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The Urban Affordance for Longevity: Toward an Integrated Approach for Healthy Ageing in Place in Medium-Sized Cities

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Abstract

Addressing global urbanization and demographic shifts, this study argues that urban affordance—the environment's capacity to promote or constrain healthy activities—is the critical link missing in current ageing in place (AIP) models. The research introduces a new multidisciplinary approach bridging urbanism, statistics, and psychology to evaluate the relationship between urban space and ageing through the lens of environmental affordance. It synthesizes 47 indicators across five macro-areas (demographic, economic, healthcare, social–relational and urban–environmental) into a composite index named the index of Vulnerability for Ageing in place and Longevity (VAL index). It maps over 65 vulnerabilities related to AIP at the neighbourhood level in Bergamo, an Italian medium-sized city. The VAL index reveals critical discrepancies between objective urban determinants and subjective resident conditions (e.g., high walkability contrast with low perceived safety). In conclusion, this index reorients urban planning for ageing, leveraging an AIP approach to advance spatial justice and demographic resilience.

Keywords: ageing in place; composite index; affordance; medium-sized cities; healthy longevity

1. Urban Space and Ageing

This section introduces the research context and provides the theoretical background by exploring the relationship between urban environments and ageing populations. The contemporary global landscape is defined by the convergence of two major demographic shifts: rapid urbanization and an unprecedented ageing of the population [1,2]. By 2050, it is projected that over 20% of the world's population will be over 60 years old, with nearly 70% of all people living in cities. This transformation necessitates a profound rethinking of urban spaces to ensure they remain inclusive and accessible for ageing people and the concept of "ageing in place" has become a cornerstone of sustainable urban development.

Ageing in place (AIP) is defined by the World Health Organization [3] as the ability of individuals to live in their own home and community safely, independently, and comfortably, regardless of age, income, or ability level. This paradigm shifts the focus from institutional care to the urban community, emphasizing that the neighbourhood is

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the primary theatre of life for ageing. However, AIP is not merely a static condition of remaining in a physical dwelling; it is a relational process [4,5]. The urban environment, in fact, can act as either a protective factor—promoting social participation and physical activity—or a source of risk, where barriers like poor walkability, social isolation, and environmental stressors (e.g., heat waves) increase vulnerability [6–8]. In sum, AIP is not the act of "staying at home"; it is a dynamic process where individuals maintain independent mobility and community participation across their lifespan. Accordingly, Rogers et al. [9] categorize the drivers of AIP into three pillars: people, places, and time. However, AIP is inherently ambiguous. More recently, Butti and Morganti [10] defined AIP as a "thin space" between individuals and places. Thus, without adequate individual conditions and urban space characteristics, AIP risks leading to "institutionalization at home," where isolation, economic precariousness, and service depletion transform the home from a sanctuary into a site of vulnerability, particularly concerning domestic usability [11]. On the other side, if healthy longevity should be understood as a pathway where the individuals actively plan their health within a specific context, growing old in adequate urban spaces [12], AIP could be a strong resource for the future. For this reason, AIP requires spatial planning that takes into account the specific characteristics of neighbourhoods and the healthy longevity profiles of residents.

The spatial and functional organization of urban space exerts a significant influence on well-being, operating through several fundamental mechanisms [13], and the concept of mobility and walkability is of particular relevance in this context. Walkability, road connectivity and the safety of pedestrian routes are all of paramount importance in the promotion of active ageing [14,15], the encouragement of socialization and the combatting of social isolation [16,17], as shown by the inverse correlation between good pedestrian mobility and a reduced risk of dementia [17] and cardiovascular disease [18,19]. Moreover, the relationship between green spaces and ecosystem services is a subject that has attracted much attention from researchers in the field. The presence of public parks and green areas has been demonstrated to engender positive effects on cognitive health, with a concomitant reduction in stress levels and a stimulation of neuroplasticity [16]. Furthermore, green spaces have been demonstrated to function as social and environmental "buffers", thereby fostering friendship networks and intergenerational connections [20–22]. Temperatures that are increasing and the "Urban Heat Island effect" also presents a genuine threat to the health of the elderly population, due to an increased vulnerability to conditions such as dehydration, heatstroke, and respiratory or cardiovascular complications. In addition, extreme temperatures—often 10 °C higher in urban cores than in rural surroundings [23]—act as a barrier that traps seniors indoors, accelerating physical and cognitive decline. At last, in studying AIP, the issue of accessibility to services is of particular concern. The capacity of older individuals to reside independently is contingent upon their proximity to health, commercial, cultural and religious services. It is important to note that phenomena such as neighbourhood gentrification in some Italian cities have the potential to disrupt this equilibrium, resulting in the erosion of social cohesion and the economic unsustainability of local services [24,25].

This study is grounded in the hypothesis that AIP possibilities, based on the relationship between urban space and ageing individuals, can be best understood through the psychological lens of "affordance". Originating from James Gibson's ecological psychology [26] and expanded in the context of healthy longevity by Butti and Morganti [10], the concept of affordance moves beyond viewing the environment as a collection of neutral, objective properties. Instead, it emphasizes the fundamental complementarity between the individual and the environment. An affordance represents the possibilities for action that an environment offers to an individual. Crucially, perceiving an affordance is not a passive reception of sensory information; it is an active process of recognizing opportunities for action based on the person's specific bodily capabilities, neural architecture, and current intentions. In this regard, it is essential to distinguish between natural and conventional affordances. Natural affordances are action possibilities that depend on the physical properties of the environment; to illustrate, a public bench does not merely exist as a structural object, but directly affords the action of sitting, provided the individual intends to rest and possesses the physical ability to transition from a standing to a sitting position. On the other hand, conventional affordances are action possibilities rooted in implicit expectations, cultural norms, and cooperative social practices. Because affordances emerge from this continuous interplay, as the characteristics of a place or the capabilities of the ageing person change, the affordances of that environment change accordingly. The concept of affordance extends beyond physical spaces to include human relationships. As Gibson noted [26], people provide the richest affordances for one another, creating a dynamic where "behavior affords behavior." Consequently, social interactions rely on how we perceive others, establishing a continuous system of "mutual affordance".

In the context of longevity, urban space is not a neutral backdrop. Rather, it constitutes a "thin space" where individual capabilities intersect with environmental demands and opportunities. Urban features (e.g., green spaces, wide pavements, proximity to pharmacies) and shared community space actively provide natural and conventional affordances that promote the maintenance of health and autonomy in old age for older adults ageing in place. Conversely, physical and psychological barriers in urban spaces, like poor walkability and social fragmentation, can act as negative affordances and constitute a constraint that increases vulnerability in AIP. Therefore, in the proposed framework, the urban environment is not a passive container but an active participant in the individuals' ageing process. At the same time, by recognizing older adults as "agents of change" [12], urban space planning can foster environments that actively support longevity, treating the ageing process as a shared responsibility rather than a clinical liability.

Observed through the lens of affordance, longevity emerges as a resource for healthy development rather than a demographic burden, requiring a rethinking of how cities adapt to demographic change to achieve spatial justice [27]. Vulnerability in ageing is therefore not a fixed biological trait but a relational outcome between individuals and their environment. It manifests when the "possibilities for action" offered by the neighbourhood are insufficient to meet the individual's needs. For example, an older person with moderate mobility issues is only "vulnerable" if their environment lacks the necessary affordances (e.g., public benches, accessible services, or supportive community interaction) to support their agency. Conversely, healthy longevity is fostered when the urban environment provides a dense network of "positive affordances" that allow individuals to enact their agency regardless of physical limitations. Capturing these complex flows requires a non-compensatory, multidimensional approach that moves beyond simple averages to identify specific spatial–individual unbalances.

A significant proportion of the population over 65 lives in medium-sized cities [28], and the vast majority of these people continue to practice AIP model by living in their own homes even in the later stages of life. Medium-sized urban environments appear as "affordable" for ageing. They can offer an ideal balance between access to services (health, commercial, cultural) and the maintenance of local social networks. Unlike large cities, these environments allow for easier management of socio-spatial relationships, provided that the context does not become a factor favouring social isolation. Studying AIP, medium-sized cities—particularly in the Italian context, where they constitute the territorial "backbone"—offer a distinctive laboratory for longevity studies as their clearly defined urban structures balance service accessibility with community-scale social networks.

Furthermore, their territorial heterogeneity can be taken as a model [29]. Medium-sized cities have an urban structure divided into neighbourhoods that differ greatly in terms of density, landscape, green areas and traffic [30,31]. This internal variety makes them exemplary of different urban dynamics, making the results of observations conducted in these contexts transferable and scalable to both other medium-sized cities and smaller urbanizations [30]. In particular, in medium-sized cities, neighbourhoods emerge as the fundamental spatial unit for understanding how the urban context can act as a resource or barrier to ageing [32,33]. The compact spatial dimensions of medium-sized cities allow for detailed and comprehensive mapping (a biography of the city) to identify the features of different neighbourhoods, which is useful for conducting comparative analyses between neighbourhoods with "different biographies".

