(02-036) - Exploring Smart and Sustainable City Models in Intermediate Spanish Cities: A Preliminary Study

Lo-Iacono-Ferreira, Vanesa Gladys [2]; Esteban-Narro, Rafael [2]; Artacho-Ramírez, Miguel [2]; Torregrosa-López, Juan Ignacio [3]

[1] Universitat POlitecnica de València, [2] Universitat Politecnica de València, [3] Universitat Politècnica de València

This article presents a preliminary investigation into the relationship between ongoing Smart and Sustainable City (SSC) initiatives in selected intermediate Spanish cities and the theoretical dimensions of SSC models. The research begins with an overview of established SSC models, outlining key dimensions like technological innovation, environmental sustainability, socio-economic factors, and governance. These urban areas, often overlooked in favor of larger metropolises, provide insights into the challenges and opportunities of implementing SSC concepts.

The methodology involves a qualitative analysis of existing SSC projects. It aims to assess how these initiatives align with SSC models, identifying strengths, gaps, and scalability potential.

Key findings indicate that while technological advancements and environmental considerations are prominent in these projects, socio-economic inclusion and participatory governance require more attention. The study also highlights the role of local cultural and historical contexts in shaping SSC initiatives, often downplayed in theoretical models.

The article concludes by discussing the implications for future SSC projects in similar urban settings, emphasizing the need for a holistic approach that integrates technological innovation with robust socio-economic and governance frameworks. This preliminary study sets the stage for further research, contributing to the evolving discourse on smart and sustainable urban development, particularly in intermediate-sized cities.

Keywords: Cities; Smart; Intermediate; Projects; Sustainable

Explorando Modelos de Ciudades Inteligentes y Sostenibles en Ciudades Intermedias en España: Un Estudio Preliminar

En este artículo se presenta una investigación preliminar sobre la relación entre las iniciativas en curso de Ciudades Inteligentes y Sostenibles (CIS) en ciudades intermedias en España y las dimensiones teóricas de los modelos CIS. La investigación contempla una descripción de los modelos CIS establecidos, fijando la atención en dimensiones clave como la innovación tecnológica, la sostenibilidad ambiental, los factores socioeconómicos y la gobernanza.

La metodología implica un análisis cualitativo de proyectos CIS existentes. El objetivo es evaluar cómo se alinean estas iniciativas con los modelos CIS, identificando fortalezas, brechas y potencial de escalabilidad.

Los hallazgos clave indican que, si bien los avances tecnológicos y las consideraciones ambientales están contempladas, la inclusión socioeconómica y la gobernanza participativa requieren más atención. El estudio también destaca el papel de los contextos culturales e históricos locales en la formación de las iniciativas CIS.

El artículo concluye discutiendo las implicaciones para futuros proyectos CIS en entornos urbanos similares, enfatizando la necesidad de un enfoque holístico que integre la innovación tecnológica con sólidos marcos socioeconómicos y de gobernanza. Este estudio sienta las bases para investigaciones adicionales, contribuyendo al discurso sobre el desarrollo urbano inteligente y sostenible en ciudades de tamaño intermedio.

Palabras clave: Ciudades; Inteligentes; Intermedias; Proyectos; Sostenibles

Correspondencia: Juan Ignacio Torregrosa-López jitorreg@iqn.upv.es

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1. Introduction

The concept of sustainability in urban contexts is multifaceted, encompassing environmental, economic, and social dimensions (Huang *et al.*, 2015a). The way to sustainability heavily relies on the efforts of cities. To decrease environmental impacts, make the cities more resilient, and improve the population's quality of life, new intelligent technologies must be deployed. These technologies should be smart, lean, integrated, cost-efficient, and resource-efficient (Ahvenniemi *et al.*, 2017).

