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Bottleneck-Constrained Prioritisation of Urban Green Infrastructure Policies in Madrid

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Abstract

The importance of urban green infrastructure can be stated in terms of contributions to climate adaptation, biodiversity preservation, health benefits, community revitalisation, and environmental justice. Nevertheless, the potential contribution of urban green infrastructure to resilience may be overstated because strong ecological or innovation components can offset poor performance in terms of governance, autonomy, and social cohesion. In the case of the municipal programme for urban green infrastructure in Madrid between 2015 and 2019, one may distinguish 21 districts with more than three million inhabitants, a population density of 5512 inhabitants per km^2, 18.3 m^2 of green space per inhabitant, 1.4 trees per three inhabitants, 27 urban green infrastructure policies, 620 geolocated actions, 30 resilience indicators, six factor scores, and district vulnerability values. From a set of six factor scores, one can discern the following picture of the profile of this municipality: learning and innovation and social-ecological justice have reached 0.98 on the 0–2 scale; diversity – 0.95; social cohesion – 0.81; self-sufficiency and autonomy – 0.76; and polycentric governance – 0.69. The highest mean score (6.97) among all sets of three policies belongs to HI_plan, MD_info, and MI_plan. Together with GIB_plan and GS_plan, this constitutes a five-policy strategic core with a mean score of 6.74 and a better municipal balance due to the link between neighbourhood participation and planning continuity. District action scores correlate rather strongly ($r = 0.569$) and positively with the proportion of low-education or no-education residents, i.e., a partial pro-vulnerability orientation exists.

Keywords: urban green infrastructure; urban resilience; policy prioritisation; polycentric governance; environmental justice; Madrid

1. Introduction

urban gardens, riparian areas, green roofs, peri-urban areas, and green corridors mitigate heat effects, promote ecological connectivity, manage stormwater flows, offer recreation, and enhance regular interaction with nature [12, 25]. These benefits require more than the presence of vegetation. They depend on accessibility, safety, maintenance, accountability, social legitimacy, and alignment between investment and neighbourhood vulnerability [9, 17]. An urban green area that is inaccessible, poorly maintained, or isolated from heat-affected districts has fewer resilience benefits than a green area that serves ecological, social, and institutional functions.

Urban resilience has traditionally been understood as the capacity of urban systems to absorb disturbance, adapt,

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and transform situations of vulnerability [1, 19]. From the perspective of green infrastructure, resilience appraisals need to consider both ecological dynamics and governance processes. A tree-planting programme could add canopy cover but neglect the most heat-exposed neighbourhoods. River interventions could enhance habitat while affecting land value and affordability. Community gardens could support local management yet remain vulnerable due to insecure tenure and maintenance. Resilience assessment thus needs to explore who stands to benefit from a given policy intervention, which citizens participate in shaping it, which departments implement it, and whether it has enough durability post-delivery.

Madrid is a promising context to conduct such assessments because the municipality has abundant urban green provision and considerable district diversity. The municipality has more than three million inhabitants and 21 districts. Its population density reaches 5512 inhabitants per km^2. Madrid has more than 18 m^2 of green space per inhabitant and 1.4 trees per three inhabitants. Parks account for more than 90% of the green structure, whereas peri-urban green space occupies more than 25% of the municipal area. Although there is no doubt about Madrid's capacity to provide greenspace, there are questions regarding the governance, maintenance, accessibility, and distribution of such green assets.

This study examines 27 green infrastructure policies and 620 geolocated actions implemented in Madrid between 2015 and 2019. The policies include planning and legislative measures, economic and market instruments, and citizen engagement or information measures. District action values and policy scores enable the direct comparison between policy strength, resilience-factor balance, and vulnerability alignment. The six resilience factors are diversity, self-sufficiency and autonomy, polycentric governance, social cohesion, learning and innovation, and social-ecological justice. These resilience factors demonstrate that the major limitation of Madrid's policy group lies not in its environmental discourse or learning content, but in its poor polycentric governance and social cohesion.

The focus of this article is on the most problematic aspects of Madrid's resilience profile. A policy system cannot be assessed merely based on the best-performing policy and the number of implemented actions. Policy system should perform consistently in all relevant fields like governance, finance, participation, distribution, learning, and ecological diversity. Strong learning does not help much if polycentric governance fails to integrate various departments and districts in implementing a policy system. Social-ecological justice might prove insufficient if citizens fail to acquire durable roles in the governance of their environments. Likewise, the average performance of a policy group matters less than its city-wide consistency and financial sustainability.

2. Urban green infrastructure, governance and justice

Green infrastructure planning has shifted from focusing on connected landscapes towards considering ecosystem services, climate adaptation, health, and social justice [5, 25]. Early literature highlighted connections between landscapes and communities [5, 25]. More recently, studies of urban ecosystems have demonstrated the importance of vegetation, soil, water, and urban public space to maintaining regulating, provisioning, and cultural services under changing urban conditions [18, 20]. Multifunctional urban greenspaces could provide cooling, stormwater regulation, wildlife habitat, recreation, and neighbourhood identity at once [9, 17]. However, in dense cities, such greenspaces are unevenly distributed among districts depending on walking distance, safety, maintenance, disability access, cultural value, and political power.

Green infrastructure planning operates at the intersections between ecological, social, economic, and institutional systems. Greenspace planning considers biodiversity, hydrology, soils, and climatic regulation. Moreover, green infrastructure affects public space, health, recreation, social inclusion, and conflict. Green infrastructure planning demands significant capital expenditures, ongoing maintenance, and continuous management. Lastly, green infrastructure planning involves various municipal departments responsible for the environment, transport, planning, health, public works, emergencies, and district coordination. Thus, policy appraisal in green infrastructure must go beyond demonstrating whether green interventions exist to ensuring consistent institutional support [11, 23].

