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*Research Article*

# From Indicators to Insights: Measuring Urban Quality of Life in Medium-Sized Greek Cities with the DPRD-20 Urban Indicator System

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**Abstract:** Urban Quality of Life (UQoL) is a critical concept in urban studies, capturing the well-being of city residents through environmental, social, and economic conditions. This study refines the existing DPRD-50 system—originally developed to assess UQoL in Greek cities—by applying Principal Component Analysis (PCA) to the indicator dataset from its first application ten years ago. This process resulted in the DPRD-20 system, a more concise and flexible tool for comparative urban analysis. Beyond improving usability, the new system enables a longitudinal comparison of UQoL across time, revealing how selected Greek cities have evolved over the past decade. The findings highlight significant differences: cities like Ioannina, Volos, and Heraklion perform well due to strengths in healthcare, cultural amenities, or sustainable mobility. In contrast, cities like Kavala and Kalamata face infrastructure challenges despite strong environmental assets. The research underscores the importance of benchmarking as a means for cities to learn from each other, while supporting data-driven governance through an open-source monitoring framework with broader relevance to the European urban context.

**Keywords:** Urban Quality of Life (UQoL); Comparative Analysis; Benchmarking; DPRD-20 System; Open-Source Data; Greek Cities; medium-sized cities

**Highlights:**

- Development of a new urban indicator system, through PCA, based on the existing DPRD-50 framework.
- Use of open-source data to assess Urban Quality of Life in Greek medium-sized cities.
- Benchmarking tool for supporting evidence-based urban policies and cross-city comparisons.

## 1. Introduction

Urban Quality of Life (UQoL) is a multifaceted concept encompassing a wide array of environmental, social, and economic factors that shape the well-being of city residents. As urban environments continue to expand and transform, understanding and enhancing UQoL has become increasingly critical for policymakers, urban planners, and researchers. Far from being a matter of individual satisfaction alone, UQoL reflects collective urban conditions—such as access to public services, environmental quality, social infrastructure, and economic opportunities—that influence the daily experiences of inhabitants (Diener et al., 2018; Weziak-Bialowolska, 2016).

Equally important is recognizing that UQoL is shaped by governance and planning practices. The organization and delivery of services, the allocation of resources, and the institutional capacity of local governments are not merely contextual factors but fundamental drivers of urban well-being (Le Galès & Vitale, 2013). Consequently, the reliable assessment of UQoL is essential for designing effective urban policies, especially in cities facing complex challenges such as inequality, environmental degradation, and social exclusion.

Robust data is indispensable for this purpose. Urban governance relies on information that not only reflects the present state of UQoL but also highlights strengths and weaknesses across multiple domains. Systematic monitoring of UQoL is thus essential, serving as a key tool for identifying disparities and tracking progress over time (Wolniak & Jonek-Kowalska, 2020). It is also crucial to recognize that the determinants of UQoL are dynamic rather than fixed. Economic crises, demographic shifts, and evolving governance regimes may recalibrate urban inequalities and alter the ways resources are distributed (Maloutas, 2015; Le Galès & Vitale, 2013). These temporal dynamics highlight the need to situate indicator-based assessments within a broader socio-economic context, as the salience of specific determinants may shift across time and space. However, scholarly research on UQoL in Greece remains limited. This scarcity underscores the need for context-sensitive, indicator-based approaches that can support both academic research and evidence-informed urban governance.

One persistent challenge in evaluating UQoL lies in the absence of standardized tools that produce reliable, comparable data across different urban settings. Existing frameworks are often either too general to capture urban complexity or overly narrow in scope. Moreover, many rely on subjective indicators—such as self-reported life satisfaction—that are vulnerable to personal bias and contextual variability (Angur et al., 2004; Merschdorf et al., 2020). There is thus a clear need for objective, data-driven approaches that enable meaningful comparisons and support evidence-based decision-making.

While comprehensive indicator systems are often perceived as more reliable, increasing their size does not necessarily translate into better insights. The core challenge is to identify a minimal yet sufficient set of indicators that can meaningfully capture UQoL's multi-dimensional nature. Can the quality of life in Greek cities be assessed with just 20 indicators? Which ones offer the most explanatory power? And what findings emerge from applying such a system today? These are the key questions addressed by this study through the development and testing of the DPRD-20 framework.

The DPRD-20 system builds upon the original DPRD-50 framework developed in 2014, which consisted of 50 indicators across 10 domains. In the current study, Principal Component Analysis (PCA) is used to identify the two most influential variables per domain, resulting in a refined set of 20 indicators. This approach preserves the theoretical and empirical integrity of the original system while enhancing its efficiency and comparability. The resulting framework remains multidimensional yet manageable, facilitating its application across diverse urban contexts and over time.

The structure of the article is as follows: Section 2 provides a literature review on QoL with emphasis on its urban dimensions. Section 3 outlines the methodology, including the DPRD-50 and DPRD-20 systems and the use of PCA. Section 4 presents the findings, including the PCA results and the composite UQoL index for the medium-sized Greek cities. Sections 5 and 6 discuss the implications, limitations, and potential for future research.

Ultimately, this article aims to contribute to the growing body of knowledge on UQoL by offering a replicable, data-driven framework grounded in open-access information. The DPRD-20 system promotes transparency, facilitates benchmarking, and provides a practical tool for policymakers—particularly in contexts where technical capacity for systematic monitoring is limited.

## 2. Literature Review

### *2.1. Defining Quality of Life*

Quality of life (QoL) is a broad, multidimensional concept that includes both objective and subjective aspects of human existence. Interestingly, despite extensive research, no universally accepted definition of QoL exists. This is, partly, due to the different well-being theories that offer different perspectives and measurement approaches (Brockmann & Fernandez-Urbano, 2024; Costanza et al. 2008). These theories include (Crisp, 2021):

- Hedonism: QoL derives from positive experiences (sensory or ethical), with social hedonism advocating for maximizing collective well-being—often expressed as "the greatest good for the greatest number."
- Desire theories: QoL is assessed by how well personal preferences and desires are fulfilled.
- Objective list theories: QoL consists of universally accepted factors that may conflict with personal subjective judgment.

This distinction is essential both conceptually and methodologically. At the individual level, QoL primarily refers to an individual's overall satisfaction with their life, while at the collective level, it is associated with the level of well-being within a society or city, and the resulting well-being of the residents. Unlike living standards, which focus on material factors such as income and housing, QoL incorporates broader psychological, social, and emotional dimensions of well-being (Drăgoi, 2019; Nussbaum & Sen, 1993). Thus, even if a city ranks high in living standards, some residents may still experience low QoL due to challenges like unemployment or social isolation.

At the individual level, QoL is linked to subjective well-being, which refers to self-reported life satisfaction influenced by factors such as health, economic conditions, personal relationships, and social environment (Diener, 2000; Diener et al., 2018). The World Health Organization (WHO) defines QoL as a quality encompassing physical, mental, and social well-being (WHO, 1997). At the collective level, factors influencing the QoL in a city include social infrastructure, the natural environment, economic prosperity, public safety, quality of public services, and living conditions. Together with social capital, these elements shape the well-being of a community, which extends beyond individual well-being (Ballas 2013; Marans & Stimpson, 2011; Psatha et al. 2011).

Additionally, QoL depends on subjective perceptions, making it challenging to quantify. Various frameworks have been proposed to measure QoL, each highlighting different dimensions depending on the context (Blomquist, 2006; Cummins, 2000; Marans & Stimpson, 2011; OECD, 2013).

In conclusion, QoL is a dynamic, multifaceted concept that integrates both subjective and objective indicators. It is shaped by individual perceptions and socio-economic and environmental factors. Thus, measuring QoL requires a comprehensive approach that considers the interrelation of various factors and their impact on people's lives.

### *2.2. Urban Quality of Life*

The concept of Urban Quality of Life (UQoL) is multifaceted, influenced by environmental, social, and economic factors. The key challenge in studying UQoL is defining and measuring it in a way that reflects the complexity of urban life. While individual QoL plays a central role, UQoL is not the aggregate of individual experiences. It rather reflects collective conditions and the availability of opportunities and services that affect citizens' well-being (Mouratidis, 2021; Psatha et al., 2011; Weziak-Bialowolska, 2016).