The implementation of the Sustainable Development Goals (SDGs) established by the United Nations requires a rigorous and efficient assessment of progress towards sustainability in cities. In recent times, many academics have developed various indicator frameworks and indexes to measure the progress of cities toward achieving the Sustainable Development Goals (SDGs). These frameworks are designed to ensure consistency and fairness for all, promoting inclusivity, equal treatment, and global acceptance (Couto *et al.*, 2023; Giles-Corti *et al.*, 2020; González-García *et al.*, 2019; Gustafsson and Ivner, 2018; Lo-Iacono-Ferreira *et al.*, 2022; López *et al.*, 2021; Rama *et al.*, 2020; Sánchez de Madariaga *et al.*, 2020; Sánchez de Madariaga I *et al.*, 2018; Sebestyén *et al.*, 2024; Suárez *et al.*, 2016).

Assessing the sustainability of cities is a complex process that requires a thorough understanding of data from various domains. To achieve this, data is collected as sustainable indicators chosen based on scientific rigor and their relevance to urban sustainability goals. The indicators are selected to accurately capture various factors and dimensions, from carbon emissions and energy consumption to economic growth and social equity. These metrics serve as benchmarks for sustainable performance and set targets for future achievements. They enable cities to navigate the complex pathway toward sustainability with greater precision and insight, thus guiding policymaking and implementation. Furthermore, these metrics provide a basis for evaluating the effectiveness of sustainability initiatives and interventions within the urban context (Roy *et al.*, 2023).

Since the last decade of the XX century, several researchers and organizations have proposed various indicators and evaluation methodologies to measure progress toward city sustainability and the ranking of cities (Huang *et al.*, 2015b; Phillis *et al.*, 2017). To better gauge urban sustainability, the indicators have been aggregated in indexes that combine many indicators using various normalization and weighting schemes (Michalina *et al.*, 2021).

Indexes help cities compare themselves and assess their performance based on smart, sustainable, resilient, prosperity, environment, poverty, or health concepts. As a result of this comparison, different rankings can be created to highlight cities with better performance as sustainable cities. Thanks to that, city rankings have been a powerful tool for evaluating and comparing the sustainability credentials of cities worldwide for some time (Giffinger, 2007; Giffinger et al., 2010; Phillis et al., 2017).

These rankings assess cities based on various environmental, social, and economic dimensions and indicators and serve multiple purposes: providing valuable insights into the current state of urban sustainability, highlighting best practices, and encouraging competition and learning among cities. As a result, reputable international organizations, academic spheres, and media outlets have published rankings based on an index that compares the sustainability performance of different sets of cities from different sets of indicators grouped in dimensions (Phillis *et al.*, 2017). Some examples of such indicator frameworks, indexes, and rankings include “Urban Resilience Index” (Sánchez de Madariaga *et al.*, 2020; Suárez *et al.*, 2016; “The Arcadis Sustainable Cities Index 2022 | Arcadis”, n.d.; “World Cities Report 2022”, n.d.);

When calculating aggregated indicators, it is important to remember that the methodology used can result in varying outcomes (Lafortune *et al.*, 2018). The way indicators are aggregated into dimensions, subdimensions, and objectives can significantly impact the result of a composed indicator. Therefore, it is crucial to carefully analyze the results and rankings to fully understand the implications of the methodology used in the calculation process.

This research endeavor aims to scrutinize the influence of two distinct sets of dimensions in gauging the degree of intelligence and sustainability of small cities in Spain. For this purpose, we have assessed the dimensions by employing the outcomes of 107 indicators pertinent to smart and sustainable small cities. Subsequently, we have aggregated the dimensions into a single composite indicator and delved into the impact of selecting them.

2. Material and Methods

In our study, we have analyzed the impact of selecting different dimensions for measuring the progress and development of small, smart, and sustainable cities. We have specifically used the subset of 40 Spanish cities within the population range of 80,000 to 100,000 inhabitants. By evaluating the influence of dimension selection, we aim to better understand how to accurately measure and track the advancement of cities in this category.

Since the work of Giffinger et al. in 2007, "Ranking of European Medium-sized Cities," in which a qualitative model of evaluation of medium-sized European cities is set to perform a ranking of them, the six dimensions of the smart city are established, and in most subsequent conceptual models are generally accepted by the scientific community as the basis for holistic Smart Cities models. These are: Economy, Human Capital, Governance, Mobility, Environment, and Quality of Life (Esteban-Narro *et al.*, 2022; Giffinger, 2007).