Aggregate composite scoring enables comparative analysis but may conceal the weakest component of a policy group. Aggregation might present balanced performance even if high values in one field offset lower values in another [21]. In the case of green infrastructure planning, however, such compensatory practices are highly dangerous. A programme with ecological but not social goals may experience low legitimacy. A green intervention rich in actions but lacking financial resources may be unsustainable. Lastly, a strategy characterised by robust discourse but low district participation will probably produce few benefits in vulnerable neighbourhoods. Low performance of a particular factor must be read as a constraint rather than a minor flaw in an otherwise good policy group.

Polycentric governance is critical to this analysis. Polycentricity implies that a system consists of several decision-making centres that can collaborate while preserving autonomy [22]. This feature is relevant for green infrastructure planning since climate adaptation, biodiversity protection, mobility, public health, water management, and maintenance cannot reside in the same office. Research on greenspace stewardship suggests that multiple stakeholders generate several benefits of urban greenspace use [2, 8]. In other words, polycentric governance is essential to ensure successful implementation of a technically sound policy intervention.

Social justice represents the other constraint for this assessment. Green infrastructure could mitigate inequality when its benefits reach vulnerable neighbourhoods affected by exposure to summer heat or other negative externalities. At the same time, green interventions might exacerbate inequality when investments are channelled to better-off districts or increase displacement pressures [3, 26]. In this respect, policy appraisals in greenspace governance must consider issues of distribution, participation, and recognition. Distribution entails the assessment of where ecological benefits or nuisances lie. Participation refers to the question of which stakeholders determine greenspace governance. Finally, recognition is about the sensitivity of the greenspace policy to local history, needs, identities, and attachments [24]. Several European greenings have failed to consider distributional inequalities caused by rising housing costs [4, 13].

3. Materials and methods

3.1. Madrid municipal setting

Madrid is an urban European capital with 3+ million residents. It has 21 districts and density equal to 5512 inhabitants per km^2. The municipality has provision of 18.3 m^2 per inhabitant and 1.4 trees per three inhabitants. Urban parks account for more than 90% of green spaces. Peri-urban greenspaces account for more than 25% of Madrid municipal area. Urban greenspaces include landscaped streets, urban gardens, building plots, leisure zones, forests, pastures, and greenspaces along Manzanares river.

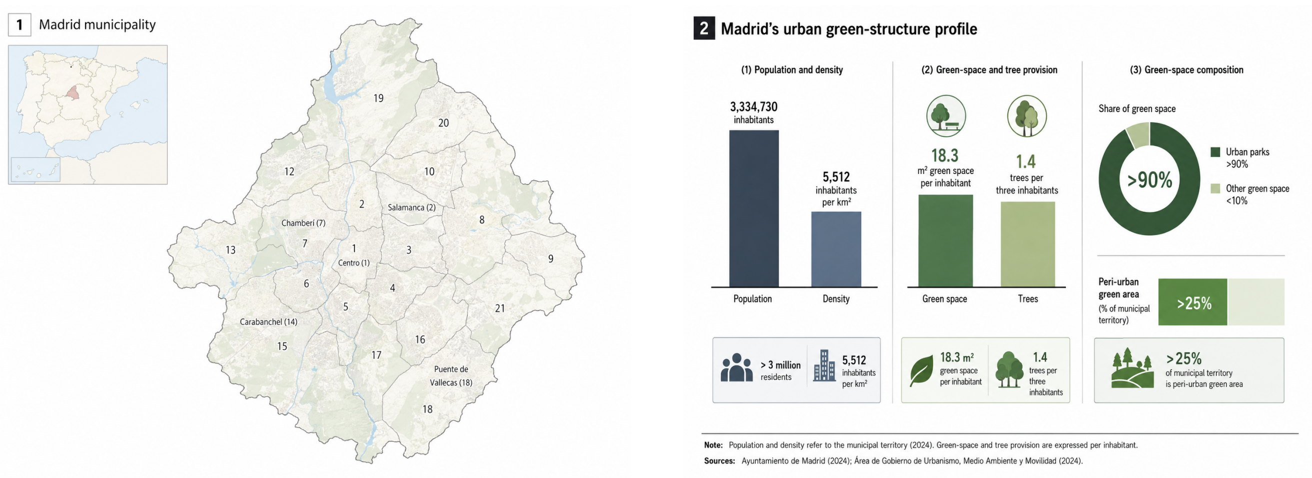

Figure 1. Madrid municipal profile and green-structure condition. The left panel shows the municipality and district structure; the right panel summarises population, density, green-space provision, tree provision, and green-space composition.

Figure 1 juxtaposes the geography of Madrid and its municipal green-structure metrics. Panel 1 maps the municipality and its 21 districts. Panel 2 presents population size, density, green-space provision, tree provision, and proportion of parks/peri-urban greens that constitute the basis for Madrid green infrastructure setting.

The municipal policy set comprises 27 green infrastructure policies and 620 geo-referenced actions. Policies are differentiated into planning or legal instruments, economic or market-based instruments, and civic engagement or information instruments. The institutional material relates to seven individuals who work at Environment and Transport, Sustainable Urban Development, Territorial Coordination and Civic and Social Cooperation, and Health, Safety and Emergencies institutions. Thus, there is no doubt that green infrastructure implementation in Madrid requires management of the environment, sustainable development of the city, coordination of districts, civic involvement, health care, and emergency planning.