A major determinant of UQoL is the environment, particularly green spaces and air quality. Green spaces have been shown to improve physical and mental health, foster social cohesion, and encourage physical activity, which is linked to improved health outcomes (Maas et al., 2006; Van den Berg et al. 2015; WHO, 2016; Zhang et al. 2017). Moreover, green and open spaces facilitate social interactions, strengthening community ties (Gehl, 2010; Pfeiffer et al., 2016).

Social factors, including safety, social inclusion, and access to education and healthcare, are also critical in determining UQoL. Inequalities, such as income disparities and limited access to essential services, negatively impact the urban experience, with cities that fail to address these issues seeing lower overall happiness and QoL (Ballas, 2013; Helliwell et al., 2020; Wilkinson & Pickett, 2009).

Furthermore, urban mobility and infrastructure have a significant impact on UQoL. Efficient public transport systems, reduced traffic congestion, and road safety all enhance daily life, reducing stress and improving life satisfaction (Ettema et al., 2016; Litman, 2005). More specifically, sustainable modes of mobility have been shown to be significant contributors to neighborhood satisfaction and to improvements in overall UQoL (Leyden, 2003; Soni & Soni, 2016; Stefansdottir et al., 2019; Talen & Kosdinsky, 2014; Wood et al., 2010). In the same context, European-scale composite walkability frameworks have been developed to evaluate accessibility to key amenities within 15 minutes, providing useful benchmarks for cross-city comparisons and sustainable mobility planning, an approach grounded in the idea that proximity to essential services enhances UQoL (Bartzokas-Tsiompras & Bakogiannis, 2022).

Lastly, cultural and aesthetic aspects of a city, including access to cultural activities and well-designed public spaces, play a key role in shaping residents' perceptions of their urban surroundings. Cities with rich cultural offerings tend to foster a sense of belonging and satisfaction, contributing to a positive urban experience (Florida, 2002; Gehl, 2010; Mouratidis, 2021; Seresinhe et al., 2019; Sirgy & Cornwell, 2002).

All in all, commonly accepted determinants of UQoL include features of the economic and social environment (such as income, employment, social inclusion, and networks), the natural and built environment (including environmental quality, housing, and aesthetics), green and public spaces, culture and leisure opportunities, education, healthcare services, civic participation, and transportation (Psatha et al., 2011; Bolzan Wesz et al., 2023).

Based on the literature review, Psatha et al. (2011) identified the following categories for assessing UQoL. These categories, drawn from the World Health Organization's framework for subjective well-being WHOQOL100 (WHO, 1997), and further refined by complementary findings from multiple studies, provide a comprehensive understanding of both individual and collective aspects of UQoL.

**Table 1.** Categories and Parameters for Assessing Urban Quality of Life.

| **Category** | **Parameters** |
|---|---|
| Economic Environment | Income, Employment opportunities, income distribution, cost of living, etc. |
| Social Environment | Crime rate, social inequalities, exclusion, family structure, aging, etc. |
| Natural Environment | Air quality, water resources, waste management, accessibility to natural areas, etc. |
| Urban and Peri-urban Green Spaces | Area, condition, accessibility, visitation rates, etc. |
| Built Environment | Building density, housing conditions, protected buildings, neighborhoods, etc. |
| Culture – Leisure | Cultural infrastructure, sports facilities, recreational activities, etc. |
| Healthcare | Health services, accessibility, social welfare, etc. |
| Education | Education levels, quality of educational institutions, enrollment rates, etc. |
| Traffic and Sustainable Mobility | Traffic conditions, public transport, accessibility to areas, etc. |
| Access and Technical Infrastructure | Infrastructure improving citizens' daily life, media access, public service levels, etc |

Since multiple factors shape UQoL in complex ways, the previous categories serve as a comprehensive framework for its evaluation. By assessing these factors, we can gain an improved understanding of urban well-being and the challenges faced by the cities in their efforts to ensure a high UQoL level.

### *2.3. Measuring UQoL*

We have established that the concept of UQoL is multifaceted, shaped by a combination of environmental, social, and economic parameters. Even if consensus is achieved around key determining factors such as economic stability, environmental quality, and social infrastructure, the real challenge lies in developing reliable tools that can accurately capture both the objective conditions and the subjective experiences that define urban life.

The existing measurement methods for UQoL broadly divide into two categories: subjective and objective. As subjective well-being includes perceptions of physical and mental health along with social conditions, the subjective methods assess individuals' self-reported satisfaction with various aspects of life (Cummins, 2000; Marans & Stimpson 2011; Veenhoven, 2012; OECD, 2013). These are typically measured through surveys that ask individuals to rate their happiness, life satisfaction, or sense of achievement. Subjective methods are often used in urban studies to assess residents' satisfaction with their living conditions, offering insights into emotional and psychological well-being (Blomquist, 2006; Marans & Strimpson, 2011; Woniak & Jonek-Kowalska, 2020).

In contrast, objective methods focus on measurable factors contributing to well-being, such as income levels, healthcare access, and environmental quality. These indicators, including income, education, and pollution levels, allow for cross-sectional comparisons across cities (Costanza et al., 2008). Although they provide valuable data for assessing urban policies and living conditions, they often fail to capture the subjective experiences of residents. Additionally, the complexity of socio-economic factors makes direct comparisons difficult (Angur et al., 2004; Liao, 2009; McCrea et al., 2006; Merschdorf et al., 2020; Oswald & Wu, 2010).

A variation of the objective method is the hedonic pricing model, which connects UQoL to property values. This method assesses environmental characteristics, such as air quality, noise, and green space accessibility, by observing their impact on real estate prices. It is widely used in environmental economics and property value studies to quantify the value of urban amenities (e.g., green spaces) based on the price people are willing to pay for accessing them (Blomquist, 2006; Carlsen & Leknes, 2020; Lora et al. 2010).

In any case, measuring QoL in cities is challenging due to issues of validity, accuracy, and data availability. Furthermore, transforming diverse factors into a consistent quantitative system is difficult, requiring subjective judgments, particularly in weighting indicators. Many studies suffer from inconsistencies in theoretical frameworks, leading to contradictory results (Blomquist, 2006; Veenhoven, 2012).

While both objective and subjective approaches are widely used in UQoL research, it is important to recognize that they capture fundamentally different aspects of urban life. Objective indicators assess measurable living conditions—such as infrastructure, environmental quality, or access to services—providing a structural view of the urban environment. Subjective indicators, on the other hand, capture the residents' perception of these conditions, reflecting personal experiences and expectations. Understanding this distinction is essential when designing QoL measurement systems, as the choice of method should align with the research goals and data availability (Liao, 2009; McCrea et al., 2006; Oswald & Wu, 2010; Von Wirth et al., 2015; Wesz et al., 2023).

Several studies have assessed UQoL using either approach, or both. For example, the OECD's Better Life initiative uses social indicators to evaluate QoL across member countries. The EU's Quality of Life Survey primarily uses subjective methods, capturing life satisfaction through questionnaires (European Commission, 2023). Additionally, journalistic surveys such as Monocle's rankings of the most livable cities rely on a mix of objective indicators like cultural offerings and transportation (Monocle, 2024). The USNews Best Places to Live ranking follow a similar approach, using a blend of objective data on factors such as affordability and healthcare access. A similar logic underpins the Happy City Index developed by the Institute for Quality of Life, which ranks cities worldwide based on 82 objective indicators across six domains: environmental quality, healthcare, mobility, public services and infrastructure, economic performance, and education and culture (Institute for Quality of Life, 2025). The index is fully based on measurable, objective data. Its multidimensional structure makes it methodologically comparable to systems like DPRD-20, although it applies a different weighting scheme and includes a broader set of variables, reflecting its global scope.