So these six dimensions are generally accepted and used with a slight difference in most of the recent models, a large part of them with exactly the same nomenclature: (Cohen, 2014, Fernández Añez, 2019, Giffinger et al., 2007 and its later version TUW, 2013, TUW, 2014 and TUW, 2015, , Manville et al., 2014, Monzón, 2015, Moreno Alonso, 2016, The Transport Research center-UPM, 2017). They are reflecting the holistic nature of a smart city in a conceptual model and the necessary characteristics for project assessment.

Recently**,** (Esteban-Narro *et al.*, 2022) completed this categorization of 6 dimensions with 24 subdimensions according to Table 1**.** This set of dimensions is the first set of dimensions considered in this study**.**

Table 1: 1st Dimensions and Subdimensions according to (Esteban-Narro et al., 2022)

1st set of dimensions (A)	Subdimensions (description)
Economy and Competitiveness	Business and labour innovation, Entrepreneurship, Productivity, Local-global interconnectedness
Human and Intellectual Capital	Academic and digital training, Creativity, Management and promotion of urban life, Work flexibility and work-life balance
Governance	Transparency and citizen communication channels, E-government and online services, Participation in decision-making, Innovation and efficiency in municipal management
Infrastructure and Mobility	Public transport and multimodal network, ICT infrastructures, Urban logistics, Sustainable mobility

Environment and Energy	Energy efficiency, Resource and waste management, Environmental monitoring, Renewable energy and social awareness
Social Welfare and Services	Public, social and security services, Tourism, culture, and leisure Social cohesion and inclusion, Health and welfare.

On the other hand, the second set of 5 dimensions are those generally accepted for 17 SDGs. The list is taken by (Lo-Iacono-Ferreira *et al.*, 2022). Table 2 shows the 2nd set of dimensions and a short description.

Table 2: 2nd set of dimensions based on SDGs (Lo-Iacono-Ferreira *et al.*, 2022)

2nd set of dimensions (B)	Description
People	End poverty and hunger, and ensure dignity and equality, and in a healthy environment.
Prosperity	Ensure prosperous and fulfilling lives in harmony with nature
Planet	Protect the planet and natural resources and climate
Peace	Foster a peaceful and inclusive society
Partnership	Implement the agenda through a global partnership

When creating a composite indicator that aims to measure the overall result of each dimension, it is essential to have a set of indicators for each dimension. These indicators help evaluate each dimension's performance (A and B), combined to create a comprehensive measure. Using multiple indicators for each dimension ensures that the composite indicator accurately reflects the performance of all the dimensions considered. This comprehensive approach is critical in creating a reliable and informative composite indicator.

The indicator framework used in this study is common for the two sets of dimensions. This set of indicators was developed by the Sustainable Development Solutions Network (SDSN) in Spain and applied in 2020 to a group of 104 cities in Spain with more than 80.000 inhabitants (Sánchez de Madariaga *et al.*, 2020). This dataset presents a comprehensive set of meticulously selected and validated indicators to measure progress towards the 17 SDGs.

The total of these 107 indicators has been proposed to construct a decision matrix, including the data set of normalized indicators $\theta = \theta ij$ (i = 1,…, n; j = 1,…, m) where n denotes the number of cities and m the number of scoreboard indicators. Each indicator was assigned to a specific dimension according to table XXX.

Normalization was performed on the values of each indicator, using the 2.5th and 100th percentiles and disregarding NaN values. This normalization method allows for a better comparison of the indicators and results in values ranging from 0 to 100. Percentile-based normalization was performed by calculating each indicator's 2.5th and 100th percentiles, disregarding NaN values in the calculation. Indicator values were normalized within 0 to 100, considering their relative position in the data distribution.

Equal weights are used for each indicator at the dimension. As a result, the relative weight of each indicator in a dimension was inversely proportional to the number of indicators considered under that goal. We used the arithmetic mean to aggregate indicator scores within each dimension (Lafortune *et al.*, 2018)

To arrive at a composite index, equal weights were used at the dimension and indicator levels, following the SDSN methodology. To calculate de composite indicator for de A set of dimensions, first, we calculate the arithmetic media for each dimension:

$$\Phi_{Aik} = \frac{1}{g_k} \sum_{j \in D_k} \theta_{ij} \quad (1)$$

Where *i* is the city D_K is defined as the set of indicators associated with the kth dimension, and g_k corresponds to the number of indicators for the kth dimension.

$$\Gamma_{Ai} = \frac{1}{d} \sum_{1}^{d} \Phi_{ik} \quad (2)$$

Where *d* is the number of dimensions. For the case of B set of dimensions, the equations are similar. Table 3 shows the linking of indicators to Dimensions set A and B.