Figure 2 shows the municipal policy set and resilience dimensions applied in the analysis. The first table shows the categories of instruments that policies fall into and the policies themselves with quantitative assessments. The second table lists six dimensions that include 30 indicators.

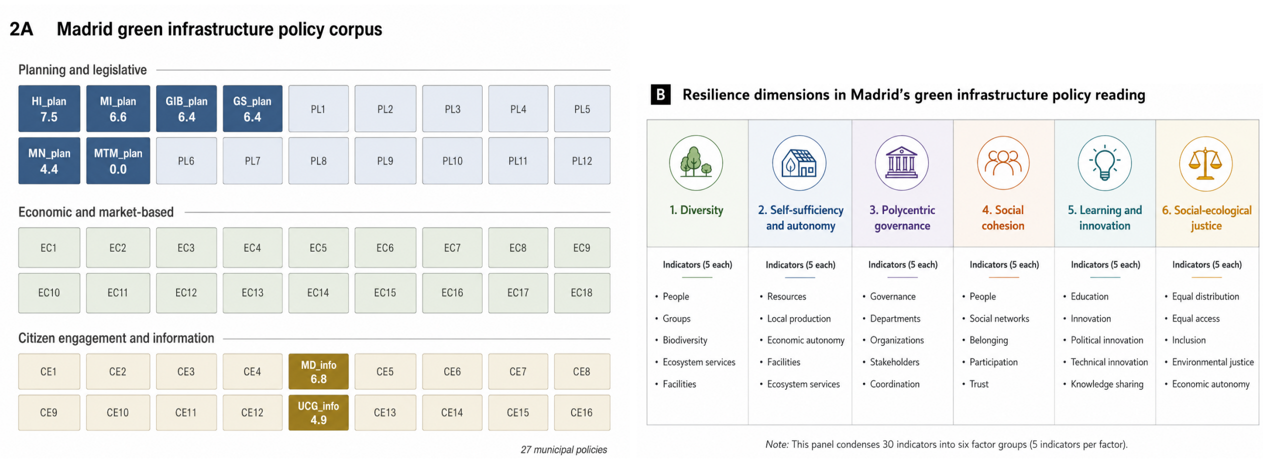

Figure 2. Policy set and resilience dimensions for Madrid's green infrastructure assessment. The upper panel groups municipal policies by instrument type and marks policies with numerical scores; the lower panel summarises the six resilience dimensions and their indicator content.

The 30 indicators cover diversity of people, organised citizen groups, businesses, biodiversity, green infrastructure, ecosystem services, human-made facilities, participating residents, participating organised groups, participating economic sectors, participating public administrations, participating government departments, social networks, multilevel and decentralised governance, demand for provisioning ecosystem services, demand for regulating ecosystem services, supply of provisioning ecosystem services, supply of regulating ecosystem services, supply of cultural ecosystem services, social innovation, education, equal distribution of green infrastructure, equal access to green infrastructure benefits, sense of belonging, political innovation, technical innovation, temporary impact, universal accessibility, social conflicts, and economic autonomy. The six factor dimensions are diversity, self-sufficiency and autonomy, polycentric governance, social cohesion, learning and innovation, and social-ecological justice (Table 1).

3.2. Resilience-factor calculation

Let $\mathcal{P}$ denote the policy set and $\mathcal{F}$ denote the six resilience factors. Each policy $p \in \mathcal{P}$ has a resilience score R_p on a 0–10 scale when a numerical policy score is available. Each factor $f \in \mathcal{F}$ has a mean score s_f on a 0–2 scale. The strongest factor value is denoted $s^{\max}$. In Madrid, $s^{\max} = 0.98$, reached by learning and innovation and social-ecological justice. The relative factor deficit is calculated as

$$\delta_f = \frac{s^{\max} - s_f}{s^{\max}}. \tag{1}$$

The value δ_f measures the distance between each factor and the strongest factor in the Madrid values. A larger value indicates a stronger constraint on the municipal resilience profile. The calculation does not treat 0.98 as a universal

Table 1. Madrid green infrastructure values.

Domain	**Value**
Municipal profile	More than three million residents in 21 districts, with 5512 inhabitants per km^2.
Green-space condition	18.3 m^2 of green space per inhabitant and 1.4 trees per three inhabitants.
Spatial composition	Urban parks account for more than 90% of green space; peri-urban green areas exceed 25% of municipal territory.
Policy set	Twenty-seven municipal green infrastructure policies during the 2015–2019 term.
Action set	Six hundred and twenty geolocated actions with sufficient spatial definition for district interpretation.
Institutional participation	Seven officials and policymakers from environment, transport, sustainable urban development, territorial coordination, public-social cooperation, health, security, and emergency domains.
Resilience dimensions	Diversity, self-sufficiency and autonomy, polycentric governance, social cohesion, learning and innovation, and social-ecological justice.
District alignment values	Action-score intervals of 49–73, 74–117, 118–177, 178–220, and 221–278; low-education intervals of 19–23%, 24–33%, 34–45%, 46–55%, and 56–64%.

ideal. It identifies the weakest part of Madrid's own factor distribution. The same factor scores can be multiplied by five to express them on a 0–10 interpretive scale, but the 0–2 values remain the primary numerical values.