The aim of this research is to analyze the characteristics at the neighbourhood level of Bergamo, a medium-sized Italian city, in order to understand how there may be possibilities/constraints in terms of affordance for healthy longevity among residents who live permanently in a specific neighbourhood. This analysis is based on a new measure of AIP vulnerability for longevity, calculated on the basis of anagraphical, socio-economic and health data matched with urban analysis information. This composite index, named the Vulnerability for Ageing in place and Longevity (VAL index), can be used to measure the possibilities offered by the interaction between each neighbourhood and their residents to achieve healthy longevity, potentially avoiding particular vulnerabilities in facing this life journey. The indicators were selected based on local data availability, while the five macro-categories define transferable and scalable dimensions for medium-sized cities. In this way, the VAL index overcomes the limitations of existing AIP models by providing an integrative framework that balances multiple dimensions without imposing a predefined hierarchy. A diagram (diagram 1) to visually demonstrate how the VAL index indicators were selected and combined is available in the Appendix A.

2. Methods

The methodological approach adopted was a theory-driven, multi-step design that linked concepts of ageing in place, urban affordances and multidimensional vulnerability to a composite index operationalized at the neighbourhood scale. Utilizing the aforementioned theoretical framework as a foundation, the study initiated with an urban and territorial analysis of Bergamo's neighbourhoods, aimed at identifying various issues and themes relevant to understanding the spatial characteristics of each neighbourhood. Thereafter, it compiled a set of 47 indicators derived from diverse data sources, encompassing five macro-areas: demographic, economic, healthcare, social–relational, and urban–environmental. The methodological approach is illustrated in Figure 1. These indicators were subsequently normalized, polarity-adjusted and aggregated into the Vulnerability for Ageing in place and Longevity (VAL) index. The VAL index provides a synthetic measure of comparative vulnerability across neighbourhoods and supports ranking, data visualization and policy interpretation.

The analysis involved two sequential steps: (1) data collection and analysis of the urban characteristics of the selected neighbourhoods (population density, mapping of services, green spaces, etc.), as shown in Section 2.1; (2) data collection and construction of the VAL index (see Section 2.2). The research was developed between October 2024 and 2025 by a transdisciplinary team (statisticians, urbanists, and psychologists) within the CASA project (ageing in medium-sized cities: how housing conditions and urban spaces can reduce or increase opportunities for healthy longevity) funded by the Italian PNRR (National Recovery and Resilience Plan) programme "Age-It" (Ageing Well in an Ageing Society) framework. The study focuses on the municipality of Bergamo (a medium-sized

Italian city in Lombardy), specifically analyzing six neighbourhoods selected for their territorial heterogeneity: Borgo Palazzo, Celadina, Centro Pignolo, Città Alta, Colognola, and Valverde-Valtesse. The map in Figure 2 highlights the six neighbourhoods covered by the research within the municipality of Bergamo.

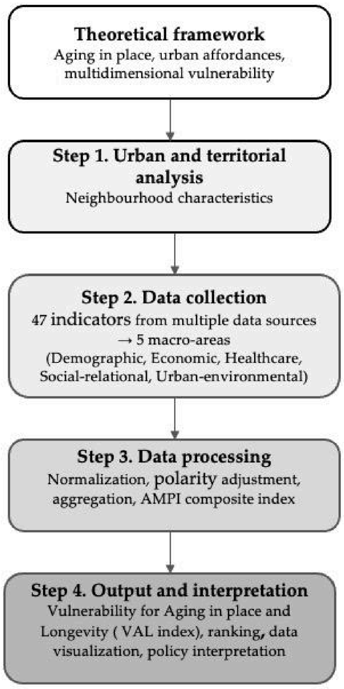

Figure 1. Diagram of the research design and workflow for the construction of the VAL index.

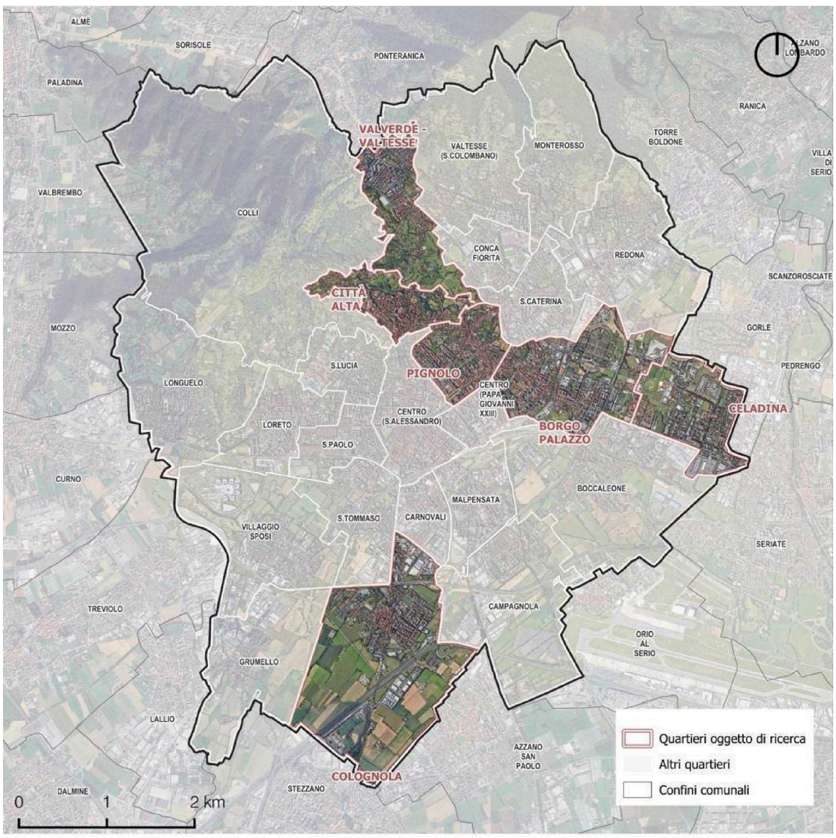

Figure 2. Bergamo neighbourhoods considered for the analysis: Borgo Palazzo, Celadina, Centro Pignolo, Città Alta, Colognola and Valverde-Valtesse.

2.1. The Multifocal Analysis of Urban Space for Longevity

Data collection involved a multi-source strategy combining open data portals, municipal shapefiles (from the Territorial Government Plan—PGT), and formal requests to local institutions like ALER (the Lombard public housing agency) and ATB (local public transport company). Data analysis and processing were supported by experts from various disciplines (e.g., urban planning, geography, demography, geomatics, landscape architecture, and ecology), integrating these results with direct observation of the urban environment, which was necessary to obtain certain data. For each neighbourhood, a "biography" was constructed by mapping building settlement systems, active and passive mobility, and environmental systems. To facilitate comparison, key differences among neighbourhoods are first highlighted, supported by synthetic indicators such as population density. These biographies provided the baseline for calculating part of the elementary indicators described in Section 2.2. In particular, an analysis of urban services, of areas and ecosystem services, and of climatic vulnerability were conducted.

2.1.1. Analysis of Urban Services

The evaluation of urban services focused on two primary metrics: density and accessibility.

Density was calculated as the ratio between the number (or square metres) of a service (commercial, health, socio-cultural, religious, or mobility) and the resident population aged 65 and over.

Accessibility was measured using spatial analysis based on proximity buffers. Following World Health Organization guidelines [34], 300 m buffers (approx. 5 minutes' walk) were applied to essential services like pharmacies, general practitioners, and small food shops and cultural venues; 500 m buffers were utilized for medium and large shopping centres and retail areas. These buffers were intersected with census-level demographic data to determine the percentage of elderly residents with "reasonable" access to essential facilities. Accessibility percentages were calculated by identifying the spatial location of each service, generating buffer zones (300 m and 500 m), and estimating the proportion of the elderly population residing within each buffered area.

2.1.2. Green Areas and Ecosystem Services

Green infrastructure was analyzed by combining quantitative density (m^2 of public green $\times$ old resident) with qualitative assessments of ecosystem services (SE) [35,36].

- Spatial Accessibility: Access to public parks was evaluated using a tiered buffer system: 300 m for neighbourhood parks smaller than 1 hectare and 500 m for larger urban parks [37].
- Quality Assessment: A specific matrix of 38 variables was developed to evaluate three SE categories: regulation (climate and microclimate), support (biodiversity), and cultural/recreational [38,39]. This assessment utilized the RECITAL tool [40], adapted for over 65 residents to include criteria such as seating comfort, safety, and sensory–perceptual quality.

2.1.3. Climatic Vulnerability: Land Surface Temperature and Urban Heat Island

To identify thermal risks, the study estimated Land Surface Temperature (LST) and the Urban Heat Island (UHI) effect [41].