Table 3: Indicator linked to Dimensions A and B

Dimension A	Dimension B	Indicator
Economy and Competitiveness	Prosperity	R&D expenditure per capita
Economy and Competitiveness	Prosperity	Patent applications
Economy and Competitiveness	Prosperity	Area of land planned for economic activities
Economy and Competitiveness	Prosperity	Urban resilience
Environment and Energy	People	Organic agriculture
Environment and Energy	People	Food consumer prices
Environment and Energy	People	Agricultural and forestry holdings
Environment and Energy	People	Cultivated area by municipality
Environment and Energy	Planet	Balance between revenues and expenditures in water service budgets for inhabitants
Environment and Energy	Planet	Water supply and sanitation fee
Environment and Energy	Planet	Domestic user effort index for water supply payment
Environment and Energy	Planet	Liters of water distributed per day per inhabitant
Environment and Energy	Planet	Water supply price
Environment and Energy	Planet	Water sanitation price
Environment and Energy	Prosperity	Reduction in public lighting expenditure compared to 2012
Environment and Energy	Prosperity	Impact of electricity expenditure on average household income
Environment and Energy	Prosperity	Renewable energy
Environment and Energy	Prosperity	Quality of supply index
Environment and Energy	Prosperity	NO2
Environment and Energy	Prosperity	O3
Environment and Energy	Prosperity	PM10
Environment and Energy	Prosperity	Days the worst station exceeds PM10 limits

Environment and Energy	Prosperity	Annual average of PM10
Environment and Energy	Planet	Plastic and packaging recycling
Environment and Energy	Planet	Improper waste
Environment and Energy	Planet	Paper recycling
Environment and Energy	Planet	Glass recycling
Environment and Energy	Planet	Per capita CO2 emissions from buildings and industry
Environment and Energy	Planet	Per capita CO2 emissions
Environment and Energy	Planet	Per capita CO2 emissions from transport
Environment and Energy	Planet	Covenant of Mayors
Environment and Energy	Planet	Blue flags
Environment and Energy	Planet	Quality of bathing waters
Environment and Energy	Planet	Built-up land in the coastal strip of the first 500 m
Environment and Energy	Planet	Protected maritime-terrestrial public domain
Environment and Energy	Planet	Protected coastal and marine natural habitats
Environment and Energy	Planet	Territory and diversity of habitats. Artificial coverage
Environment and Energy	Planet	Territorial protection of protected natural spaces
Environment and Energy	Planet	Territory and diversity of habitats. Forest area
Environment and Energy	Planet	Green areas
Governance	Planet	Sustainable tourism
Governance	Peace	Electoral participation
Governance	Peace	Index of citizen participation and collaboration
Governance	Peace	Strength and autonomy of the municipal institution
Governance	Peace	Transparency index
Governance	Peace	Economic-financial transparency index
Governance	Partnership	Open data index
Governance	Partnership	National networks to achieve objectives
Human and Intellectual Capital	Prosperity	Employees in industry
Human and Intellectual Capital	People	Employment rate in agriculture
Human and Intellectual Capital	Prosperity	Workplace accidents
Human and Intellectual Capital	Prosperity	Unemployment rate
Human and Intellectual Capital	Prosperity	Impact of COVID-19 on unemployment
Human and Intellectual Capital	Prosperity	Youth unemployment rate
Human and Intellectual Capital	Prosperity	Long-term unemployed