Policy groupings are evaluated by their mean score and score dispersion. For any policy subset $S \subseteq \mathcal{P}$, the mean policy score is

$$\bar{R}S = \frac{1}{|S|}\,{}_{p\in S} R_p. \tag{2}$$

The coefficient of variation is

$$CVS = \frac{\sigma_R S}{\bar{R}S}, \tag{3}$$

where $\sigma_R S$ is the population standard deviation of the policy scores in S. A lower CVS indicates more even performance among included policies. The conservative score floor is calculated as $\bar{R}S - \sigma_R S$. This value prevents a policy grouping from appearing strong only because one component has a very high score. Three groupings are considered: the neighbourhood participation core formed by HI_plan, MD_info, and MI_plan; the strategic resilience core formed by those three policies plus GIB_plan and GS_plan; and the corrective social-ecological expansion formed by the five-policy core plus UCG_info and MN_plan.

3.3. District vulnerability alignment

Equity at the district level is determined by the connection between district action scores and the percentage of residents with low education or uneducated residents. Action-score ranges include 49–73, 74–117, 118–177, 178–220, and 221–278, while the low-education ranges are 19–23%, 24–33%, 34–45%, 46–55%, and 56–64%. The relation between district resilience action scores and the low-education variable is $r = 0.569$ at $p < 0.05$. The positive correlation is a sign of partial pro-vulnerability alignment. It cannot illustrate full environmental justice because educational achievement is just a vulnerability aspect and the district intervals are unable to indicate access, maintenance, safety, displacement risk, or actual experience.

4. Results

4.1. Municipal green-structure characteristics

The green structure value system includes significant provision and differentiation for Madrid. Green space availability is 18.3 m^2 per inhabitant, which means that green resources are abundant in this municipality. Peri-urban green space availability exceeds 25%, indicating large vegetated areas located outside inner-city parks. Meanwhile, urban parks constitute over 90% of green space availability. Consequently, park-based green space provision is dominant. Such green structure characteristic is essential because parks, peri-urban areas, streets, gardens, and riverside areas have different service, accessibility, and social attributes.

The 620 geolocated actions help understand green infrastructure policy processes at the district level. Otherwise, the connection between policy activities and social vulnerability could not be explored. Additionally, 27 policies mean that the municipality has applied more than one policy instrument in their activities. The planning and legislation instruments contribute to defining the strategy and providing rules. The economic and market instruments affect the resource and incentive aspects. Information and citizen engagement tools focus on participation, learning, and legitimacy dimensions. However, the factor analysis indicates that a wide range of instruments does not mean high governance and autonomy.

4.2. Factor imbalance

Six factor scores demonstrate the principal weaknesses of Madrid's green infrastructure policy process. The Learning and Innovation and Social-ecological Justice are two strongest factors, both having scores equal 0.98. The Diversity factor is 0.95. These figures show that the content of the process is strong in terms of education, learning, and distribution access, as well as ecological and ecosystem-service diversity and participant diversity. All other factors are less significant. Social Cohesion has a score of 0.81. The Self-sufficiency and Autonomy scores are equal to 0.76, while Polycentric Governance has the lowest factor score – 0.69 (Table 2).

Table 2. Factor balance and relative deficit in Madrid's green infrastructure policy set.

Resilience factor	**Score on 0–2 scale**	**Relative deficit**	**Policy interpretation**
Learning and innovation	0.98	0.000	Strong educational, social, political, and technical learning content.
Social-ecological justice	0.98	0.000	Strong attention to distribution, access, and vulnerable districts.
Diversity	0.95	0.031	Broad ecological, social, institutional, and service variety.
Social cohesion	0.81	0.173	Community networks and durable stewardship remain weaker than justice and innovation.
Self-sufficiency and autonomy	0.76	0.224	Financing, maintenance continuity, and local capacity constrain policy durability.
Polycentric governance	0.69	0.296	Interdepartmental and multilevel coordination form the main system constraint.

Figure 3 presents the same ordering graphically. The horizontal profile makes the weak end of the factor distribution explicit and shows that the strongest constraint is institutional rather than ecological.

The relative deficit calculation makes the imbalance clear. Polycentric governance is 29.6% below the strongest factor. Self-sufficiency and autonomy are 22.4% below the strongest factor, and social cohesion is 17.3% below it. These differences are large enough to alter policy priorities. Additional actions focused only on biodiversity, innovation, or spatial targeting would not resolve the main constraint if governance and autonomy remain weak. The immediate resilience priority is stronger interdepartmental coordination, budget continuity, maintenance ownership, and participatory stewardship.