Academic studies, including those by Royuela et al. (2003, 2010) in Barcelona and Faka et al. (2021) in Athens, have utilized social indicators to compose composite indexes for assessing UQoL. Similarly, Carlsen and Leknes (2020) assessed QoL in Oslo's neighborhoods using both hedonic and subjective methods, comparing the results to identify discrepancies in the evaluation of urban well-being, while Patil and Sharma (2022) ranked 14 Indian cities using composite indicators. Other indicator-based research focuses on evaluating specific aspects of UQoL, such as sustainable mobility and pedestrian environments. For example, Bartzokas-Tsiompras et al. (2023a) developed a novel Microscale Walkability Index for 59 European city centres, aggregating factors such as sidewalk quality, pedestrian crossings, and streetscape aesthetics into a composite indicator, providing a benchmark for cross-city comparisons. Complementarily, Bartzokas-Tsiompras et al. (2023b) introduced an open-access dataset and geospatial web platform containing 17 microscale walkability indicators for the same cities, offering spatial data to support the monitoring of urban sustainability and well-being.

To better illustrate the diverse methods and frameworks used to assess UQoL, Table 2 summarizes the key measurement approaches, their underlying theoretical backgrounds, and the corresponding application fields (Psatha, 2025). It highlights the differences in how each method conceptualizes UQoL and the specific proxy measures they employ. Understanding these distinctions is crucial for selecting the most appropriate method for evaluating UQoL based on the research context and objectives.

**Table 2.** Characteristics and application fields of the UQoL measurements.

| | **Hedonic (pricing) method** | **Social Indexes (including Composite Index)** | **Subjective method** |
|---|---|---|---|
| **Theoretical background**[1] | Objective List theory | Objective List theory, Utilitarianism | Hedonism, Desire theories |
| **Proxy measure** | Total value of amenities | Living conditions | Average satisfaction with life |
| **Subjectivity** | None | Moderate[2] | Large |
| **Precarity of assumptions** | Large | Moderate[2] | Minor |
| **Basic discipline** | Urban economics | Urban studies, Regional Science | Social Sciences |
| **Spatial level** | Neighborhoods, urban areas | Cities, regions, countries | Neighborhoods, urban areas, cities, countries |
| **Application fields (non-academic)** | Real estate | Quality of Living and/or Livability city rankings (by media and organ zations), Better Life Index (OECD) | European Quality of Life surveys |

[1] According to the established well-being theories.

[2] The level of subjectivity and the precarity of assumptions depend on how the QOL factors are selected.

These diverse approaches underscore the difficulty of comparing studies that use different definitions and sets of indicators. In response to this, the International Organization for Standardization (ISO) developed ISO 37120:2018—the first global standard for city indicators—which includes 104 metrics covering areas such as economy, education, and the environment. These standardized indicators facilitate international comparisons of urban services and QoL (ISO, 2018). However, the ISO framework has yet to be widely adopted in academic research or policymaking.

## 3. Methods

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### *3.1. Conceptual and Methodological Background*

This study builds upon the DPRD-50 system, originally developed to assess UQoL in medium-sized Greek cities. The selected cities meet the criteria set by the European Commission, Eurostat, and the OECD for defining urban areas—specifically, a minimum population of 50,000 and a density of at least 1,500 inhabitants per km² in the urban core (European Commission et al., 2021).

Although the DPRD-50 system was not initially developed for the current research, it is selected as the foundation due to its comprehensive and systematic approach. It consists of 50 indicators, which are calculated using 70 variables, across 10 domains, covering a broad range of factors that determine UQoL, such as economic conditions, the social environment, the natural environment, and more (Table 3). The system is an application of the social indicators method (objective method), however the selection of indicators was informed by the findings of large-scale UQoL studies with the subjective method, such as the EU Quality of Life surveys (Psatha & Deffner, 2014).

**Table 3.** DPRD-50 Domains and Indicators.

| **Economic Environment (EE)** | **Social Environment (SE)** |
|---|---|
| Average income (xEE1[1]) | Crime rate (xSE1) |
| Income quintile ratio (xEE2) | Graduates from higher education-percentage (xSE2) |
| Poverty rate (xEE3) | Aging Index (xSE3) |
| Unemployment rate (xEE4) | Married adults – percentage (xSE4) |
| Number of private cars/ 1000 residents (xEE5) | Social supporting Networks – score (xSE5) |
| **Natural Environment (NE)** | **Urban /Suburban Green Spaces (GS)** |
| CI[2] for waste management (xNE1) | Area of public spaces per capita (xGS1) |
| CI[1] for the Climate (xNE2) | Area of green spaces per capita (xGS2) |
| CI for drinking water (xNE3) | Sub-urban green spaces per capita (xGS3) |
| Quality of the bathing waters - score (xNE4) | Number of tress per capita (xGS4) |
| Air quality: PM10 average concentration (xNE5) | Maintenance of green spaces and trees per capita (xGS5) |
| **Housing and Built Environment (BE)** | **Sports and Culture (SC)** |
| Sq. meters of house per capita (xBE1) | CI for sports activities (xSC1) |
| Percentage in very small or atypical homes (xBE2) | Number of cinemas (xSC2) |
| Ratio of home ownership (xBE3) | Number of bookstores/ 1000 residents (xSC3) |
| Average current price of homes (xBE4) | Number of restaurants (xSC4) |
| Number of monumental buildings (xBE5) | Number of museums and art galleries (xSC5) |
| **Health care (HC)** | **Education Facilities (EF)** |
| Hospital beds / 1000 residents (xHC1) | Number of students/classroom (xEF1) |
| Private doctors/ 1000 residents (xHC2) | Number of teachers/ 100 students (xEF2) |
| Pharmacies/ 1000 residents (xHC3) | Number of University Departments (xEF3) |
| Beds in private hospitals/ 1000 residents (xHC4) | Expenditure on schools' maintenance per student (xEF4) |
| Access to tertiary care units-score (xHC5) | Performance in the Panhellenic School Exams (xEF5) |
| **Sustainable Mobility (ST)** | **Technical infrastructures (TI)** |
| Road accidents/ 1000 residents (xST1) | CI for Modern environmental infrastructures (xTI1) |
| Parking spots /1000 pr. cars – city center (xST2) | CI for the Municipal social infrastructures (xTI2) |
| Length of pedestrianized network/ 1000 residents (xST3) | CI for Information infrastructures (xTI3) |
| Length of the cycle lanes/ 1000 residents (xST4) | CI for the transport networks (xTI4) |
| Number of bus routes/ 1000 residents (xST5) | CI for the quality of municipal services (xTI5) |

[1] Original DPRD-50 indicators are marked with an "x" prefix to avoid confusion with the revised DPRD-20 indicators introduced later in the analysis.
[2] Composite Index.

In line with Sen's capability approach, the DPRD-50 system emphasizes the importance of measuring the availability of choices and opportunities for individuals, rather than merely focusing on outcomes (Sen, 1993; Sen, 1994). Enhancing QoL involves creating conditions in which individuals can freely choose and act according to their preferences, leading to improved well-being. In DPRD-50, the capability approach translates as focusing on the opportunities available to urban residents, such as access to public transportation or cycling paths, rather than simply measuring how often the relevant amenities are used. By using generalizable indicators that align with Sen's approach and the broader framework of utilitarianism, the system avoids arbitrary variable selection and promotes a reliable measure of urban life.

According to the DPRD-50 methodological framework, the 5 indicators per domain are normalized to ensure comparability across different units and data sources. Then they are aggregated into domain-specific composite indices, which are subsequently averaged to produce the overall UQoL index for each city, following an isobaric linear model:

$$UQoL_i = (1/10) \times \Sigma\, CI_{ki}, \quad (1)$$

where $CI_{ki}$ denotes the composite index of domain k (out of 10) in city i

This process follows the general principles outlined in the OECD & EU/JRC Handbook on Constructing Composite Indicators (OECD & EC–JRC, 2008), including indicator selection, normalization, aggregation, and interpretation, ensuring methodological consistency with internationally recognized standards.