Human and Intellectual Capital	Prosperity	Employment dependency index by sector
Human and Intellectual Capital	Prosperity	Annual real per capita GDP growth rate
Human and Intellectual Capital	Prosperity	Annual productivity growth rate
Infrastructure and Mobility	Prosperity	3G and 4G penetration index
Infrastructure and Mobility	Prosperity	Broadband penetration index
Infrastructure and Mobility	Prosperity	Transport infrastructure
Infrastructure and Mobility	Partnership	White zones
Social Welfare and Services	Partnership	Cooperation and development projects
Social Welfare and Services	People	20:20 ratio
Social Welfare and Services	People	Expenditure on social promotion services
Social Welfare and Services	People	High poverty population rate
Social Welfare and Services	People	Child poverty rate
Social Welfare and Services	People	Population at risk of poverty rate
Social Welfare and Services	People	Teenage fertility
Social Welfare and Services	People	Deaths from alcohol and drug abuse
Social Welfare and Services	People	Deaths from infectious disease of the respiratory system
Social Welfare and Services	People	Deaths from viral hepatitis
Social Welfare and Services	People	Infant mortality
Social Welfare and Services	People	Deaths from non-communicable diseases
Social Welfare and Services	People	Premature deaths (<65 years)
Social Welfare and Services	People	Deaths from suicides
Social Welfare and Services	People	Deaths from traffic accidents
Social Welfare and Services	People	Deaths from tuberculosis
Social Welfare and Services	People	Deaths from tumors of the respiratory system
Social Welfare and Services	People	Life expectancy
Social Welfare and Services	People	Deaths from AIDS and HIV
Social Welfare and Services	People	Population enrolled in a higher degree
Social Welfare and Services	People	Education spending
Social Welfare and Services	People	Access to services in preschool education
Social Welfare and Services	People	Population with maximum secondary education level
Social Welfare and Services	People	Population with maximum upper secondary education level
Social Welfare and Services	People	Population with tertiary or higher education level
Social Welfare and Services	People	Pension wage gap
Social Welfare and Services	People	Employee wage gap
Social Welfare and Services	People	Sexual violence and exploitation

Social Welfare and Services	People	Gender violence
Social Welfare and Services	People	Parity in elected positions
Social Welfare and Services	Prosperity	Integration of disabled people into work
Social Welfare and Services	Prosperity	Employed foreigners
Social Welfare and Services	Prosperity	Gini Index
Social Welfare and Services	Prosperity	Dependency index
Social Welfare and Services	Prosperity	Wealth in the top 1% of the population
Social Welfare and Services	Prosperity	Population below the poverty line
Social Welfare and Services	Prosperity	Housing access index
Social Welfare and Services	Prosperity	Places in residences
Social Welfare and Services	Prosperity	Protected housing
Social Welfare and Services	Prosperity	Urban vulnerability
Social Welfare and Services	Peace	Drug trafficking
Social Welfare and Services	Peace	Crime rate
Social Welfare and Services	Peace	Homicide and murder rate
Social Welfare and Services	Peace	Violence against children (0-13 years)

3. Results and Discussion

Table 4 shows the statistics for each dimension and the aggregated indicators.

Table 4: statistics of aggregated indicators (Γ_A and Γ_B) and dimensions.

Set of Dimensions	Dimension	Number of indicators	count	mean	std	min	max
A	Economy and Competitiveness	4	40.0	21.66	13.53	1.05	49.23
	Environment and Energy	36	40.0	49.08	8.05	28.2	62.80
	Governance	8	40.0	47.09	14.63	12.29	77.61
	Human and Intellectual Capital	10	40.0	54.05	9.50	32.37	67.70
	Infrastructure and Mobility	4	40.0	42.31	12.95	8.71	66.56
	Social Welfare and Services	44	40.0	53.79	6.65	31.67	66.57
B	Partnership	4	40.0	33.91	14.52	5.33	70.76
	Peace	9	40.0	57.59	14.16	7.83	82.09
	People	34	40.0	50.37	6.39	32.05	62.97

Planet	24	40.0	50.40	9.00	28.77	67.98
Prosperity	35	40.0	49.72	5.52	36.94	59.57
Γ_A	107	40.0	44.66	5.14	34.23	54.89
Γ_B	107	40.0	48.40	6.06	32.59	60.60

The position on the ranking for the set of cities is shown in Table 5. As can be seen, most cities change their position depending on the ranking, some more than 5 positions.