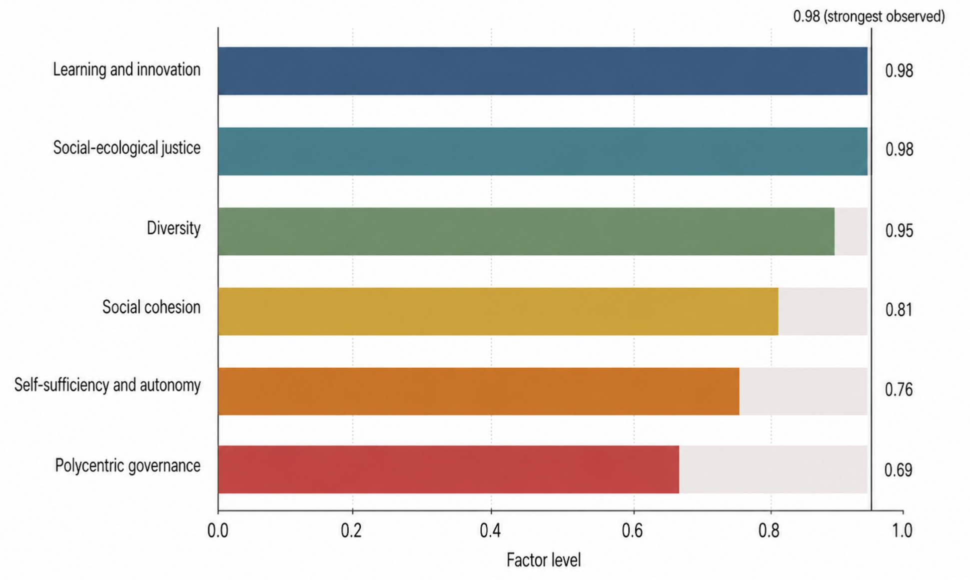

Figure 3. Bottleneck profile across the six resilience factors. Scores are displayed on the 0–2 factor scale, with the strongest observed level at 0.98. Polycentric governance, self-sufficiency and autonomy, and social cohesion form the principal constraints in the Madrid policy set.

4.3. Policy group performance

The highest numerical policy score is HI_plan at 7.5. MD_info scores 6.8, MI_plan scores 6.6, and both GIB_plan and GS_plan score 6.4. UCG_info scores 4.9, MN_plan scores 4.4, and MTM_plan scores 0. These values show that participatory and vulnerable-neighbourhood policies form the strongest group, while some technical or narrowly administrative actions have much lower resilience value.

Figure 4 shows how the numerical policy scores translate into group performance. The first panel ranks the policies with available values. The second panel compares the mean score of the three policy groupings used in the prioritisation.

The neighbourhood participation core with HI_plan, MD_info, and MI_plan attains the maximum mean of 6.97. The corresponding population standard deviation and coefficient of variation are 0.39 and 0.055 respectively, while the conservative score floor stands at 6.58. Such a grouping of policy initiatives shows good social anchorage through high mean score and minimal dispersion. The weakness in this group is that it may not contribute much to continuity in city-wide planning.

Strategic resilience core includes GIB_plan and GS_plan. It has the mean of 6.74 that is just 0.23 points less than that of the previous grouping. The population standard deviation of this core amounts to 0.41, the coefficient of variation to 0.061, and the conservative score floor to 6.33. The current combination represents a slightly lower mean score but better municipal arrangement than before through the inclusion of neighbourhood participation policies. Therefore, it constitutes the optimal policy group for Madrid.

The corrective social-ecological expansion includes UCG_info and MN_plan. The mean of this combination goes down to 6.14 while the population standard deviation reaches 1.01 and the coefficient of variation becomes 0.165. At the same time, the conservative score floor drops to 5.13. In this expansion, the range of policies associated with community garden, nature, and neighbourhood ecology has been expanded. Yet it should be regarded as a mere extension (Table 3).

The zero score for MTM_plan reflects that the zero score for MTM_plan is significant. The tree pruning and planting are essential for environmental management, public safety, and canopy management in an urban