The above methodology allows for a comprehensive evaluation of UQoL across various factors, while maintaining consistency with the theoretical framework that underpins the system. However, drawing on the implementation experience from 2014, it became evident that the complexity of the DPRD-50 system is exacerbated by the reliance on information that required time-consuming communication with various services. Limited availability of primary data, compounded by the large number of variables, renders the system unwieldy, prompting a shift to a more manageable set of 20 rather than 50 indicators. To streamline the approach, Principal Component Analysis (PCA) was conducted on the original set of 50 variables, identifying the most influential components while preserving theoretical consistency. The primary aim was to retain the robustness of the original framework while offering a more efficient, user-friendly tool for comparative urban analysis.

Figure 1 illustrates the methodological workflow adopted in this study, from identifying the determinants of UQoL and selecting the appropriate indicators, through the normalization and aggregation stages, to the construction of the final composite index.

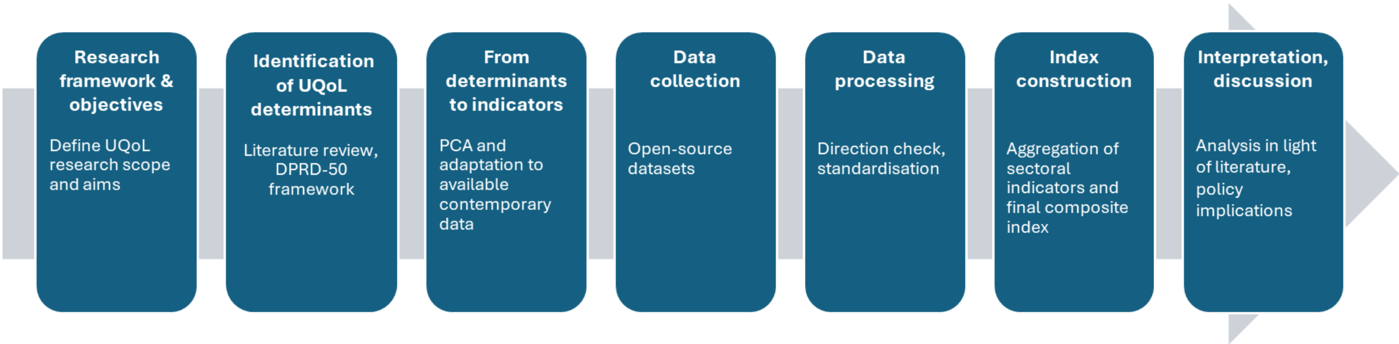


**Figure 1.** Overview of the research design, methodological steps, and analytical focus adopted in this study.

This structured process guided the refinement of the original DPRD-50 system into the streamlined DPRD-20, as described in the following subsections, beginning with the meta-analysis of the original dataset using PCA.

### *3.2. Meta-Analysis of the original data using PCA for a more flexible system*

To refine the DPRD-50 system, we performed a meta-analysis of the data collected during the 2014 research, which included 70 variables across 10 UQoL domains. This approach assumes relative stability in the correlation structure of variables over time—an acknowledged limitation—but was chosen due to the completeness and comparability of the 2014 dataset across all selected cities. Consequently, PCA is employed here as a dimensionality reduction tool rather than for drawing time-specific conclusions. The objective was to identify the most influential indicators in each domain while making the system more manageable and adaptable for ongoing monitoring and comparative analysis.

We applied Principal Component Analysis (PCA), a statistical method that detects patterns in the data and reduces dimensionality by transforming correlated variables into principal components—linear combinations that capture the maximum possible variance. PCA was performed separately for each of the 10 UQoL domains. For each domain, we examined the loadings of the original variables on the first principal component (PC1), which captures the largest share of variance. In our methodology, PC1 serves as the domain-specific composite index. By identifying the two variables with the highest absolute loadings on PC1, we retained those that contribute most strongly to the underlying construct of each domain, thereby ensuring both theoretical coherence and empirical robustness in the refined DPRD-20 system.

For example, in the Social Environment domain, the domain-specific composite index (PC1) was expressed as a linear combination of the indicators for crime rate (SE1), education (SE2), population aging (SE3), marital status (SE4), and supporting networks (SE5):

$$PC1 = w_1 \cdot SE1 + w_2 \cdot SE2 + w_3 \cdot SE3 + w_4 \cdot SE4 + w_5 \cdot SE5 \quad (2)$$

where $w_1$ to $w_5$ represent the respective loading coefficients derived from the PCA.

This domain-specific approach, rather than selecting the top 20 indicators overall, ensured that all key UQoL dimensions remained represented in the final composite index. By treating each domain's composite score as an independent component of the overall index, the method preserves the ability to assess each domain's distinct contribution to UQoL, capturing urban complexity without sacrificing clarity or comparability.

### *3.3. Development of the Final Composite Index for UQoL*

The 20 final indicators were aggregated into a composite index, constructed as an equally weighted linear combination. This composite index yields a single value, enabling straightforward comparison across cities and/or time periods and offering a concise snapshot of relative QoL in each urban area.

The indicators were adapted to the available open-source data, as the study's primary goal was to calculate UQoL using readily accessible information, thereby ensuring transparency and replicability. Where adjustments were required, the conceptual integrity of each indicator was preserved, with only the proxy measure modified. For example, the car ownership indicator—used in 2014 as a proxy for household economic well-being—was recalculated: in the DPRD-50 system it was defined as the number of registered cars per 1,000 residents, whereas in the DPRD-20 it is expressed as the percentage of households with one or more cars. This change aligns the indicator with the revised data structure of the 2021 household census, which differs from that of 2011, while maintaining its original conceptual meaning.

To ensure comparability, all indicators were standardized using z-scores, with their directionality adjusted so that higher values always represent better performance. For example, indicators such as unemployment rate and air pollution levels were reverse-coded. A detailed overview of the means, standard deviations, and directional adjustments is provided in Annex/Table A1.

For indicators where higher values are desirable (e.g., green space), the following formula was applied:

$$\text{Standardized Value}=100+(x-\bar{x})/\sigma*10 \quad (3)$$

For indicators where lower values are preferable (e.g., crime rate), the reversed formula was used:

$$\text{Standardized Value}=100-(x-\bar{x})/\sigma*10 \quad (4)$$

where x is the original value, $\bar{x}$ is the mean, and σ is the standard deviation.

This standardization process ensured that all indicators were directly comparable and consistently scaled, facilitating the aggregation of the 20 selected indicators into the final composite UQoL index.

## 4. Results

### *4.1. PCA on the original dataset and new indicators*

As previously explained, the selection of the 20 final indicators was based on Principal Component Analysis (PCA) applied to the standardized DPRD-50 dataset. PCA was used to transform the original variables into principal components (PCs), which are linear combinations of the original indicators. For each domain, the first principal component (PC1) was treated as a domain-specific composite index that captures the greatest share of variance. Mathematically, PC1 is expressed as:

$$PC1 = w_1X_1 + w_2X_2 + \ldots + w_5X_5$$

where $X_1$ to $X_5$ are the standardized original variables within each domain (as listed in Table 3), and $w_1$ to $w_5$ are the corresponding loading coefficients.

From this analysis, the two variables within each domain with the highest absolute loadings on PC1 were selected as the most representative indicators. These results are summarized in Table 4.