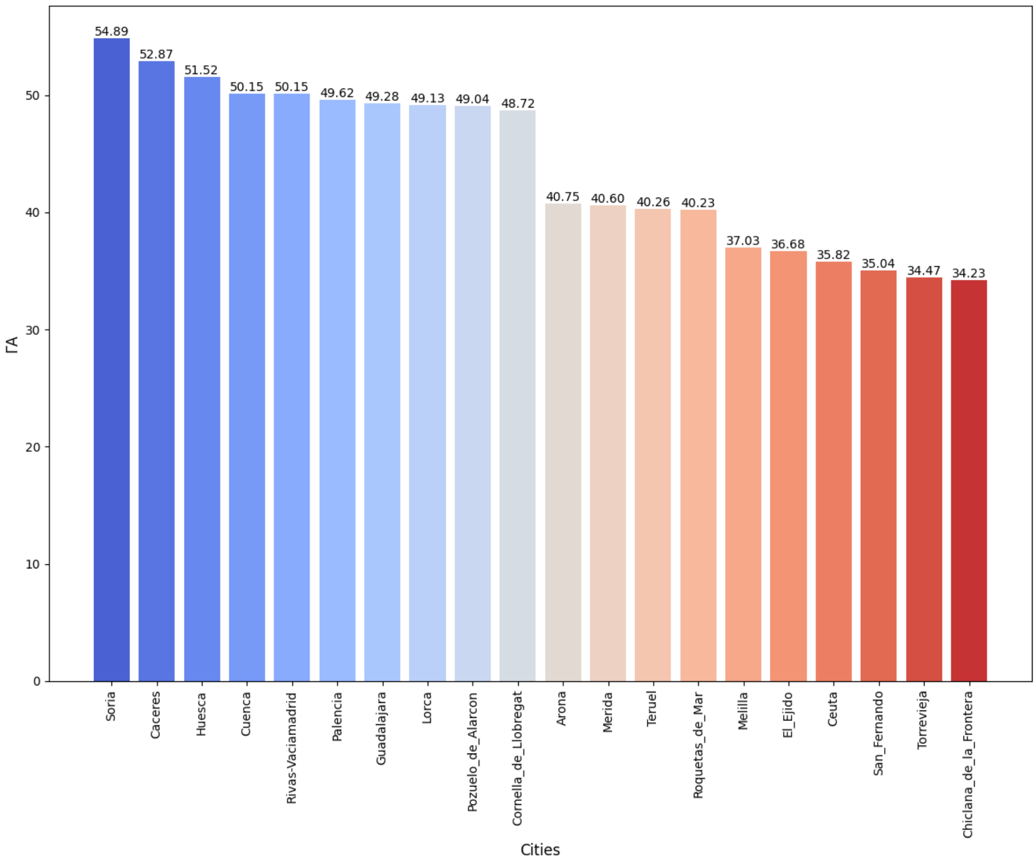
Table 5. Ranking for Γ_A and Γ_B. Cities with a difference of more than 5 positions show an *.

City	Ranking Γ_A	Ranking Γ_B	±
Soria	1	3	-2
Caceres	2	2	0
Huesca	3	4	-1
Cuenca*	4	16	-12
Rivas Vaciamadrid	5	1	4
Palencia	6	6	0
Guadalajara	7	11	-4
Lorca	8	5	3
Pozuelo de Alarcón	9	8	1
Cornellà de Llobregat	10	10	0
Las Rozas de Madrid	11	7	4
Mijas*	12	26	-14
Santiago de Compostela	13	15	-2
Lugo	14	12	2
Vélez-Málaga*	15	31	-16
Sant Boi de Llobregat	16	19	-3
Torrent*	17	9	-8
Ciudad Real	18	17	1
Ávila	19	14	5
San Fernando	20	13	7
Segovia	21	20	1
San Cugat del Vallés	22	21	1
Zamora	23	25	-2
Coslada	24	28	-4
Toledo	25	24	1
Talavera de la Reina*	26	36	-10

