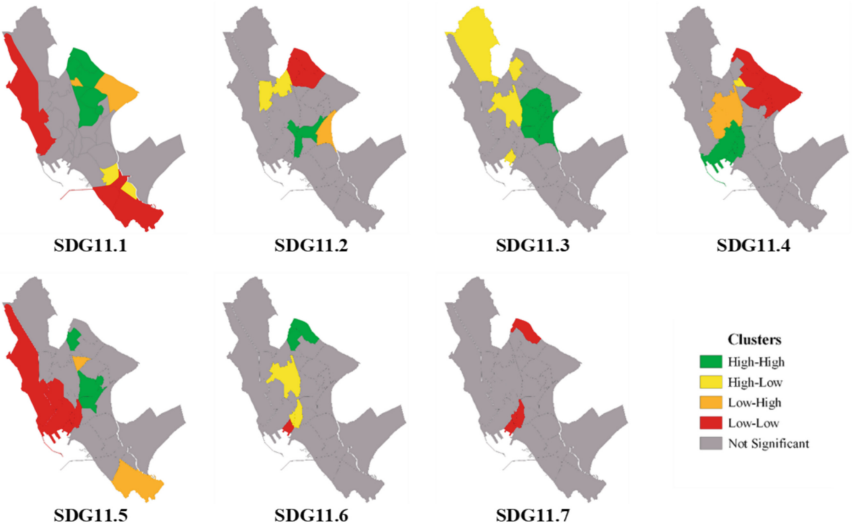

Fig. 3. Spatial clusters of SDG 11 targets in Cagliari

previous section, which is a result of their urban development history. Another Low-Low cluster can also be observed in the northern periphery of the city.

4.3 Correlation Analysis

Finally, we analyze the correlations among the different SDG 11 targets, as shown in Table 4. A negative correlation is observed between SDG 11.5 (disaster resilience) and SDG 11.4 (cultural heritage), suggesting that areas with a higher concentration of cultural heritage sites are also more exposed to disaster risk. This inverse relationship may be attributed to the presence of older infrastructure in these neighborhoods, which increases their vulnerability to natural disasters. A negative correlation is also found between SDG 11.6 (urban environmental quality) and SDG 11.4. This may be explained by the absence of major high-traffic road infrastructure in central neighborhoods, which also serve as the city's cultural hubs.

Interestingly, a positive correlation ($r = 0.578$) emerges between SDG 11.5 and SDG 11.6. This result may indicate that high-traffic road infrastructure tends to be located outside areas with high hydrogeological risk, thereby contributing to greater disaster resilience.

As for the correlations among the other SDG 11 targets, they generally show only weak or modest relationships. This suggests that interventions targeting a specific dimension of sustainability are unlikely to produce unintended consequences, positive or negative, on others.

Table 4. Correlation analysis

	SDG 11.1	SDG 11.2	SDG 11.3	SDG 11.4	SDG 11.5	SDG 11.6	SDG 11.7
SDG 11.1	1						
SDG 11.2	−0.179	1					
SDG 11.3	−0.062	0.393	1				
SDG 11.4	−0.162	0.127	−0.241	1			
SDG 11.5	−0.052	0.039	0.258	−0.609	1		
SDG 11.6	0.282	−0.405	0.086	−0.512	0.578	1	
SDG 11.7	−0.342	0.105	0.204	−0.135	−0.011	−0.132	1

5 Conclusions

The pursuit of SDG 11 in a city requires a detailed understanding of the current status and progress of sustainable development at the neighborhood level. Neighborhoods often experience varying levels of progress toward SDG 11 targets, which can lead to spatial disparities in access to essential services and overall quality of life. Nevertheless, although identifying spatial clusters and correlations among different SDG 11 targets is critical for effective urban planning and policy interventions, only a few studies have attempted such analyses at the neighborhood scale.

To address this gap, the present study proposes a methodology to investigate the spatial distribution of SDG 11 targets at the neighborhood level. The methodology involves identifying the indicators underpinning each SDG 11 target, computing target values through indicator aggregation, spatially characterizing the aggregated SDG 11 targets, and analyzing spatial autocorrelation and cross-target correlations.

The construction of neighborhood-level maps for each SDG 11 target enabled a clearer understanding of the city's progress at the local scale. While some neighborhoods perform well across multiple SDG 11 dimensions, others reveal localized challenges or fragmented sustainability outcomes in key areas such as housing, public transport, green spaces, and disaster resilience.

The results of the spatial autocorrelation analysis revealed that spatial relationships are a relevant dimension for understanding how sustainable development outcomes vary within urban areas. Global Moran's I analysis showed statistically significant spatial clustering for most SDG 11 targets, with particularly high values for SDG 11.1 and SDG 11.4, suggesting strong spatial structuring influenced by urban form and historical development. In contrast, targets such as SDG 11.3, 11.6, and 11.7 exhibited weak or non-significant spatial autocorrelation at the city level.

Local Moran's I analysis further highlighted the presence of distinct spatial clusters and outliers across neighborhoods. For example, low-low clusters for SDG 11.1 were observed in the southern peripheral neighborhoods, aligning with the presence of informal settlements, while high-low outliers represented affluent areas that stand out from their surroundings. Similar spatial dynamics were observed across other SDG 11 targets, including sustainable mobility (SDG 11.2), disaster resilience (SDG 11.5), and access

to green spaces (SDG 11.7), revealing the uneven distribution of urban sustainability indicators.

As for the correlations among different SDG 11 targets, no significant relationships were detected for most of them. The only identified synergy was between SDG 11.5 and SDG 11.6, while trade-offs were observed between SDG 11.4 and SDG 11.5, as well as between SDG 11.4 and SDG 11.6.

From a policy standpoint, the findings of the current study emphasize the importance of neighborhood-scale analysis for monitoring progress toward SDG 11. Understanding where spatial clusters and disparities occur allows for more targeted and effective urban policy interventions, promoting equitable and sustainable urban development. At the same time, the presence of trade-offs and synergies among certain SDG 11 targets enables the identification and implementation of interventions that can positively impact multiple aspects of SDG 11, or draw attention to those that may have detrimental effects on other aspects of SDG 11. The proposed methodology offers a replicable approach for other cities seeking to localize SDG assessments and address spatial inequalities in urban sustainability.

Nevertheless, this study is not without limitations. First, the selection of indicators was constrained by data availability. Although additional indicators relevant to the SDG 11 targets could have been used, we excluded them due to insufficient data for reliable computation. Since both the spatial autocorrelation analysis and the cross-target correlation analysis are influenced by the specific indicators selected, the results could be biased by the choice of indicators. Second, our analysis was conducted at the neighborhood level. However, in some cases, neighborhoods may be too large or heterogeneous, suggesting that a more granular scale, such as the census tract level, would yield more detailed insights. This is a direction future studies could explore. Despite these limitations, our study emphasizes the importance of spatially localizing SDG 11 targets at the neighborhood level. Further research is encouraged to deepen the understanding of spatial dynamics and interconnections between sustainable development goals in urban contexts.

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