- Data Integration: The methodology combined thermal bands from Landsat 8 and 9 (native 100 m resolution, resampled to 30 m) with multispectral bands at 10 m resolution from the Copernicus Sentinel-2 mission [42,43].
- Downscaling via Random Forest: A machine learning model (Random Forest regression) was implemented to refine the LST spatial resolution from 30 m to 10 m.

The model used eleven predictive features, including spectral indices (e.g., NDVI, NDBI, NDWI) [44], topographic variables (elevation, slope), and urban structural data (building density, Sky View Factor).

- UHI Calculation: The UHI intensity was calculated as the absolute difference between the mean LST of built-up areas and the rural baseline, as well as via a normalized Z-score to identify significant thermal anomalies within the urban fabric. While the NDVI and LST were included among the indicators of the VAL index, the UHI was used as an intermediate analytical step to better interpret spatial temperature variations.

2.2. The Development of VAL Index for Measuring the Multidimensionality of Vulnerability in AIP for Residents over 65

The VAL index features a rigorous, multidimensional approach to assessing vulnerability in ageing in place from an affordance perspective. It employs the Adjusted Mazziotta–Pareto Index (AMPI, ref. [45]), a composite index methodology specifically suited to multidimensional phenomena in which dimensions should not be fully compensatory. In our study, AMPI is used to aggregate sub-indices related to five macro-areas into the final VAL index, while penalizing unbalanced profiles across dimensions. This is particularly relevant in the case of ageing in place vulnerability, where strengths in one area (e.g., excellent healthcare) cannot fully compensate for weaknesses in another (e.g., social isolation). In this context, an unbalanced profile refers to a neighbourhood in which vulnerability is unevenly distributed across macro-areas; from a statistical perspective, this corresponds to greater variability among the macro-area sub-indices, which is explicitly incorporated into the AMPI formulation.

The composite index was developed following established guidelines for composite indicator construction [46,47], by harmonizing data from Bergamo urban environment observation and analysis (see Section 2.1 for details) with additional data from city municipal registries, local health agencies and social services.

In total, data were collected for 47 variables/items/indicators (see Figure 3 and Table A1 in the Appendix A for their complete description), grouped into five macro-areas.

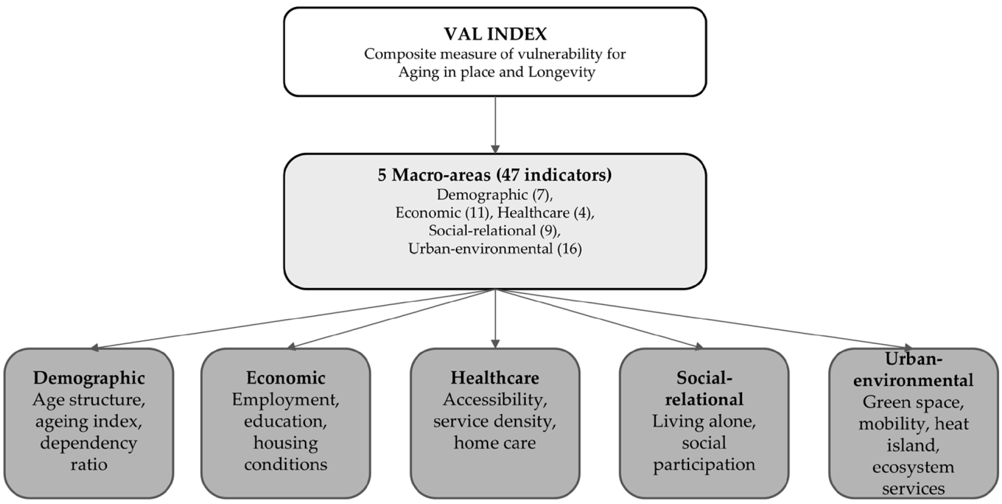

Figure 3. Diagram depicting how the VAL index is defined and the distribution of the 47 indicators across macro-areas. The figure provides a simplified overview of the five dimensions composing the index. The complete list of indicators is reported in Appendix A Table A1.

This approach makes it possible to capture the multidimensional nature of the vulnerability of the ageing population in urban contexts:

- Demographic Area (7 indicators): The variables in this area describe the age structure and composition of the population to understand the degree of ageing in a neighbourhood. It includes indicators such as the proportion of the elderly population (65–74 and over 75), the old-age index (ratio of older to younger people) and the old-age dependency ratio.
- Economic Area (11 indicators): The variables in this area describe material living conditions, social capital and housing quality. It includes indicators such as the percentage of employed people, levels of education, the presence of public housing, the economic conditions of tenants (e.g., ISEE—Equivalent Economic Situation Indicator) and the density of essential commercial services.
- Healthcare (4 indicators): The variables in this area focus on access to healthcare and assistance services, which are essential for the safety of residents. It includes the coverage of home care services, the density of general practitioners and pharmacies, and the physical proximity to these healthcare services.
- Social–Relational Area (9 indicators): The variables in this area evaluate social networks, participation in community life and access to services that reduce isolation. It considers factors such as the proportion of older people living alone, the presence of intergenerational households and participation in social, cultural, religious or educational activities.
- Urban–Environmental Area (16 indicators): The variables in this area examine the physical characteristics of the territory that influence mobility and well-being. As detailed in Section 2.1, the indicators concern the availability of public green spaces, the presence of dedicated pedestrian and cycle paths, the provision of public transport and critical factors such as the average surface temperature to identify Urban Heat Islands.

The selection of indicators was guided by the study's theoretical framework on AIP and urban affordances, and informed by the existing literature on multidimensional vulnerability in urban contexts, age-friendly urban environments and neighbourhood-scale assessment tools, e.g., [48–50]. In addition, the final set of indicators reflects data availability at the neighbourhood level and the integration of different disciplinary perspectives (urban planning, demography, and public health) within the research team. In line with this framework, the VAL index adopts a formative approach [51], whereby vulnerability is defined as the result of its constituent indicators; this assumption guides the normalization and aggregation choices implemented in the analysis.

Once the dataset (6 rows and 47 columns) had been assembled, we normalized the indicators to account for differences in measurement units and variability. We applied min–max normalization, rescaling each indicator to the unit interval [0, 1], where 0 corresponds to the minimum observed value and 1 to the maximum, as commonly recommended in composite indicator construction [47]. This transformation preserves the rank order of territorial units for each indicator, retains proportional differences among values, and enables the meaningful combination of variables originally measured on different scales. In addition to normalization, we adjusted the polarity of the indicators. Because the composite index is defined so that higher values indicate greater vulnerability, indicators representing favourable conditions (e.g., ecosystem services or community service density) were reverse-coded by taking the complement of their normalized values (i.e., $1 - x$) [47]. As a result, all indicators have positive polarity and contribute consistently to higher overall vulnerability.

Subsequently, the 47 indicators were aggregated within each macro-area using the arithmetic mean [47], an additive synthesis function that permits a degree of compensability among indicators within the same macro-area. This choice reflects the assumption that indicators within the same macro-area capture related aspects of vulnerability and can partially compensate for each other. As a result of the aggregation, we obtain five sub-indices, one for each macro-area, expressed on the interval (0, 1). Following the AMPI methodology [45], these values were transformed into the AMPI scale given by the (70, 130) interval, which facilitates a more immediate interpretation of the absolute intensity of vulnerability and ensures metric continuity with other composite indices constructed using the same approach. For a given neighbourhood, a value of 70 indicates the minimum relative vulnerability in that macro-area, whereas a value of 130 denotes the maximum vulnerability for that dimension relative to the other neighbourhoods. A value of 100 represents the reference (benchmark) level, i.e., an intermediate condition with respect to the set of neighbourhoods considered; values below (above) 100 indicate lower (higher) vulnerability than the benchmark.

Finally, for each neighbourhood, the five macro-area sub-indices are aggregated into a single measure, the VAL index. Aggregation is performed using a weighted average in which each macro-area sub-index receives equal weight, so that all dimensions contribute equally to the overall score. In the present study, equal weighting is adopted as the baseline specification, in order to avoid introducing arbitrary assumptions about the relative importance of dimensions in the absence of a strong empirical or theoretical basis for differential weighting. Alternative weighting schemes can nevertheless be explored to assign greater importance to specific dimensions. In accordance with the AMPI methodology [46], the VAL index for generic *i*-th neighbourhood it is computed as follows:

$$VAL_i = M_i + S_i \cdot CV_i \tag{1}$$

where M_i is the mean of the five sub-indices, S_i is their standard deviation, and $CV_i = S_i/M_i$ is the coefficient of variation. This formulation introduces a non-compensatory logic across macro-areas through the $S_i \cdot CV_i$ term, which increases the index value when variability among macro-area sub-indices is higher. As a result, neighbourhoods with more uneven vulnerability profiles across dimensions receive higher scores, whereas more homogeneous configurations are rewarded. The final VAL index is expressed on the AMPI scale (with values between 70 and 130), with a benchmark value of 100. Higher values indicate greater vulnerability, as they capture both the average level across dimensions and the degree of internal imbalance introduced by the penalty term.