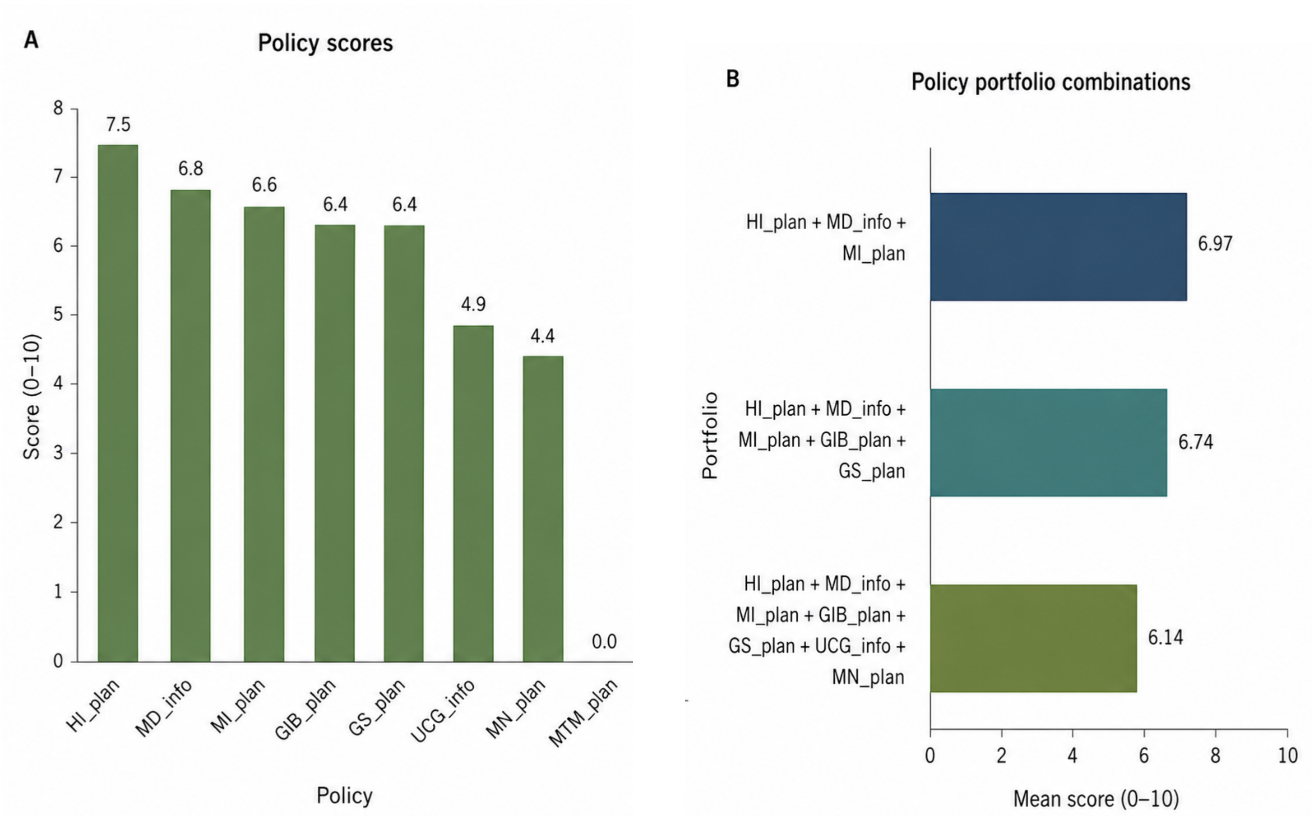

Figure 4. Policy scores and policy groupings. The left panel shows policy scores on the 0–10 scale; the right panel compares the mean scores of the neighbourhood participation core, strategic resilience core, and corrective social-ecological expansion.

Table 3. Policy groupings and score stability.

Policy grouping	Included policies	Mean / floor	Interpretation
Neighbourhood participation core	HI_plan; MD_info; MI_plan	6.97 / 6.58	Highest mean and strongest social anchor.
Strategic resilience core	HI_plan; MD_info; MI_plan; GIB_plan; GS_plan	6.74 / 6.33	Best balance between participation and citywide planning continuity.
Corrective social-ecological expansion	HI_plan; MD_info; MI_plan; GIB_plan; GS_plan; UCG_info; MN_plan	6.14 / 5.13	Wider thematic coverage, but weaker score stability.

environment. It suggests that the policy formation does not involve other resilient factors such as participation, justice, multifunctionality, and governance. Hence, the maintenance must relate to shade equity, biodiversity pathways, water management, district cooling, transparency in budget, and public reporting.

4.4. District alignment

The action score at the district level has a positive correlation with educational vulnerability measured as the percentage of people who are less educated or have not received any education. The value of r is 0.569 while the significance of the result is $p < 0.05$. Hence, districts that experience greater vulnerability regarding education also tend to perform better in terms of green infrastructure actions.

Action intensity, educational vulnerability, and their positive association are illustrated together in Figure 5. The pair of maps show both variables for the districts in New York City.

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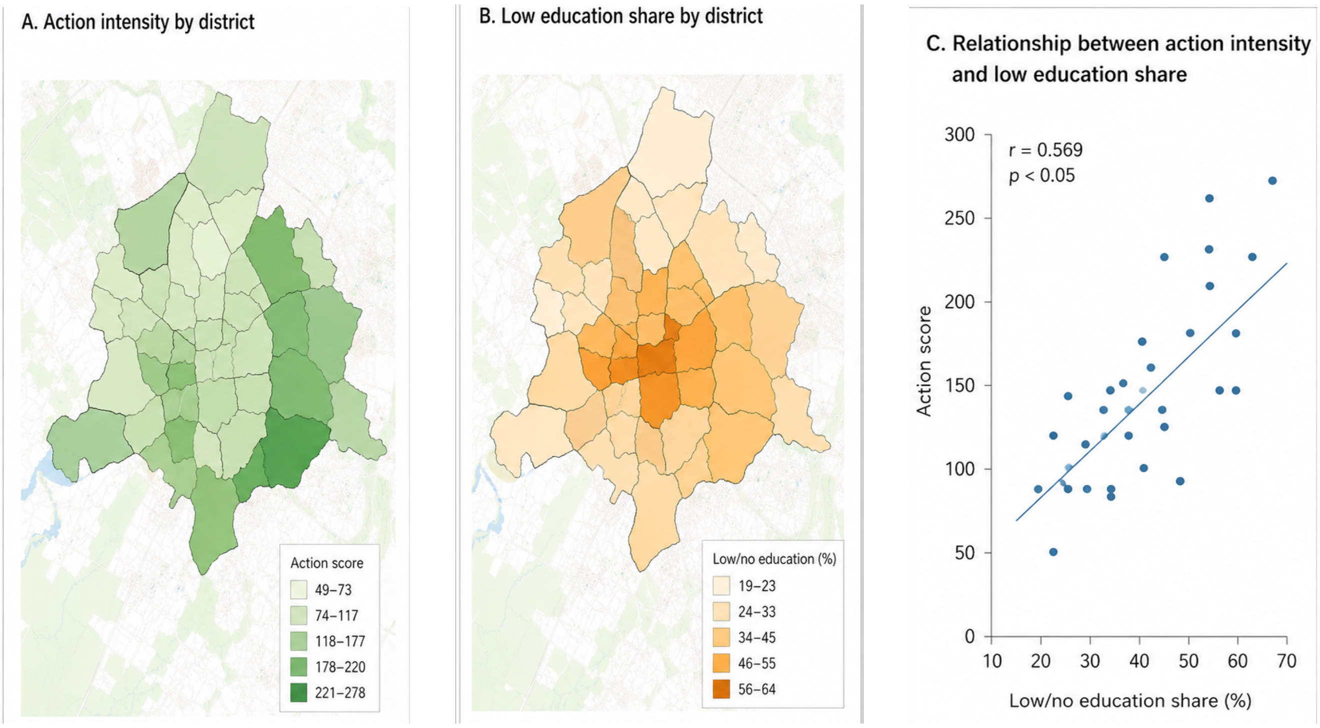

Figure 5. District action intensity and educational vulnerability in Madrid. The panels show district action-score intervals, low/no education intervals, and the positive relationship between action score and educational vulnerability ($r = 0.569$, $p < 0.05$).