**Table 4.** PCA Results.

| | **UQoL Domain / weights of variables** | **W1** | **W2** | **W3** | **W4** | **W5** |
|---|---|---|---|---|---|---|
| **$PC1_1$** | Economic Environment (xEE1 to xEE5) | -0.26 | 0.47 | -0.10 | -0.51 | 0.61 |
| **$PC1_2$** | Social Environment (xSE1 to xSE5) | 0.62 | -0.11 | 0.57 | -0.23 | 0.35 |
| **$PC1_3$** | Natural Environment (xNE1 to xNE5) | 0.48 | 0.62 | -0.17 | 0.41 | 0.57 |
| **$PC1_4$** | Green Spaces (xGS1 to xGS5) | 0.59 | -0.21 | 0.64 | -0.18 | 0.32 |
| **$PC1_5$** | Built environment (xBE1 to xBE5) | 0.29 | -0.18 | 0.35 | 0.66 | 0.61 |
| **$PC1_6$** | Sports and Culture (xSC1 to xSC5) | 0.61 | -0.23 | 0.29 | 0.67 | 0.38 |
| **$PC1_7$** | Health Care (xHC1 to xHC5) | 0.64 | -0.22 | 0.19 | -0.15 | 0.67 |
| **$PC1_8$** | Education Facitlities (xEF1 to xEF5) | 0.58 | -0.21 | 0.62 | -0.19 | 0.30 |
| **$PC1_9$** | Sustainable Mobility (xSM1 to xSM5) | 0.21 | -0.18 | 0.66 | 0.72 | 0.19 |
| **$PC1_{10}$** | Technical Infrastructures (xTI1 to xTI5) | 0.65 | -0.19 | 0.28 | 0.71 | 0.33 |

To maintain continuity with the original DPRD-50 framework while enhancing comparability and applicability, the selected indicators were aligned with open-access data sources. Minor adjustments were made to some variables to reflect changes in data availability, but their conceptual content and role within the system were preserved. Certain constructs—such as social cohesion, environmental quality, and sustainable mobility—were deemed theoretically indispensable and therefore retained, even when data limitations required slight modifications in their calculation. Variables showing strong multicollinearity with the retained indicators or minimal variance across cities were excluded, as they added little analytical value. In the Technical Infrastructure domain, indicator TI.2 corresponds conceptually to xTI4, one of the top-loading variables in the PCA, but its calculation method was updated to incorporate a continuous, distance-based metric, thereby enhancing consistency with the rest of the DPRD-20 indicators.

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The final constructs, corresponding indicators, and data sources are presented in Table 5.

**Table 5.** The DPRD-20 Urban Indicator System.

| UQoL Domains | Constructs | Indicators | Open Source of data / corresponding year |
|---|---|---|---|
| Economic Environment | Employment opportunities | EE1: Unemployment rate | Hellenic Statistical Authority (ELSTAT) - Census Data / 2021 |
| | Prosperity | EE2: Percentage of households with one or more private cars | |
| Social Environment | Crime Index | SE1: Criminal code offenses / 1000 inhabitants | Hellenic Police - Statistical Yearbook / 2022 |
| | Population renewal | SE2: Old-Age Dependency Ratio | Hellenic Statistical Authority (ELSTAT) - Census Data / 2021 |
| Natural Environment | Composite climate index | NE1.1: average monthly hours of sunshine,<br>NE1.2: average humidity,<br>NE1.3: average temperature of coldest month,<br>NE1.4: average temperature of warmest month | Hellenic Meteorological Service - Climate Data (Processed by Author) / 2024 |
| | Air quality | NE2: Average annual concentration of suspended particles PM10 | Ministry of Environment and Energy - Air Quality Data (Processed by Author) / 2022 |
| Green Spaces | Green public spaces | GS1: Percentage of green infrastructure | European Environment Agency- Urban Green Infrastructure / 2018 Dashboards |
| | Trees | GS2: Percentage of tree coverage in the city's functional areas | European Environment Agency - Urban Tree Cover Dashboards / 2018 |
| Built environment | Affordable housing | BE1: Average real property price (€/m2) | Spitogatos.gr - Property Prices 2022 (Processed by Author) |
| | Architectural Heritage | BE2: Number of designated listed buildings and complexes | Ministry of Environment and Energy - ESTIA Database for Listed Monuments (Accessed at estia.minenv.gr` |
| Sports and Culture | Sports facilities | SC1: Sports facilities / 10,000 inhabitants | General Secretariat for Sports - National Sports Facilities by Region (Accessed at gga.gov.gr |
| | Cultural facilities | SC2: Libraries, museums, theaters, cinemas (total) | General Web Search, (Processed by Author / accessed March 2025) |
| Health Care | Adequacy of health care | HC1: Hospital beds / 1000 inhabitants | Ministry of Health - Beds, Inpatients, and Length of Stay Data 2022 (Accessed at https://www.moh.gov.gr/articles /bi-health/stoixeia-noshleytikhs-kinhshs/11344-klines- noshleythentes-hmeres-noshleias-2022) |
| | Access to specialized medical care | HC2: Distance from a tertiary health facility (University Hospital) | General Web Search, (Processed by Author / accessed March 2025) |
| Education Facilities | Quality of public schools | EF1: Students / teacher in primary education | data.gov.gr - Student and Teacher Data (Processed by Author) |
| | Academic Environment | EF2: Number of University departments | General Web Search, (Processed by Author / accessed March 2025) |
| Sustainable Mobility | Pedestrian-Friendly Environment | SM1: Meters of pedestrian and low-traffic roads / 1000 inhabitants | Overpass Turbo (OpenStreetMap) - Pedestrian and Low-Traffic Roads Data (Processed by Author) |
| | Bike-Friendly Environment | SM2: Meters of bicycle paths / 1000 inhabitants | Overpass Turbo (OpenStreetMap) - Bicycle Path Data (Processed by Author) |
| Technical Infrastructures | Composite index for technical infrastructure | TI1.1: Population coverage of biological urban wastewater treatment | Municipalities Official Websites - Wastewater Treatment Data (Processed by the Author) General Web Search, (Processed by Author / accessed March 2025) |
| | | TI1.2: population coverage of natural gas network | |
| | Composite index for accessibility | TI2.1: distance from nearest port<br>TI2.2: distance from nearest railway station (functional)<br>TI2.3: distance from national highway network<br>TI2.4: distance from nearest airport<br>TI2.5: distance from nearest Border Entry Point | General Web Search, (Processed by Author / accessed March 2025) |

[1] All distance-based indicators were calculated as road distances reported by Google Maps, measured from the city center of each examined medium-sized city to the relevant facility.
[2] Facility counts (e.g. number of university departments, museums) reflect the range of options available to residents, in line with Sen's capability approach to well-being, whereas basic service provision indicators (e.g., hospital beds) are population-adjusted.

With the final set of indicators established, the following step involved collecting the required data and calculating the composite Urban Quality of Life (UQoL) index for the selected medium-sized Greek cities.

### 4.2. Data Processing and Composite Indicator Construction

Following the selection of the 20 final indicators, we collected the data for the Greek medium-sized cities, including Volos, Heraklion, Ioannina, Kavala, Kalamata, Larissa, and Patras. The data collected for each UQoL indicator is presented in Table 6:

**Table 6.** Raw Data for the Calculation of the DPRD-20 Composite Indicator in Medium-Sized Greek Cities

| No | Indicator/City | Heraklion | Ioannina | Kavala | Kalamata | Larissa | Patra | Volos |
|---|---|---|---|---|---|---|---|---|
| 1 | EE1 | 16,19 | 12,73 | 14,74 | 16,46 | 15,48 | 14,39 | 18,13 |
| 2 | EE2 | 66,49 | 72,91 | 69,38 | 67,41 | 71,95 | 71,63 | 64,56 |
| 3 | SE1 | 7,45 | 11,85 | 9,37 | 9,29 | 12,34 | 7,13 | 17,24 |
| 4 | SE2 | 165,5 | 110,0 | 134,9 | 197,7 | 150,3 | 120,6 | 131,2 |
| 5 | NE1.1 | 87 | 96 | 79 | 85 | 96 | 81 | 89 |
| | NE1.2 | 64,5 | 66,0 | 72,6 | 69,7 | 68,5 | 66,2 | 66,0 |
| | NE1.3 | 7,0 | 12,0 | 5,0 | 6,0 | 10,0 | 5,0 | 10,0 |
| | NE1.4 | 27,0 | 27,0 | 25,0 | 26,0 | 27,0 | 28,0 | 27,0 |
| 6 | NE2 | 34,27 | 32,90 | 29,89 | 33,50 | 33,50 | 32,12 | 38,30 |
| 7 | GS1 | 38,5 | 31,1 | 19,2 | 73,9 | 70,3 | 15,4 | 55,8 |
| 8 | GS2 | 35,60 | 34,71 | 55,31 | 45,47 | 65,72 | 10,00 | 50,24 |
| 9 | BE1 | 1250 | 1625 | 1452 | 1818 | 1848 | 1169 | 1330 |
| 10 | BE2 | 83 | 111 | 126 | 84 | 74 | 7 | 399 |
| 11 | SC1 | 6,44 | 0,84 | 4,74 | 5,27 | 3,43 | 5,24 | 2,18 |
| 12 | SC2 | 34 | 40 | 33 | 17 | 19 | 25 | 35 |
| 13 | HC1 | 1,86 | 3,90 | 7,06 | 3,04 | 1,93 | 3,40 | 3,74 |
| 14 | HC2 | 60 | 10 | 6 | 150 | 240 | 10 | 10 |
| 15 | EF1 | 8,16 | 8,25 | 8,41 | 8,26 | 9,07 | 8,75 | 9,02 |
| 16 | EF2 | 14,00 | 12,00 | 19,00 | 6,00 | 8,00 | 10,00 | 30,00 |
| 17 | SM1 | 127,44 | 53,51 | 154,08 | 18,52 | 59,52 | 95,50 | 70,28 |
| 18 | SM2 | 7,5 | 11,0 | 1,5 | 6,0 | 18,0 | 20,0 | 27,0 |
| 19 | TI1.1 | 95,0 | 75,0 | 77,0 | 82,5 | 98,0 | 89,0 | 96,5 |
| | TI1.2 | 0,0 | 0,0 | 0,0 | 0,0 | 95,0 | 0,0 | 90,0 |
| 20 | TI2.1 | 0 | 80 | 0 | 0 | 60 | 0 | 0 |
| | TI2.2 | NA | 150 | 60 | 150 | 0 | 80 | 60 |
| | TI2.3 | NA | 5 | 100 | 5 | 5 | 10 | 20 |
| | TI2.4 | 0 | 0 | 35 | 10 | 65 | 40 | 20 |
| | TI2.5 | 0 | 75 | 65 | 215 | 160 | 0 | 200 |