3. Results

The results are presented in Section 3.1, which analyses the urban characteristics of each neighbourhood, with particular attention given to affordances for ageing in place for people over 65. Section 3.2 reports the results of the VAL index calculation for each of the six neighbourhoods. Given the limited number of territorial units, the analysis is descriptive and comparative in nature and is not intended for inferential purposes.

3.1. Multifocal Analysis of Urban Space for Longevity

Table 1 summarizes the main demographic and land use characteristics of the six neighbourhoods and the municipality of Bergamo, providing the basis for the descriptive comparisons discussed in this section. The percentages and indicators reported in the text are derived from the values presented in Table 1, calculated as proportions of total surface areas or population groups. Overall, the neighbourhoods show significant variability in terms of ageing rates, population density, and the availability of green spaces, with Città Alta and Colognola presenting the highest shares of older residents, and Valverde-Valtesse and Città Alta standing out for the highest green space availability per elderly inhabitant.

Table 1. Comparative overview of the six study neighbourhoods and the city of Bergamo.

	Neighbourhood Area (sq m)	Residents	Population Density (Inhabitants/sq km)	Residents Aged 65–74	Residents Aged 75 And Over	Total Aged 65 and Over Population	Residential Use—Housing (sq m)	Public Housing (sq m)	Administrative and Services (sq m)	Military (sq m)	Commercial (sq m)	Religious Services (sq m)	Recreational (Culture, Sports) (sq m)	Industrial and Productive (sq m)	Other (sq m)
BERGAMO	40,304,393	121,987	3026.64	13,862	17,093	30,955	2,884,697	76,418.63	467,593	58,064.96	197,187	100,810.7	64,970.28	827,293.7	1134.079
BORGO PALAZZO	1,783,710	9953	5579.94	992	1192	2184	225,181.4	1525.844	27,833.89	3332.835	8556.227	7837.816	2390.476	70,826.09	2.735
CELADINA	1,130,447	5230	4626.49	593	662	1255	63,912.68	7379.802	42,158.91	10,904.58	19,601.83	1254.983	5757.93	8436.278	92.716
CENTRO PIGNOLO	791,731.2	4877	6159.92	556	637	1193	194,495	0	25,959.27	8113.906	3102.468	9932.522	5549.541	2468.355	32.492
CITTÀ ALTA	739,108	2647	3581.34	346	356	702	116,554.8	485.121	19,586.47	0	1424.505	20,886.28	7214.543	345.003	410.64
COLOGNOLA	3,208,418	5547	**1728.89**	597	861	1458	121,640.8	4174.995	24,050.99	0	15,409.1	2731.759	0	92,657.72	412.389
VALVERDE	1,155,546	3835	3318.78	465	529	994	94,996.12	3512.403	5290.355	0	303.458	3109.748	207.016	2066.313	0

Bold represent significant values.

3.1.1. Borgo Palazzo

From a demographic point of view, Borgo Palazzo has 9953 inhabitants, covering an area of approximately 1.78 km^2 with a high population density of 5580 inhabitants per km^2, which is higher than the municipal average (3026.64 inhabitants per km^2), as reported in Table 1. The neighbourhood has a significant ageing population (approximately 22%), with 2184 residents over the age of 65 (see Table 1).

In terms of land use, the neighbourhood has a coverage index of 19.5%, while urban green spaces and "other" areas (roads, squares, car parks, etc.) are distributed almost equally at around 40% each. These percentages are calculated based on the distribution of surface areas reported in Table 1.

The predominant use is residential, accounting for approximately 65% of the built-up area, while the share of public housing is very low (0.44%), indicating a limited presence of social housing.

Approximately one-fifth of the built-up area (20.4%) is used for industrial and manufacturing activities, reflecting the strong economic and employment component of the neighbourhood. Administrative and service functions account for 8%, while commercial, recreational and religious functions account for smaller percentages. The presence of military buildings is marginal (0.96%).

The distribution of services (defined as the surface area occupied by services in square metres) shows a strong presence of technological facilities and services of general interest (29.4%) due to the presence of the municipal cemetery, and mobility services (19.4%), followed by education (16%). Religious services (8.7%) and those related to green spaces (8.5%) are well-represented, while cultural and sports services account for only 5.6%. Social services are very limited (0.9%), and administrative and public order services cover 4.3% of the total area covered by services. Healthcare services mainly refer to the presence of the hospital, located between the Borgo Palazzo and Celadina districts.

The most significant figure is the density of public green space, equal to 66.34 m^2 per elderly inhabitant, which is a very high and positive value for well-being and liveability. Cycle paths and footpaths are also well-distributed (1.53 m/inhabitant), promoting soft mobility.

In terms of pedestrian accessibility for elderly people to services, the percentages are medium–high:

- Over 95% of the elderly population lives within 300 m of commercial services.
- Medium and large retail outlets are accessible to 99% of elderly people within 500 m.
- Health services are within 300 m for 88% of elderly residents.
- Cultural and religious services are accessible to 85% and 73% of elderly people, respectively.
- Small urban parks (<1 ha) are accessible to 98.7% of elderly residents, while large parks (>1 ha) are accessible to only 65.9%.

3.1.2. Celadina

From a demographic point of view, Celadina has a total population of 5230 inhabitants, with a population density of around 4626.49 inhabitants per square kilometre. Elderly people represent 24% of the total population, a significant proportion.

In terms of land use, the neighbourhood has a good supply of green areas (45.72% of the surface area), while the area covered by buildings stands at 14.11%. The remaining 40.17% is classified as "other surface area", which could include public spaces, infrastructure or undeveloped areas.

The predominant function is residential (40.07%), with public housing accounting for 4.63%. Administrative and service functions account for a significant part of the built-up area (26.43%), followed by commercial (12.29%) and military (6.84%) functions. Recreational (3.61%) and religious (0.79%) functions are marginal.

In terms of public infrastructure, Celadina is home to important urban facilities, including the city prison, the fruit and vegetable market and the fairground. The neighbourhood preserves historical traces such as the remains of the Villa dei Tasso and the evocative "Portone del Diavolo" (Devil's Gate), an ancient triumphal arch.

The composition of services (in terms of surface area occupied by services in square metres) shows good variety: cultural and sports services are the most represented (16.08%), followed by health services (12.62%), administrative services (13.38%), plant engineering services (13.07%) and green spaces (13.80%). Housing and religious services are less prevalent, at 6.56% and 2.60%, respectively. All values and percentages are derived from the data reported in Table 1.

In terms of density, a significant figure is that of public green space, equal to 50.31 m^2 per elderly inhabitant, which is a high and positive value for well-being and likeability. Cycle paths and footpaths are well-distributed (3.89 m/inhabitant), promoting soft mobility. This relatively high value suggests a good potential for walkability and active mobility among older residents, although its effectiveness also depends on the quality and continuity of the infrastructure.

In terms of pedestrian accessibility to services, there are divergent percentages:

- Approximately 46% of the elderly population lives within 300 m of commercial services.
- Medium and large retail outlets are accessible to 67% of elderly residents within 500 m.
- Health services are within 300 m for 47% of elderly residents.
- Cultural and religious services are accessible to 63% and 59% of elderly people, respectively.
- Small urban parks (<1 ha) are accessible to 92.3% of elderly residents, while large parks (>1 ha) are accessible to only 66%.

3.1.3. Centro Pignolo

The neighbourhood has 4877 inhabitants, covering an area of approximately 0.79 km^2, and has one of the highest population densities in the city, at around 6173.42 inhabitants per km^2. This high density may facilitate proximity to services but can also imply higher urban pressure and limited availability of open spaces. The elderly population amounts to 1193 residents, 53% of whom are aged 75 or over.

In terms of land use, the neighbourhood has a good balance between built-up and natural areas. Although 31.53% of the area is covered by buildings, the percentage of green space is higher, at 39.19% (see Table 1).

The main use is residential (77.9%), while administrative and service functions cover 10.4% of the built-up areas, and religious services cover around 4%. Commercial and industrial/manufacturing functions are more limited.

The distribution of services (out of the total number of services in the neighbourhood) reveals that almost half are dedicated to green areas (27.23%) and administration/public order (17.22%). Services closely linked to well-being and quality of life, such as health (0.45%) and social services (0.38%), represent a marginal percentage.

Accessibility to services for the elderly population is generally excellent for immediate needs, with 98.8% of elderly people having access to commercial services within 300 m and 99.7% to places of worship. However, there are gaps in healthcare facilities and large green areas:

- Only 48.1% of the elderly population can reach healthcare services within 300 m.
- Accessibility to large urban parks (over 1 ha) within 500 m is limited to 56.9% of elderly residents.