Fuengirola	27	27	0
Avilés	28	30	-2
Pontevedra	29	22	7
El Puerto de Santa María	30	23	7
Arona*	31	18	13
Mérida	32	34	-2
Teruel	33	32	1
Roquetas de Mar	34	35	-1
Melilla	35	38	-3
El Ejido	36	37	-1
Ceuta	37	40	-3
San Sebastián de los Reyes*	38	29	9
Torrevieja	39	39	0
Chiclana de la Frontera*	40	33	7

Figures 1A and 1B display the top and bottom ten of Γ_A and Γ_B, respectively. Among the top ten list shows four disparate cities: Cuenca, Torrent, Guadalajara and Las Rozas de Madrid. Meanwhile, the bottom ten list shows also six disparate cities: San Sebastián de los Reyes, El Puerto de Santa María, Arona, Avilés y Vélez-Málaga.

Figures 1A and 1B: top and bottom ten of Γ_A and Γ_B respectively.


54.89
52.87
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48.72
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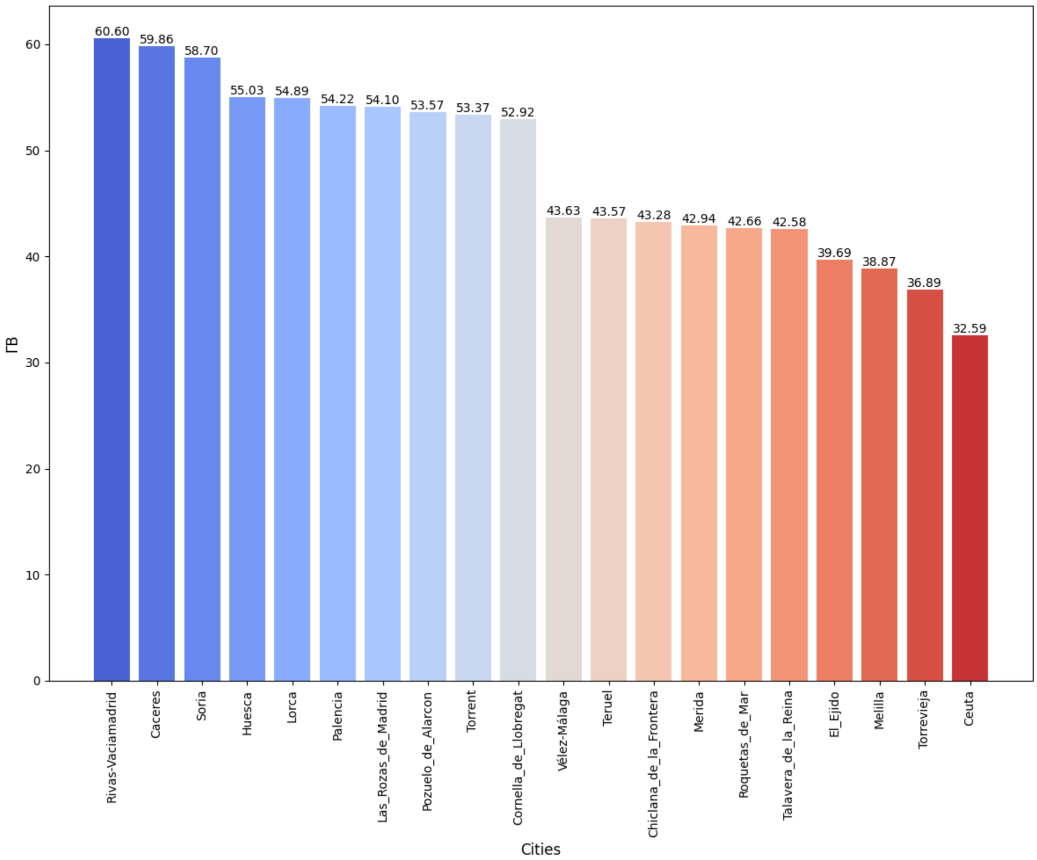
40.60
40.26
40.23
37.03
36.68
35.82
35.04
34.47
34.23
ΓA
0
10
20
30
40
50
Soria
Caceres
Huesca
Cuenca
Rivas-Vaciamadrid
Palencia
Guadalajara
Lorca
Pozuelo_de_Alarcon
Cornella_de_Llobregat
Arona
Merida
Teruel
Roquetas_de_Mar
Melilla
El_Ejido
Ceuta
San_Fernando
Torrevieja
Chiclana_de_la_Frontera
Cities