The next step involved standardizing the data using the z-score method, setting the mean to 100 and the standard deviation to 10, as described above. The standardization process allows for the comparative evaluation of cities within a common reference framework.

Table 7 presents the standardized values of the selected indicators, as derived from the previously described methodology.

**Table 7.** Standardized Indicator Values for DPRD-20 in Medium-Sized Greek Cities

| No | Indicator/City | Heraklion | Ioannina | Kavala | Kalamata | Larissa | Patra | Volos |
|---|---|---|---|---|---|---|---|---|
| 1 | EE1 | 115,80 | 104,10 | 94,10 | 99,80 | 106,10 | 84,40 | 95,70 |
| 2 | EE2 | 111,80 | 100,60 | 94,30 | 108,80 | 107,80 | 85,30 | 91,40 |
| 3 | SE1 | 96,60 | 103,70 | 103,90 | 95,20 | 110,10 | 81,30 | 109,20 |
| 4 | SE2 | 111,50 | 103,20 | 82,10 | 98,00 | 108,00 | 104,40 | 92,90 |
| 5 | NE1.1 | 113,60 | 86,10 | 95,80 | 113,60 | 89,40 | 102,40 | 99,10 |
| | NE1.2 | 105,90 | 82,30 | 92,60 | 96,90 | 105,20 | 105,90 | 111,20 |
| | NE1.3 | 114,80 | 89,80 | 93,40 | 107,70 | 89,80 | 107,70 | 96,90 |
| | NE1.4 | 97,00 | 118,00 | 107,50 | 97,00 | 86,50 | 97,00 | 97,00 |
| | NE1 | 107,83 | 94,05 | 97,33 | 103,80 | 92,73 | 103,25 | 101,05 |
| 6 | NE2 | 102,50 | 115,30 | 100,00 | 100,00 | 105,80 | 79,60 | 96,70 |
| 7 | GS1 | 94,80 | 89,70 | 112,90 | 111,40 | 88,10 | 105,20 | 97,90 |
| 8 | GS2 | 95,70 | 107,20 | 101,70 | 113,00 | 81,90 | 104,30 | 96,20 |
| 9 | BE1 | 95,30 | 101,70 | 88,20 | 87,10 | 112,20 | 106,20 | 109,20 |
| 10 | BE2 | 98,80 | 100,00 | 96,60 | 95,80 | 90,50 | 121,60 | 96,60 |
| 11 | SC1 | 83,90 | 103,70 | 106,30 | 97,00 | 106,20 | 90,70 | 112,30 |
| 12 | SC2 | 112,60 | 104,60 | 86,30 | 88,60 | 95,40 | 106,90 | 105,70 |
| 13 | HC1 | 101,90 | 120,10 | 97,00 | 90,60 | 99,10 | 101,00 | 90,20 |
| 14 | HC2 | 106,50 | 106,90 | 91,20 | 81,40 | 106,50 | 106,50 | 101,00 |
| 15 | EF1 | 108,10 | 103,90 | 107,80 | 86,70 | 95,00 | 88,00 | 110,50 |
| 16 | EF2 | 97,40 | 105,90 | 90,00 | 92,50 | 94,90 | 119,40 | 99,80 |
| 17 | SM1 | 93,70 | 115,40 | 86,20 | 95,00 | 102,80 | 97,30 | 109,60 |
| 18 | SM2 | 93,90 | 97,80 | 87,20 | 92,20 | 105,60 | 107,80 | 115,60 |
| 19 | TI1.1 | 107,8 | 86,8 | 88,9 | 94,7 | 111,0 | 101,5 | 109,4 |
| | TI1.2 | 94,1 | 94,1 | 94,1 | 94,1 | 115,2 | 94,1 | 114,1 |
| | TI1 | 101,0 | 90,5 | 91,5 | 94,4 | 113,1 | 97,8 | 111,7 |
| 20 | TI2.1 | 105,8 | 82,7 | 105,8 | 105,8 | 88,5 | 105,8 | 105,8 |
| | TI2.2 | 79,0 | 88,5 | 104,0 | 88,5 | 114,3 | 100,6 | 104,0 |
| | TI2.3 | 79,0 | 105,1 | 79,8 | 105,1 | 105,1 | 103,8 | 101,1 |
| | TI2.4 | 110,2 | 110,2 | 95,5 | 106,0 | 83,0 | 93,4 | 101,8 |
| | TI2.5 | 111,3 | 103,0 | 104,1 | 87,5 | 93,6 | 111,3 | 89,1 |
| | TI2 | 97,06 | 97,9 | 97,9 | 98,6 | 96,9 | 103,0 | 100,4 |

[1] Directional reversal was applied to indicators EE1, SE1, SE2, NE1.2, NE1.4, NE2, BE1, HC2, TI2.1–TI2.5.

Subsequently, Table 8 illustrates the computation of the domain-specific composite indicators and the overall UQoL index for the examined cities. Each domain-level composite index was calculated as the simple average of the two standardized indicators retained for the domain.

**Table 8.** Composite Indicators for UQoL Domains and Final Composite UQoL Index in Medium-Sized Greek Cities

| UQoL Domain | Heraklion | Ioannina | Kavala | Kalamata | Larissa | Patra | Volos |
|---|---|---|---|---|---|---|---|
| Economic Environment | 113,8 | 102,4 | 94,2 | 104,3 | 106,9 | 84,8 | 93,5 |
| Social Environment | 104,1 | 103,4 | 93,0 | 96,6 | 109,0 | 92,8 | 101,0 |
| Natural Environment | 105,2 | 104,7 | 98,7 | 101,9 | 99,3 | 91,4 | 98,9 |
| Green Spaces | 95,2 | 98,5 | 107,3 | 112,2 | 85,0 | 104,8 | 97,1 |
| Built Environment | 97,1 | 100,9 | 92,4 | 91,5 | 101,3 | 113,9 | 102,9 |
| Sports and Culture | 98,2 | 104,1 | 96,3 | 92,8 | 100,8 | 98,8 | 109,0 |
| Health Care | 104,2 | 113,5 | 94,1 | 86,0 | 102,8 | 103,8 | 95,6 |
| Education Facilities | 102,7 | 104,9 | 98,9 | 89,6 | 95,0 | 103,7 | 105,1 |
| Sustainable Mobility | 93,8 | 106,6 | 86,7 | 93,6 | 104,2 | 102,6 | 112,6 |
| Technical Infrastructure | 97,1 | 97,9 | 97,9 | 98,6 | 96,9 | 103,0 | 100,4 |
| Total UQoL | 101,1 | 103,7 | 96,0 | 96,7 | 100,1 | 100,0 | 101,6 |

Figure 2 presents the composite DPRD-20 UQoL index for the seven medium-sized Greek cities, along with their domain-specific performance across the ten UQoL domains. The relative size of the circles represents indicator values (larger circles indicate higher performances). This visualisation highlights differences in overall urban well-being, as well as each city's strengths and weaknesses across thematic domains.