3.1.4. Città Alta

From a demographic point of view, Città Alta has a resident population of 2647 inhabitants, covering an area of approximately 0.74 km^2, with a population density of 3577.03 inhabitants per km^2, slightly higher than the municipal average (3026.64 inhabitants per km^2).

A significant demographic aspect is the age composition. The elderly population over 65 years of age numbers 702 individuals, of whom 346 are in the 65–74 age group and 356 are 75 years of age and over, representing approximately 26.5% of the total residents of the neighbourhood and ranking first among the neighbourhoods analyzed in terms of the percentage of elderly people.

In terms of land use, most of the area is designated as green space, covering approximately 57% of the total area, far exceeding the built-up area, which covers only 22.58% of the territory. The remaining 20.25% is classified as "other" areas. All data are derived from the data presented in Table 1.

In terms of the intended use of the buildings, residential use is clearly predominant, accounting for 69.83% of the total built area. The other most significant uses are places of worship (12.51%) and administrative/service facilities (11.73%).

An analysis of the distribution of services across the neighbourhood shows a strong concentration in two macro-areas: religious services (29.55%) and green areas (32.25%). Education (15.15%) and culture/sport (12.24%) are also significant. Services closely linked to direct assistance, such as healthcare (0.34%) and social services (1.08%), are the least represented in percentage terms.

The main access route from the lower town is provided by the historic funicular railway, which has been in operation since the late 19th century, and by footpaths; the elevated urban layout and the routes can pose a challenge in terms of mobility, particularly for the elderly population.

- Accessibility to services for the elderly population, measured by distance buffer, is generally high.
- Almost the entire elderly population has access to religious services within 300 m (99.6%).
- Cultural services (91.5%) and urban parks smaller than 1 hectare (92.9%) are also very accessible to the elderly, within 300 m.
- Access to general commercial services within 300 m is guaranteed to 79.5% of the elderly population.
- Accessibility to healthcare services within 300 m is also good, reaching 72.1% of elderly residents.

The data on the density of public green areas are significant: with 103.67 m^2 per elderly inhabitant, it is the neighbourhood with the highest figure, second only to the Valverde-Valtesse neighbourhood (107.93 m^2/inhabitant).

3.1.5. Colognola

From a demographic point of view, Colognola has a population of 5547 inhabitants, covering an area of approximately 3.21 km^2, with a population density of 1728.04 inhabitants per km^2, which is lower than the municipal average (3026.64 inhabitants per km^2) and the lowest of all the neighbourhoods considered in the study. The neighbourhood has a significant proportion of elderly people (26.3%), with a total of 1458 residents over the age of 65.

In terms of land use, over two-thirds of the territory (70.3%) consists of green (and agricultural) areas, while only a small percentage (8.14%) of the surface area is covered by buildings; "other" areas (roads, squares, car parks, etc.) cover approximately 21%.

With regard to the intended use of the buildings, the analysis reveals a mixed vocation: residential functions dominate, with housing (including public housing) accounting for almost half of the built-up area, or 46.6%. At the same time, there is a significant industrial/manufacturing presence, covering 35.5% of the total built area, suggesting that the neighbourhood is not only a residential area but also plays an economic or manufacturing role. Other functions such as administrative offices and services have a moderate presence in the neighbourhood (9.2% of the functions present).

As regards the distribution of services in the neighbourhood (in terms of the area occupied by services in square metres), the focus is clearly on the environment and education: green spaces not only dominate land use, but are also the most represented service, covering 27% of the total. Education follows with a significant share of 22.8% of total services; mobility (13.3%) and religious services (16.4%) also play an important role in the composition of the service offering.

This availability is also reflected in the density parameters calculated in relation to the elderly population: the neighbourhood offers 72 m^2 of public green space for every elderly inhabitant.

In terms of pedestrian accessibility for older people to services, the percentages are medium to high:

- Approximately 65.9% of the older population lives within 300 m of commercial services.
- Medium and large retail outlets are accessible to 52% of older people within 500 m.
- Health services are within 300 m for 66% of elderly residents.
- Cultural and religious services are accessible to 59% and 89% of elderly people, respectively.
- Small urban parks (<1 ha) are accessible to 99.8% of elderly residents, while large parks (>1 ha) are accessible to only 54.2%.

3.1.6. Valverde-Valtesse

The Valverde-Valtesse complex has a total population of 3835 inhabitants, covering an area of approximately 1.16 km^2 with a population density of 3306.03 inhabitants per km^2, slightly higher than the municipal average (3026.64 inhabitants per km^2). In this neighbourhood, the elderly population accounts for a significant percentage, equal to 25.9% of the total residents of the neighbourhood, with a total of 994 elderly people (465 in the 65 to 74 age group and 529 in the 75 and over age group).

In terms of land use, the neighbourhood is dominated by green areas (76.3%), while the area covered by buildings is limited to 9% of the total area.

Analysis of the intended use of buildings reveals a clear and almost exclusive focus on residential use (86.7% of the total built area), with a small proportion of public housing (ERP). Other functions are residual: administrative/services account for 4.8%, while all other functions each account for less than 3% of the total built area.

The distribution of services (defined as the area occupied by services in square metres) shows a clear prevalence of public green spaces (34.4%); the share of religious services is also significant, representing 26.5%. Other relevant services include housing (17.8%) and education (10.5%). The density of public green areas, with 107.9 m^2 per elderly inhabitant, is a distinctive and valuable feature of the neighbourhood.

In terms of pedestrian accessibility for older people to services, the results vary:

Religious services are the most accessible, with 88.9% of the older population able to reach them within a distance of 300 m.
A total of 84.4% of elderly residents can reach commercial services within 300 m, but coverage for supermarkets (medium- and large-sized shopping centres and retail areas) is almost half that, with 47% of elderly people reaching the service within a distance of 500 m.
Health services are reached within 300 m by 52.3% of the elderly population.
Urban parks smaller than 1 hectare are accessible to 70% of elderly residents within 300 m.
Larger green areas (>1 ha) are accessible to 55% of elderly people within 500 m.

Cultural services have the lowest pedestrian coverage, reaching only 30% of the population within 300 m.

The comparative reading of these results highlights marked differences among neighbourhoods in terms of ageing population, service distribution, and accessibility patterns. Table 1 provides a summary overview of the six analyzed neighbourhoods in relation to the city of Bergamo as a whole.

In terms of density, the average calculated on the total provision of services (normalized values) gives the following situation:

- Città Alta (average 0.46): stands out clearly for its social and cultural services (cinemas, theatres, community centres) and a good provision of public green spaces. This neighbourhood offers opportunities for socialization and open spaces, key factors for the well-being of older people. However, it lacks health services.
- Borgo Palazzo (average 0.45): shows a balanced profile, with a reasonable provision of commercial and public health services. It is a functional neighbourhood for everyday life, although it has critical issues in terms of green spaces and soft mobility (cycle and pedestrian paths).
- Celadina (average 0.42): characterized by the presence of public and private healthcare services, which are strategic for the care of the elderly population. However, it is weak in terms of green spaces and cultural services.
- Centro Pignolo (average 0.42): has a good provision of private and commercial healthcare services, but poor provision of green spaces and sustainable mobility. It is a neighbourhood that guarantees quick access to essential services.
- Colognola (average 0.29): almost all service categories have values close to the minimum, with some positive points for private healthcare services. Although it ranks second to last, the average score for green spaces is still higher than that of the neighbourhoods of Borgo Palazzo, Celadina and Centro (Pignolo).
- Valverde (average 0.20): despite having the highest score in terms of green spaces and cycle paths, the remaining services are close to the minimum score for the category, highlighting in particular a lack of local services.

The distribution of services therefore appears uneven, with neighbourhoods rich in green spaces, places of culture and socialization, and neighbourhoods more "specialized" in public and private healthcare services, with slow mobility infrastructure not always widespread.

Moreover, each of the six neighbourhoods is also analyzed in terms of ecosystem services. According to the definition of the Millennium Ecosystem Assessment [52], ES refers to the set of material and immaterial benefits that human society derives, directly and indirectly, from the ecosystems present on the planet. Four categories of services are identified: life support (e.g., as a source of genetic biodiversity), provisioning (food and raw materials), regulating (climate, terrestrial phenomena and risk mitigation) and cultural/recreational (intangible, esthetic and symbolic values). This well-established paradigm emphasizes the value of Natural Capital, which goes beyond the classic definition of landscape as a backdrop to human activities, with a predominantly perceptive/symbolic and cultural value [52]. Synthetic results are depicted in Table 2.

Table 2. Average values of ecosystem services provided by parks in each of the neighbourhoods analyzed.