(A)



(B)

The findings of the study indicate that the process of computing composite indicators is highly influenced by how the indicators are allocated to various categories or dimensions. Most cities change their position depending on the ranking, with some more than 5 or 10 positions of difference. The study's examination of the Economy and Competitiveness, Governance, and Infrastructure, and Mobility categories within Dimension A showed that each of these categories had less than 10 indicators. Similarly, the Partnership and Peace categories within Dimension B also had fewer than 10 indicators. As a result, these categories displayed greater mean deviations, as shown in Table 4.

Certain cities stand out with higher scores in both dimensions, including Soria, Caceres, Huesca, Rivas Vaciamadrid, Palencia, Guadalajara, Lorca, Pozuelo de Alarcón, Cornellà de Llobregat, and Las Rozas de Madrid. On the other hand, some cities have lower scores in both dimensions, such as Mérida, Teruel, Roquetas de Mar, Melilla, El Ejido, Ceuta, San Sebastián de los Reyes, Torrevieja, and Chiclana de la Frontera.

4. Conclusions

Our research aims to carefully examine how two specific sets of dimensions contribute to measuring the intelligence and sustainability of small cities in Spain. We have thoroughly evaluated 107 relevant indicators related to smart and sustainable small cities to achieve this goal. Using this information, we have combined the dimensions into one comprehensive indicator and analyzed the effects of selecting each dimension.

The investigation has revealed a number of cities that have consistently attained higher scores in both dimensions, while others have persistently achieved lower scores across both dimensions. Most cities change their position depending on the ranking, with some more than

5 or 10 positions of difference. These variations highlight the disparities in urban performance and underscore the need for a balanced and comprehensive approach in indicator selection and category allocation to reflect urban competencies and challenges accurately.

The study highlights the significant impact of indicator allocation on the computation of composite indicators across various categories and dimensions. In Dimension A, specific categories like Economy and Competitiveness, Governance and Infrastructure, and Mobility had fewer than 10 indicators each. This limited number of indicators contributed to greater mean deviations in these categories, as detailed in Table 4 of the report. Dimension B also revealed a similar pattern with the Partnership and Peace categories, each containing fewer than 10 indicators and displaying greater mean deviations. These findings suggest that allocating a small number of indicators to specific categories can lead to increased variability in the results.

5. Future work

In order to advance the methodology for evaluating the intelligence and sustainability of intermediate cities in Spain, it is recommended that future research be conducted in several key areas.

Firstly, expanding indicator selection would involve the integration of additional indicators that would provide a more balanced representation across all categories. This is expected to reduce the variability caused by the current uneven distribution of indicators. Secondly, dynamic weighting of indicators could be achieved by developing and testing different weighting schemes based on their relevance and impact on the overall performance of cities. Such schemes could be developed through stakeholder consultations to ensure that the weights align with the real-world importance of each indicator.

Thirdly, conducting longitudinal studies to assess how the performance of cities changes over time can provide insights into the effectiveness of policies and initiatives aimed at improving urban intelligence and sustainability.

Fourthly, extending the analysis to include a broader range of cities, perhaps comparing small cities with medium or large ones, or comparing Spanish cities with those in other European countries, would help in understanding the scalability of the indicators and the generalizability of the findings.

Fifthly, supplementing the quantitative data with qualitative research methods, such as interviews or focus groups with city planners and residents, can provide a better understanding of the contextual factors affecting the performance in various dimensions.

Sixthly, utilizing more sophisticated statistical methods or machine learning techniques to analyze the data would help identify patterns or groups of cities with similar characteristics or regression models to understand the drivers of high and low performance.

Lastly, evaluating the impact of specific urban policies on cities' intelligence and sustainability scores would help identify which policies are most effective and provide recommendations for policy adjustments.

By addressing these areas, future research can provide deeper insights and more actionable guidance for policymakers and urban planners striving to improve the intelligence and sustainability of small cities in Spain.

Communication aligned with the Sustainable Development Goals

11 SUSTAINABLE CITIES AND COMMUNITIES

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