The composite DPRD-20 scores summarized in Table 8 and visualized in Figure 2 provide a concise overview of the relative UQoL performance among the selected Greek cities. While some cities maintain a consistently strong profile across multiple domains, others demonstrate more polarized results with notable strengths and weaknesses.

Such variations underscore the importance of domain-level analysis, which is further explored in the discussion that follows. The composite index reveals persistent disparities across domains, particularly in areas directly influenced by local governments—such as healthcare access, urban greenery, and sustainable mobility. These patterns, first observed in 2014, remain relevant today and reinforce the importance of these domains as entry points for urban interventions (Mouratidis, 2019; Wolniak & Kowalska, 2020). Local authorities can use such findings to identify areas of weakness, target resources accordingly, and guide internal QoL audits.

## 5. Discussion

The findings of this study offer insights into UQoL in medium-sized Greek cities and demonstrate the strengths and limitations of the newly introduced DPRD-20 system. By reducing the 50 original indicators of the DPRD-50 framework through PCA, the DPRD-20 system achieves a more balanced structure, preserving theoretical depth while enhancing usability. Each of the 10 UQoL domains remains represented, ensuring comprehensiveness while allowing for more efficient monitoring, interpretation, and policymaking.

Nonetheless, it is important to acknowledge a potential limitation related to the use of PCA. The selection of indicators in the DPRD-20 system was based on the correlation structure of the 2014 dataset, which may not fully reflect current interdependencies among variables. However, our primary goal was not to model inter-variable relationships but to identify the strongest-performing indicators in each domain—those most capable of capturing cross-city differences. Much like student performance is evaluated across multiple subjects regardless of the correlations between them, UQoL is assessed here through performance in core domains. The use of PCA was thus a pragmatic tool to refine the original system. Future updates can revisit this selection using more recent data.

The selection of indicators was guided not only by PCA results but also by theoretical relevance and expected sensitivity to urban change. Variables with low variance or high correlation to retained indicators were excluded, not because they lacked importance in shaping UQoL, but because they contributed little to comparative analysis across similar cities. The system's spatial scale further influenced this selection: local indicators such as green space provision and sustainable mobility are particularly meaningful at the city level, whereas broader metrics (e.g., GDP per capita or life expectancy), although important, are less informative due to low intra-national variation (UNDP, 2025; Psatha et al., 2011).

Interpretation of these trends must consider the dynamic and interdependent nature of UQoL determinants. While this study remains largely descriptive, it is guided by interpretive hypotheses about how different domains respond to governance interventions and structural change. Domains like social infrastructure and local governance may react rapidly to policy shifts or targeted funding, while others—such as housing or environmental conditions—are more path-dependent. Feedback loops are also relevant: for example, improvements in social cohesion could enhance local governance capacity, while fiscal constraints may erode progress across multiple areas. Several of the indicators used in the DPRD-20 system may shift in relevance over time. Economic shocks, demographic transitions, and governance reforms can recalibrate the weight of different urban priorities (Maloutas, 2015). For instance, public service indicators may become more critical during austerity periods, while social cohesion variables may be affected by population aging or migration.

These considerations link to wider debates on indicator-based governance. Scholars warn that composite indices and rankings are not neutral: they can shape policy agendas, institutional priorities, and even public perceptions (Tilly, 2006; Le Galès, 2013). Recent research (Zhao et al., 2023) highlights the methodological risks of such tools, including data biases and the reproduction of inequalities. Benchmarking must therefore be treated as an interpretive exercise, not a deterministic assessment, especially in contexts with uneven data and governance capacities (Vintar Mally, 2021).

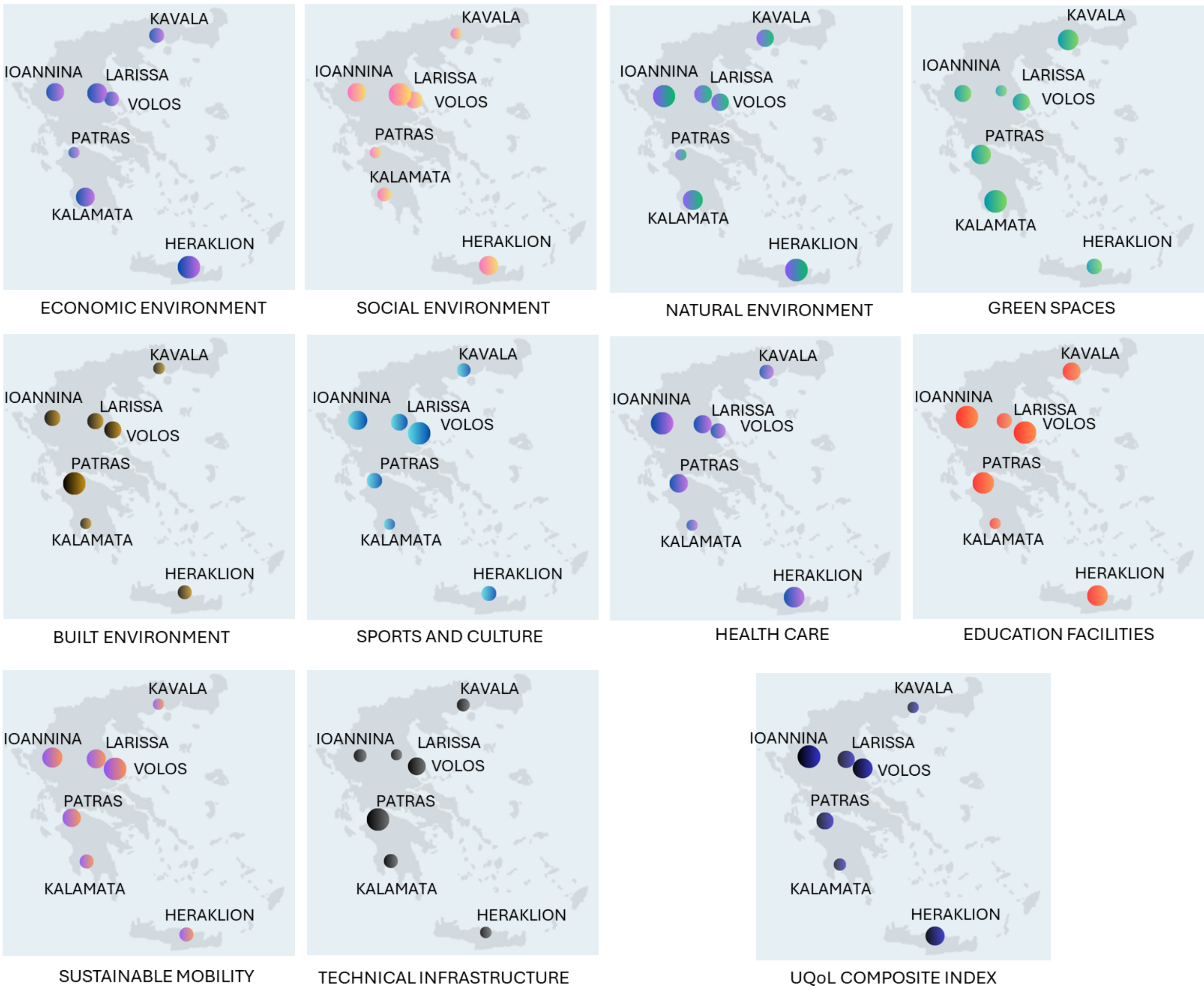


**Figure 2.** Composite UQoL Index for the medium-sized Greek cities and cities' performance in the ten thematic domains of the DPRD-20 system (circle size represents indicator value: larger circles indicate higher values).