The action score intervals range between 49–73 for the lowest level and 221–278 for the highest level. The education score intervals range between 19–23% and 56–64%. The positive correlation indicates that the green infrastructure actions in Madrid are not limited to districts where there is already a high level of development. This conclusion is significant as green infrastructure development may increase spatial segregation. The correlation does not reveal whether there are benefits such as increased shade, safety, opportunities for physical activity, better accessibility, cultural appreciation, or participation. It also cannot reveal whether there are benefits in terms of mitigating rent pressure or displacement. Equity considerations thus suggest that Madrid is indeed vulnerable while leaving room for further distributional quality and procedural justice policies.

4.5. Implementation priorities

Combining these findings leads to an implementation priority order. First of all, polycentric governance needs to be addressed because this factor has the lowest score and is 29.6% below the top-ranked factor. The development of green infrastructure requires greater coordination between environmental, transportation, planning, public health, district collaboration, and emergency services. Second, self-sufficiency and autonomy should also be prioritized. Resilience assets will benefit from financial sustainability, maintenance, monitoring, and adaptation over time. Third, social cohesion should receive attention since it is insufficient to focus only on vulnerable areas if people do not acquire long-term stewardship and dispute resolution powers.

The policy priority order can be operationalized by developing three fields of action in Figure 6.

This sequence reflects the strategic resilience core, which combines HI_plan, MD_info, MI_plan, GIB_plan, and GS_plan. HI_plan, MD_info, and MI_plan constitute the neighbourhood and participation foundation. GIB_plan and GS_plan add citywide planning continuity. The combined set preserves a high mean score without exposing the score structure to the risk that local initiatives will remain disconnected from municipal strategy. UCG_info and MN_plan can be included when governance and autonomy conditions are improved, but including them too early reduces score stability.

Figure 6. Operational priorities for strengthening Madrid's green infrastructure resilience. The panels emphasise coordination among public bodies, durable implementation through budget and maintenance capacity, and social-ecological benefits linked to access, canopy, heat exposure, and public-space quality.

5. Discussion

5.1. Governance and autonomy

The analysis of Madrid shows that the city possesses adequate green space coverage and a diversified portfolio of policies. Learning and innovation and social-ecological justice suggest meaningful educational, technological, social, and distributional components. However, the low score for polycentric governance implies that such contents can be difficult to translate into effective implementation unless various departments and levels of government work better together. This perspective is aligned with resilience theory in which adaptive capacity, safe-to-fail learning and cross-scale coordination are central to resilience [1, 6, 10].

The key contribution of the bottleneck reading is that it helps identify whether strong mean performance conceals poor conditions in one institution. In municipal practices, such weaknesses determine the sustainability of green infrastructure policies. The deterioration of a well-designed park without sufficient finance, the inability of a tree planting program to mitigate inequalities in heat stress without considering district exposure and vulnerability, the loss of credibility of a participatory process without implementation, the symbolic nature of a strategic plan without interdepartmental responsibilities, etc., correspond to factor imbalance.

Figure 7 presents the delivery domains that follow the strategic resilience core. Neighbourhood-level actions, citywide green network planning, and governance implementation correspond to complementary steps along one municipal resilience pathway rather than separated policy domains.

Polycentric governance deserves special attention as an implementation goal. There are many municipal departments that need to take responsibility for the maintenance and management of green infrastructure in terms of heat mitigation, stormwater regulation, biodiversity protection, and other purposes. The low governance score suggests that there should be routine decision-making, shared indicators, public reporting, district-level monitoring and better connectivity between municipal strategies and implementation processes [2, 22].

In the context of Madrid, self-sufficiency and autonomy imply the ability of the green infrastructure policy system to sustain and adapt the green infrastructure in question. Trees should be regularly watered and pruned, protected and

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Figure 7. Delivery domains for Madrid's strategic resilience core. The panels represent neighbourhood-level actions, citywide green network planning, and governance implementation as the three practical contexts in which the five-policy core can be performed.

replaced after dying. Community gardens require good stewardship and tenure security. Riparian and peri-urban spaces should undergo regular ecological maintenance and protection against incompatible activities. Green spaces in neighbourhoods should be maintained properly. Studies on long-term green space management stress that the provision of ecosystem services depends on regular maintenance and stewardship as much as installation [8, 27]. The importance of finance, maintenance, and monitoring follows directly from Madrid's autonomy score.

5.2. Justice, cohesion, and everyday use

The contrast between social-ecological justice and social cohesion is critical in interpreting the Madrid results. The former score is quite high, and the district correlation confirms the fact that green infrastructure activity reflects the level of educational vulnerability in the district. The latter score is relatively lower, implying that policies can direct investment toward a socially vulnerable area without building trust and cooperation, capacity for conflict resolution, and community-based stewardship. Scholars of environmental justice argue that equitable distribution should go hand-in-hand with equitable participation and recognition [4, 24]. The green-space literature also demonstrates the importance of access, perceived safety, age, mobility, and frequent use of parks [15, 16]. Participation of people living close to green infrastructure should thus be encouraged to foster community sustainability.