	Regulating		Supporting	Cultural–Recreational		
Neighbourhood	**Thermal Comfort**	**Environmental Quality**	**Biodiversity**	**User Comfort**	**Psychophysical Well-Being**	**Total**
Valverde-Valtesse	5.29	6.43	9.71	36.86	20.86	79.14
Centro Pignolo	3.22	3.56	8.11	37.33	20.56	72.78
Città Alta	4.54	5.23	4.77	33	20.92	68.46
Colognola	1.25	5.13	7.13	37.63	13.63	64.75
Borgo Palazzo	2.25	2.88	5.63	38.63	13.75	63.13
Celadina	1.67	4.78	6.33	35.67	14	62.44

3.2. VAL Index for the AIP Vulnerability

All the 47 normalized indicators grouped by the 5 macro-areas are displayed in Figure 4. We can see that, for example, the older adults dependency index (V1.1) takes a value of 0 for the neighbourhood of Borgo Palazzo and a value of 1 for Colognola. This means that Borgo Palazzo has the lowest relative incidence of older population compared to other age groups in the entire set of neighbourhoods considered. Conversely, Colognola has the highest dependency index value compared to all the other neighbourhoods considered in the analysis. As for the green space index (V5.16), on the other hand, it originally has a negative polarity, as higher values are associated with a reduction in vulnerability. After the reversal of polarity, the normalized value is 0 for the Valverde-Valtesse neighbourhood, which has the largest relative amount of green areas and therefore does not contribute to increased vulnerability. On the other hand, the neighbourhoods of Pignolo and Borgo Palazzo have a normalized value of 1, as they have the lowest relative availability of green space among all the territorial units considered, thus representing the least favourable condition within the distribution.

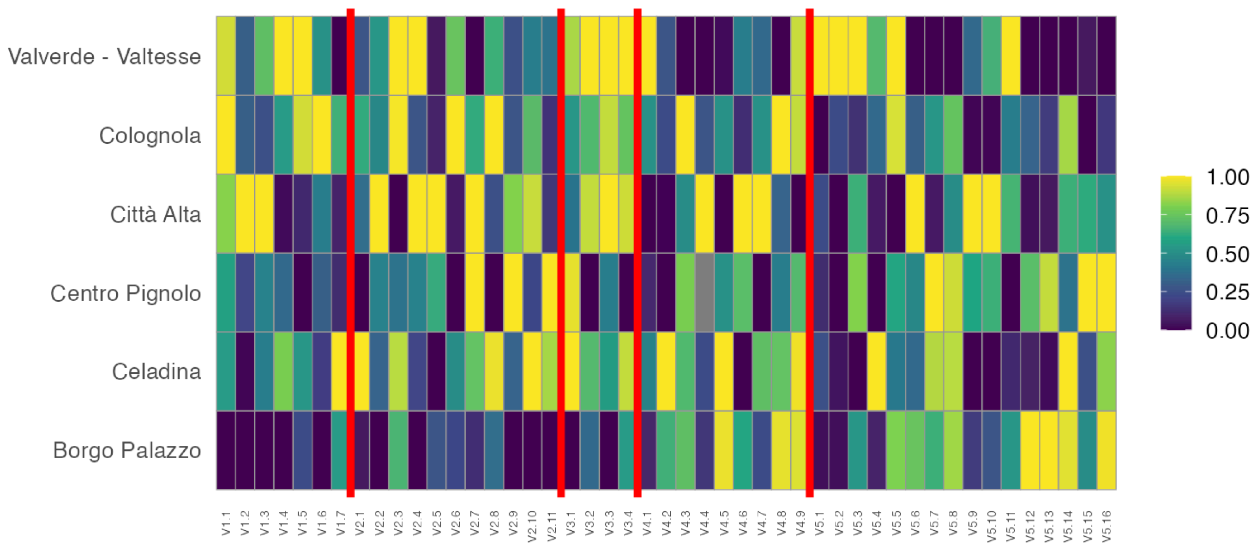

Figure 4. Heatmap of the normalized indicators by neighbourhood. Rows represent neighbourhoods and columns represent indicators coded as Vm.k, where m denotes the macro-area (1 = demographic, 2 = economic, 3 = healthcare, 4 = social–relational and 5 = urban–environmental) and k the indicator within that macro-area. Colours show min–max normalized values in (0, 1); red vertical lines separate macro-areas.

For each neighbourhood, all the indicators within the same macro-area are aggregated using the mean, as described in Section 2.2. This allows us to obtain a vector of 5 values for each neighbourhood, each associated with each macro-area. These values are depicted in Figure 5.

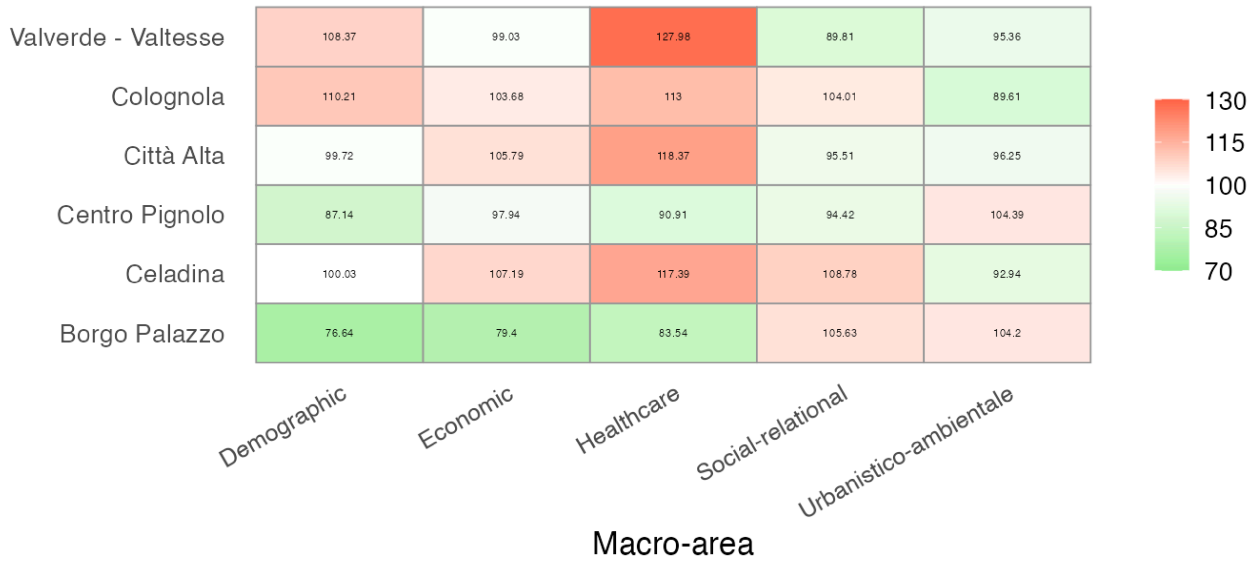

Figure 5. Heatmap of the aggregated macro-area indicators. Each column represents the value of the aggregate indicator at the macro-area level; each row represents a neighbourhood.

When reporting the data for Figure 3, a scale change is made from the (0, 1) interval to the (70, 130) interval. The use of this scale promotes comparability and maintains consistency with the formulation of the final index. This choice is justified by the Mazziotta–Pareto methodology [45,53]: a symmetrical interval around a central value of 100 is conventionally used, interpreted as a theoretical reference for each dimension analyzed. This is not an empirical threshold, but a value against which it is possible to assess the relative positioning of neighbourhoods. Therefore, values above 100 indicate that the macro-area makes a positive contribution to the overall vulnerability of the neighbourhood. For example, the health sub-index of Valverde-Valtesse (127.98) indicates a relatively more critical condition than the other dimensions. Conversely, values below 100 indicate that the macro-area contributes to reducing the overall level of vulnerability: this is the case of the demographic area of Borgo Palazzo (76.64), which represents a favourable component compared to the other dimensions for the same neighbourhood. The heatmap can also be read by row. In the case of Borgo Palazzo, the sub-indices for the demographic, healthcare and economic macro-areas are below the reference threshold, contributing to a reduction in the final index, while the urban–environmental and social–relational dimensions have values above 100 and determine a relative increase in the vulnerability of the neighbourhood. Finally, for each neighbourhood, the five values relating to the five macro-areas are aggregated using the AMPI method formula presented in Section 2.2 (with equal weights, see Section 2.2). The result represents the VAL index value for each neighbourhood. It should be noted that, with the same average, neighbourhoods with a greater imbalance between the five macro-areas will have greater variability, which will push up the value of the final housing vulnerability index. In other words, neighbourhoods with a greater balance of macro-area sub-index values are rewarded. The VAL index values for the six Bergamo neighbourhoods examined are shown in Figure 6.