Policy regimes and planning incentives can also mediate the spatial and social inequalities that underlie UQoL outcomes. Governance tools—such as land-use incentives or regulatory zoning—may either reinforce or alleviate urban disparities, depending on their configuration (Vitale, 2010; Tonkiss, 2020). Understanding these tools as active drivers of QoL, not passive enablers, allows for more effective policy design. Recent research supports the view that inequality is not inevitable but contingent on policy responses (Karadimitriou et al., 2021; Stathopoulou et al., 2018; Xu & Halsall, 2023). Based on our findings, we hypothesize that domains like healthcare accessibility, green space provision, and sustainable mobility are most responsive to governance reforms. In contrast, structural factors like housing markets and demographic patterns evolve more slowly. These hypotheses offer a foundation for future empirical testing of causal pathways.

Despite its practical benefits, the DPRD-20 system faces several limitations. First, open-source data—such as from Open-StreetMap—may reflect perceived rather than measured realities, introducing bias (e.g., in walkability and bikeability metrics). Moreover, some indicators—such as hospital beds per capita—fail to capture qualitative aspects of services, including care quality or user satisfaction. Second, exclusive reliance on objective indicators enhances comparability but omits subjective well-being metrics. Integrating survey-based data on life satisfaction or perceived QoL could enrich future analyses and triangulate findings. Third, generalizing the system beyond Greece poses challenges, particularly due to data gaps in less prominent European cities, even when using Eurostat datasets.

Nonetheless, the study yields actionable recommendations for medium-sized cities seeking to improve UQoL. Targeted interventions should prioritize domains where local governments have the greatest influence and where the data reveal persistent weaknesses:

- Increasing green spaces and enhancing urban greenery: In cities such as Larissa (85.0) and Heraklion (95.2), the Green Spaces domain scores are comparatively low, with certain sub-indicators (GS1 or GS2) revealing limited provision or accessibility. Investments in the creation, preservation, and maintenance of green areas would not only improve the visual appeal of the city but also deliver physical and mental health benefits for residents.

- Policies for pedestrian and cycling infrastructure: Sustainable Mobility scores are notably weak in Kavala (86.7) and Heraklion (93.8), indicating limited infrastructure for active transport. Expanding pedestrian paths and bicycle lanes can reduce car dependency, improve air quality, and foster healthier, more sustainable urban mobility patterns.
- Enhancing services for the elderly: Health Care domain scores are particularly low in Kalamata (86.0), Kavala (94.1) and Volos (95.6), while the demographic data show elevated aging indices. Policies should focus on improving healthcare accessibility, expanding social support networks, and ensuring safe, accessible public spaces tailored to the elderly population.
- Investing in cultural and sports facilities: The Sports & Culture domain shows below-average performance in Kalamata (92.8) and Kavala (96.3). Developing and maintaining cultural centers and sports infrastructure can strengthen community engagement, promote healthy lifestyles, and enhance social cohesion.
- Addressing housing affordability and the quality of the built environment: While domain scores for the built environment vary across cities, the analysis of housing purchase prices suggests that affordability remains a concern in all cases. Local authorities could explore measures such as promoting the adaptive reuse of vacant buildings, supporting energy-efficient renovations, and ensuring the adequate maintenance of public spaces to help preserve and enhance the urban fabric while mitigating affordability pressures.

These recommendations align with existing literature on urban policy interventions that contribute to improved UQoL—particularly in the domains of sustainable mobility, green infrastructure, social inclusion, and neighborhood well-being (e.g., Ettema et al., 2016; Leyden, 2003; Kent & Thompson, 2014; Pfeiffer et al., 2016; Talen & Kosdinsky, 2014; White et al., 2013; Wild & Woodward, 2019; Wood et al., 2010; Zhang et al., 2017; Urbact, 2024)—and underscore the role of municipalities in shaping more equitable, livable, and responsive urban environments.

## 6. Conclusions

The DPRD-20 system emerges as a practical and robust tool for monitoring UQoL in medium-sized cities, enabling both comparative analysis between cities and temporal assessment over different periods. Developed by reducing the original DPRD-50 framework through a theoretically informed PCA process, the DPRD-20 preserves domain diversity while enhancing usability for policymakers.

Compared to the 2014 baseline, notable shifts are evident in the UQoL rankings of Greek medium-sized cities. The Thessalian cities (Volos and Larissa) have dropped from the top positions, with Ioannina now ranking first—a result consistent with the 2025 Happy City Index, which also identified Ioannina as the highest-performing Greek city. This convergence between two independently developed assessment systems reinforces the robustness of our findings. Heraklion has improved significantly, now in third place, just behind Volos and ahead of Larissa, while Patras remains in the mid-range. Kavala and Kalamata continue to rank lower overall, though each demonstrates distinct strengths. These changes should be interpreted with caution, as the two studies differ in certain indicators and are separated by a significant time gap; changes in data availability and urban dynamics may also affect direct comparability.

The comparative analysis shows that all cities combine strengths and weaknesses, presenting both challenges and opportunities. Ioannina's performance reflects its strong natural environment and healthcare infrastructure; Volos benefits from sustainable mobility options and rich sports and cultural amenities; Heraklion's position is supported by low unemployment and a younger population profile; Kavala and Kalamata excel in green space provision but lag in certain infrastructure aspects due to their smaller size.

While the system has proven effective, some limitations remain. Reliance on open-source data may affect accuracy and completeness—particularly for variables such as healthcare accessibility or service quality. Moreover, the DPRD-20 provides relative rather than absolute measures of QoL, underscoring the need for regular updates to maintain relevance and accuracy. These findings should therefore be viewed as comparative benchmarks, not as definitive performance scores.

Although developed for the Greek context, the DPRD-20's methodology is broadly transferable to other European settings. Most indicators can be calculated using Eurostat, ESPON, or national statistical data; however, inconsistent and incomplete datasets—especially for smaller or less prominent cities—pose significant barriers. Addressing these gaps will be essential for scaling the framework across Europe.

Ultimately, the DPRD-20 offers municipalities an evidence-based means of identifying priority domains, benchmarking performance, and learning from cities that excel in specific areas. By supporting targeted investment, encouraging the transfer of best practices, and promoting knowledge exchange, it strengthens local governance and contributes to more equitable, livable, and resilient urban environments.

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**Conflicts of Interest:** The authors declare no conflict of interest.

**Appendix A**

**Table A1.** Descriptive statistics and directionality adjustments for the 20 DPRD-20 indicators used in z-score standardization.

| Index Code | Mean | Standard Deviation | Directionality |
|---|---|---|---|
| EE1 | 15,45 | 1,72 | (-) |
| EE2 | 69,19 | 3,14 | (+) |
| SE1 | 10,67 | 3,51 | (-) |
| SE2 | 144,31 | 29,82 | (-) |
| NE1.1 | 87,57 | 6,68 | (+) |
| NE1.2 | 67,64 | 2,80 | (-) |
| NE1.3 | 7,86 | 2,79 | (+) |

| | | | |
|---|---|---|---|
| NE1.4 | 26,71 | 0,95 | (-) |
| NE2 | 33,50 | 2,55 | (-) |
| GS1 | 43,46 | 23,64 | (+) |
| GS2 | 42,44 | 17,97 | (+) |
| BE1 | 1498,86 | 271,14 | (-) |
| BE2 | 126,29 | 125,98 | (+) |
| SC1 | 4,02 | 1,97 | (+) |
| SC2 | 29,00 | 8,74 | (+) |
| HC1 | 3,56 | 1,74 | (+) |
| HC2 | 69,43 | 91,55 | (-) |
| EF1 | 8,56 | 0,38 | (+) |
| EF2 | 14,14 | 8,17 | (+) |
| SM1 | 82,69 | 46,41 | (+) |
| SM2 | 13,00 | 9,00 | (+) |
| TI1.1 | 87,57 | 9,50 | (+) |
| TI1.2 | 26,43 | 45,16 | (+) |
| T12.1 | 20,00 | 34,64 | (-) |
| TI2.2 | 83,33 | 58,20 | (-) |
| TI2.3 | 24,17 | 37,61 | (-) |
| TI2.4 | 24,29 | 23,88 | (-) |

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