Portfolios contribute to this conclusion. The neighbourhood participation core scores highest in terms of mean performance, demonstrating that HI_plan, MD_info, and MI_plan play a pivotal role in Madrid's resilience capabilities. These policies should not be considered minor local initiatives. Rather, they should form the basis for social legitimacy of the green infrastructure strategy as a whole. The strategic resilience core, complemented by GIB_plan and GS_plan, is superior for municipal planning since it combines the participation anchor with the citywide perspective. This combination matters for a metropolitan municipality with 21 districts because the linkages among social access, maintenance, ecological continuity, and district-level public benefit should be established [11, 23].

Figure 8 highlights the physical variety of urban green infrastructure settings associated with the selected policy priorities.

Figure 8. Urban green infrastructure settings linked to Madrid's policy priorities. The panels show residential parks, metropolitan green axes, green residential streets, community gardens, cycling corridors, and tree-lined transit streets as distinct physical contexts requiring governance, maintenance, access, and equity attention.

Lower policy values for UCG_info, MN_plan, and MTM_plan do not imply that gardens, nature measures, or maintenance are not useful. Rather, they highlight the necessity of improving such policy forms in terms of participation, ecologic multifunctionality, equity orientation, and implementation capacity. Maintenance plays a crucial role here. Tree pruning and planting could remain a purely technical process, but they could also be transformed into a resilience strategy based on heat exposure, canopy distribution, biodiverse planting, water regulation, and transparency. Urban ecosystem services are generated via interactions between vegetation, management practices, and social activity rather than via planted surfaces alone [2, 27]. Thus, a weak technical policy should be improved instead of discarded.

The district equity finding deserves further clarification. Positive medium correlation with low educational attainment demonstrates that action intensity is characterized by pro-vulnerability orientation. This is a good thing because green infrastructure can become unequal if investment goes towards already favored locations. Educational attainment is not the only measure of vulnerability in this context. Other factors that define people's lived experiences of green infrastructure include income, age, disability, housing security, heat exposure, health status, public-space safety, proximity to greenery, and maintenance quality. Research on heat-risk and urban health reveals that vulnerability is unequally distributed both spatially and among other dimensions of green infrastructure use [14, 16]. An improved analysis of equity would require the combination of district scores and access values [13, 26].

5.3. Implications for Madrid

For its next advances in resilience building, Madrid needs less focus on isolated green interventions and more improvements of poor institutional and social conditions. A combination of HI_plan, MD_info, MI_plan, GIB_plan, and GS_plan represents the best combination of policies because it offers high levels of participation and planning continuity. This five-policy strategic resilience core produces a mean value of 6.74, which is quite close to the

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three-policy core despite wider coverage. This balance of scores outweighs narrow focus on the maximum mean score because resilience requires continuity across multiple scales, administrative units, and departments.

Therefore, Madrid's priorities have to be related to linking the social and justice orientation represented by HI_plan, MD_info, and MI_plan with strategic policy coverage of GIB_plan and GS_plan. The governance routines have to provide cross-department assignment of tasks, match maintenance costs with district needs, and produce publicly accessible values concerning monitoring. The autonomy needs strengthening in order to ensure budget continuity, adaptive maintenance cycles, and adjustment of green spaces to changing conditions for heat regulation, water management, biodiversification, and social use. In terms of social cohesion, there is also a need for promoting participatory stewardship, conflict resolution capacities, and influence of citizens on management of green areas.

It is necessary to recognize the limitations of numerical values that can be used here. For instance, there is no full table of policy indicator scores available; instead, we have only policy values, factor scores, district interval values, and named policy scores. With a complete list of policy indicator values, we could perform optimization of all possible policy configurations. Also, the correlation in districts cannot establish causality and lived experience of citizens. Despite this, we still can see the key constraint for Madrid's green infrastructure policies: governance and autonomy have to be strengthened prior to any efforts aimed at increasing action intensity.

6. Conclusions

Based on the current values, Madrid's policies regarding green infrastructure demonstrate strong performance in learning and innovation, social-ecological justice, and diversity. However, the resilience profile of Madrid suffers from limited polycentric governance, self-sufficiency and autonomy, and social cohesion. These weaknesses translate into a score of 0.69 and a deficit of 29.6%, while other resilience factors receive a score of one or higher. Interdepartmental and inter-level coordination are therefore central to Madrid's green infrastructure priorities.

The highest mean value can be obtained with the use of the neighbourhood participation core composed of HD_plan, HP_plan, HS_plan, MD_info, MN_plan, MU_plan, MTM_plan, MV_plan, and SI_info. The five-policy strategic resilience core with HI_plan, MD_info, MI_plan, GIB_plan, and GS_plan receives the second-highest mean score and the second-best score floor (6.74 and 6.33 respectively). Thus, this configuration of policies appears to be optimal for Madrid, as it links high participation with planning continuity. Meanwhile, the social-ecological expansion might expand thematic coverage, provided that the governance weakness is addressed first.

The district values confirm partial orientation towards vulnerable districts. Action scores show significant and positive correlation with low educational attainment ($r = 0.569$, $p < 0.05$) and zero educational attainment ($r = 0.573$, $p < 0.05$). This suggests that green infrastructure activities of Madrid possess certain orientation toward need. This, however, does not constitute full proof of environmental justice. The monitoring routine has to explore walking access, canopy distribution, thermal exposure, public-space safety, maintenance, participation, housing situation, and cultural identity of residents.

Madrid's evaluation of its green infrastructure resilience has to go beyond mere counting of policies, amount of green surface, and single policy score. The weakest factors of resilience have to be improved by strengthening coordination, finance for maintenance, implementation responsibility, and neighborhood participation in conjunction with citywide ecological planning.

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