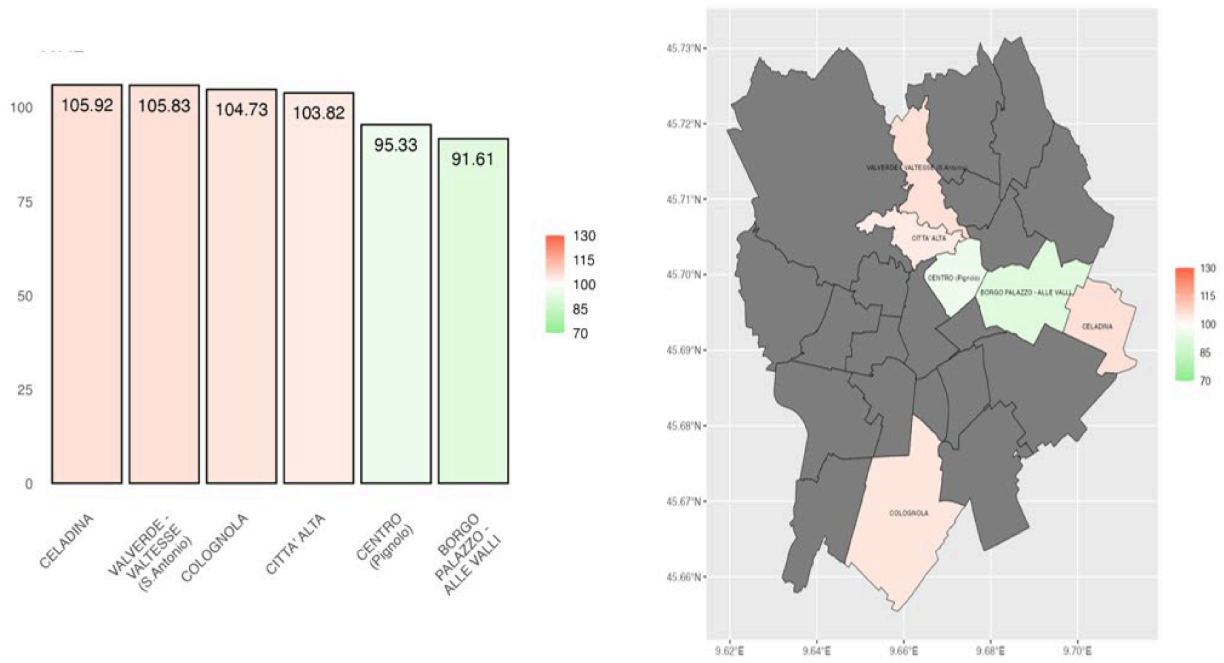

Figure 6. Bar chart and map showing the VAL index values for each of the 6 neighbourhoods analyzed in Bergamo city.

The average VAL index for the six neighbourhoods is 101.21, which is close to but above the theoretical threshold chosen. This indicates a general trend towards moderate levels of vulnerability, with significant differences between neighbourhoods. Celadina, Valverde-Valtesse and Colognola have higher levels of vulnerability, at 105.92, 105.83 and 104.73, respectively, and, confirming this, their sub-indices are predominantly distributed above the threshold of 100, with some marked deviations. In particular, the health dimension of Valverde-Valtesse reaches values significantly higher than the benchmark, while Colognola shows a uniformly high profile in several dimensions, and Celadina shows a clear criticality in the social–relational component. In these cases, not only is the average of the sub-indices high, but there is also a marked dispersion between the dimensions, which contributes to amplifying the final value of the index through the penalty mechanism provided for by the AMPI methodology. Città Alta ranks in an intermediate position: its VAL index exceeds the threshold value (103.82), but with a more moderate deviation than the three most vulnerable neighbourhoods. Confirming this, the sub-indices show a less extreme distribution: some dimensions have values above 100, while others remain close to the reference threshold.

The vulnerability is therefore attributable more to the presence of critical issues in certain macro-areas than to an overall unfavourable profile. A different picture emerges in the neighbourhoods of Pignolo (95.33) and Borgo Palazzo (91.61), which have VAL index values below both the reference threshold and the sample average. The analysis of the macro-area sub-indices shows a configuration opposite to that of the most vulnerable neighbourhoods. In the case of Pignolo, the sub-indices are distributed relatively evenly, with only the urban–environmental macro-area having a value above 100 (104.39). For Borgo Palazzo, the lower overall value of the index is explained by the presence of three macro-areas, health (83.64), economic (79.40) and demographic (76.64), which are well below the benchmark and offset the two sub-indices above 100 (105.63 for the social–relational area and 104.20 for the urban–environmental area). Consequently, the final value of the index is lower and the effect of the penalty is mitigated. In summary, this is a profile characterized by a greater balance between the dimensions analyzed, which results in a lower average level of vulnerability compared to other neighbourhoods.

Overall, the VAL index ranking is broadly consistent with the neighbourhood profiles described in Section 3.1. Higher vulnerability scores are observed in neighbourhoods such as Celadina, Valverde-Valtesse and Colognola, where more pronounced deficits or imbalances across key dimensions were identified, particularly in terms of healthcare accessibility and service provision. Conversely, lower VAL values in Borgo Palazzo and Centro Pignolo reflect more balanced configurations across macro-areas, despite the presence of specific weaknesses in some domains. Città Alta occupies an intermediate position, coherently with its mixed profile of strengths and criticalities.

Within the CASA project, we also developed a dashboard (see www.valindex.it) that computes the VAL index and graphically displays its values for the six Bergamo neighbourhoods considered, using bar charts, a heatmap, and a map. As mentioned in Section 2.2, by default, the composite index is computed as a weighted average with equal weights assigned to the macro-areas. Users can interact with the dashboard by selecting alternative weighting schemes that give greater importance to specific dimensions and observing how the VAL index values change.

4. Discussion

The analysis of six neighbourhoods in Bergamo (Borgo Palazzo, Celadina, Centro Pignolo, Città Alta, Colognola and Valverde-Valtesse) reveals significant differences in terms of spatial and functional organization, living vulnerability, accessibility to services and the availability of ecosystem services. This confirms that ageing in place is strongly conditioned by the combined configuration of socio-demographic, spatial, infrastructural, and environmental factors at the neighbourhood scale, as shown in person–environment fit and "lifetime neighbourhood" studies [54–58].

The main discrepancies can be summarized using the Vulnerability for Ageing in place and Longevity—VAL index, which measures the vulnerability of people over 65 on a scale from 70 to 130. In line with recent work on age-friendly or chrono-urbanism indices, the VAL index translates a multidimensional construct into an operational tool, while necessarily reflecting specific choices in indicator selection and weighting [59,60]. As the index is based on six neighbourhoods only, selected for their significance and their ability to reflect ideal–typical conditions, it is intended primarily as a place-based comparative tool within the Bergamo case study, similar to other exploratory neighbourhood-level indices that are used mainly for within-city monitoring rather than for large-scale generalization [58–60].

Specifically, Borgo Palazzo is a mixed-use neighbourhood, with strong residential and industrial functions, ample green space, and pedestrian access to basic services. This combination of land use mix, high density and compactness of construction, walkable infrastructure and proximity to amenities has been associated in previous research with better perceived fit and higher levels of outdoor mobility among older adults [55,61]. However, critical issues arise in social services, especially related to the significant presence of an older adult population, suggesting that physical accessibility does not automatically translate into adequate formal or informal care infrastructures, a warning also raised in studies of socio-economically heterogeneous neighbourhoods [56]. Overall, the Celadina neighbourhood has good environmental conditions thanks to its abundance of green spaces and a fair amount of functional variety, with a strong residential and administrative component. However, the distribution and accessibility of services for seniors show some gaps, especially in the healthcare, social, and cultural sectors. This mismatch between acceptable environmental conditions and limited age-specific services resonates with evidence that neighbourhoods can simultaneously offer supportive and constraining features for ageing in place, producing ambivalent person–environment relations [57,62]. The central location of the Centro Pignolo neighbourhood ensures excellent connections to the rest of the city, via pedestrian and bicycle paths, and public transportation. Social life is vibrant, supported by the presence of cinemas, theatres, museums, Centres for All Ages (CTE), and active neighbourhood networks, elements that strengthen the sense of belonging and community. This configuration mirrors “socially rich” central neighbourhoods described in the literature, where dense cultural infrastructures and strong networks support social health but may also be associated with density-related pressures and rising costs [63,64]. The Città Alta neighbourhood is a highly residential area with large green spaces and good pedestrian access to essential services, but it has a potential structural deficiency in terms of dedicated health and social services, especially given the significant ageing population. Similarly, studies on historic urban cores show that high amenity and landscape values can mask important gaps in health and care provision for older residents [65]. Centro Pignolo and Città Alta show very high levels of accessibility in almost all categories. Celadina is the neighbourhood with the greatest challenges, especially for commercial and health services. Valverde shows significant cultural deficiencies but good religious accessibility and its proximity to a wide variety of green spaces. Colognola has a more balanced but not excellent coverage, with the exception of accessibility to urban parks and religious services. Together, these differentiated configurations support the view that ageing in place unfolds within a patchwork of local “service ecologies”, in which specific combinations of strengths and deficits shape older adults’ everyday opportunities [56,62,63].

With regard to Urban Greenery and ecosystem services (ES), environmental differences are marked and not always related to the availability of other services. Such decoupling between ecological quality and social or health service provision has also been observed in other cities, where highly green neighbourhoods do not necessarily provide adequate care infrastructures for older residents. Città Alta has the highest density of public green space (103.67 m^2 per elderly resident), with outstanding features such as the Botanical Gardens. Valverde-Valtesse generates the highest level of ecosystem services (score 79.14), thanks mainly to the Greenway of the stream Morla, which offers significant ecological, psychological, physical and microclimatic benefits. This pattern is consistent with studies showing that high-quality green corridors and parks can enhance subjective well-being, physical activity and thermal comfort among older people, even in contexts of broader urban vulnerability [66,67]. Even Centro Pignolo, despite being densely urbanized, boasts a network of high-quality public parks and many private green spaces, which gives it a higher ecosystem services score than more peripheral neighbourhoods such as Celadina or Colognola. Similarly, research on dense urban fabrics indicates that well-designed and accessible green spaces can compensate for limited private outdoor areas and support social interaction in later life [68]. At last, Borgo Palazzo and Celadina present an ambivalent situation, with parks of great value coexisting with built-up areas of poorer quality or in a state of disrepair. Comparable ambivalences in green space provision and maintenance have been identified as a source of inequality in the health benefits derived from urban nature by older populations [66,69,70].

In summary, the neighbourhoods with the highest vulnerability are Celadina (105.92), Valverde-Valtesse (105.83) and Colognola (104.73), which have the highest VAL index value. This is due not only to high average scores in the various macro-areas, but also to a strong imbalance (horizontal inconsistency) between the dimensions analyzed. Our findings therefore support the argument that uneven distributions of environmental, social and service-related resources within the same city generate complex vulnerability profiles that cannot be captured by single indicators of deprivation [56,58,59]. For example, Valverde-Valtesse illustrates a clear trade-off in urban affordances: it provides a rich landscape of positive natural affordances (such as its excellent environmental resources and the Morla River Greenway), but it suffers from an extremely critical situation in terms of healthcare, effectively presenting negative affordances for health maintenance. This kind of trade-off replicates findings from other European and post-industrial medium-sized cities, where attractive green areas and environments coexist with poor access to primary or specialized care for older adults [70]. Città Alta (103.82) occupies an intermediate position in terms of vulnerability, with specific critical issues but a less extreme profile than the previous neighbourhoods. Borgo Palazzo (91.61) and Centro Pignolo (95.33) are the least vulnerable and most resilient neighbourhoods, thanks to more balanced profiles and sub-indices (demographic, economic and healthcare) that are often below the critical threshold. This is consistent with composite approaches that conceptualize neighbourhood resilience as arising from the relative balance of multiple domains rather than from excellence in a single dimension [58,59]. In developing the VAL index, it had to be taken into account that the distribution of services across the territory is highly uneven. In terms of accessibility to essential services, Borgo Palazzo, Centro Pignolo and Città Alta offer the best overall pedestrian accessibility for older adult people. On the other hand, Celadina is the most critical neighbourhood in terms of the general availability of commercial and health services. If we focus exclusively on health services, neighbourhoods such as Celadina and Centro Pignolo show a good density of public and private health services. On the other hand, Città Alta and Valverde suffer from a structural shortage in this area. Network-based accessibility studies and age-friendly city guidelines similarly show that formal service counts can obscure important gaps in walkable or multimodal access for older adults [60,70]. Città Alta also excels in terms of cultural and socialization opportunities, while it is severely lacking in this area (only 30% of older residents have access to cultural services within 300 m). Finally, Colognola presents a situation in which almost all categories of services have values close to the minimum, with the exception of religious services and urban parks. The demographic and housing characteristics of the neighbourhoods also had an influence on the vulnerability to ageing in place calculated using the VAL index. In terms of population density, the Centro Pignolo neighbourhood is one of the most densely populated (6.160 inhabitants per square kilometre), while Colognola has the lowest density (1.728 inhabitants per square kilometre). Città Alta has the highest percentage of residents over 65 (26.5%), followed by Colognola (26.3%). These patterns align with findings that ageing in place vulnerabilities emerge from the interaction between demographic structure, urban morphology, housing types and neighbourhood change processes, rather than from age composition alone [55,56,64].

Thus, the urban landscape often presents a complex matrix of competing affordances. Where some neighbourhoods offer positive affordances for socialization and open spaces, key factors for the well-being of older adults, they can lack health services or present negative affordances such as poor walkability and public transportation services. Conversely, where some urban districts stand out clearly for their conventional affordances (social and cultural services like cinemas, theatres, community centres) they are not able to provide elderly residents with a good provision of public green spaces (natural affordances). This tension between supportive and restrictive affordances is consistent with frameworks that describe ageing in place as a dynamic negotiation between resources, constraints and individual capacities, and with recent applications of person–environment fit theory to everyday mobility and walking in later life [63]. Ultimately, an urban space is capable of providing a comprehensive field of affordances. Thus, what constitutes an urban space able to provide affordances for healthy longevity has to show a balanced profile, with a reasonable provision of commercial and public health services, green spaces and soft mobility (cycle and pedestrian paths). This balance is what transforms a simple residential area into

https://doi.org/10.3390/jal6020039

a truly enabling environment for everyday life after 65, in line with current European and municipal strategies for age-friendly and accessible cities [71].

From a methodological perspective, it is important to note that no composite index is free from limitations, and different methodological choices may lead to different representations of the same phenomenon. In this study, the aim is therefore not to construct a "perfect" index, but to develop a coherent and transparent measure that is consistent with the theoretical framework and the available data. This position is consistent with recent methodological debates on urban health and age-friendly indices, which emphasize transparency and sensitivity analyses over the search for universal, one-size-fits-all metrics [57,59]. A further limitation concerns the size of the dataset used to construct the VAL index, which includes six neighbourhoods and 47 indicators. For this reason, the index should be interpreted primarily as an exploratory, place-based measure designed for within-case comparison rather than for statistical generalization. While this scale is appropriate for capturing intra-urban heterogeneity within the Bergamo case study, future research should extend the analysis to a larger number of territorial units and assess the sensitivity of results to alternative normalization, weighting, and aggregation choices. Such extensions would also enable cross-city comparisons and the testing of the VAL against other ageing in place and age-friendly indices, strengthening its contribution to comparative urban gerontology [58,60,71].

5. Conclusions

The data obtained in this research underscore that the urban and domestic environments in medium-sized cities, such as Bergamo, function not merely as neutral backdrops but as active, constitutive dimensions that can significantly shape the trajectories of healthy longevity. By integrating objective spatial metrics with granular neighbourhood data, this study provides a nuanced reinterpretation of how to observe the ageing in place possibilities for residents over 65 in urban areas. It reveals that the quality of life for the elderly is constituted through the emergent result of a complex, dynamic interaction between intrinsic individual capacities and extrinsic environmental supports—a relationship often theorized but rarely quantified with such methodological precision. The central contribution of this research is the Vulnerability for Ageing in place and Longevity Index, a multidimensional composite indicator that can be effectively used to map and describe urban vulnerability across five macro-areas: demographic, economic, healthcare, social–relational and urban–environmental. The objective analysis revealed significant spatial disparities, identifying neighbourhoods as having higher vulnerability scores due to specific gaps in balancing services with demographic trends. These findings underline the importance of considering ageing in place as the emergent outcome of interactions between individual capacities and heterogeneous urban affordances, rather than as a simple function of health status or chronological age [54–58].

In this context, a medium-sized city like Bergamo reveals what we term a "biography of the city," offering a scalable laboratory for studying demographic resilience. The results across specific districts indicate a moderate but pervasive vulnerability for individuals over 65, with stark spatial inconsistencies. For instance, certain urban districts exhibit critical social–relational gaps; despite the presence of localized health facilities, a lack of cultural and commercial accessibility renders these areas "service deserts," undermining the environmental affordances necessary for healthy longevity. Conversely, other districts present a paradox of "specialized vulnerability", by which we mean a case in which vulnerability is concentrated in specific dimensions despite relatively favourable conditions in others. While these areas may be rich in "green capital," the profound absence of local medical services contributes to a heightened state of vulnerability for older residents, who are effectively marooned in high-amenity but low-support environments.

The main contribution of the study lies in the development and application of the Vulnerability for Ageing in place and Longevity (VAL) index, which offers a transparent and theoretically grounded tool for comparing neighbourhoods across demographic, economic, healthcare, social–relational and urban–environmental dimensions. In policy terms, the VAL index can help stakeholders and local governments in identifying whether vulnerability is broadly distributed across domains or concentrated in specific dimensions, thereby informing more targeted and place-based interventions for older residents [58–60]. The Bergamo case also illustrates how medium-sized European cities can function as laboratories for demographic resilience, providing insights that are potentially transferable to other urban contexts with similar scales and governance structures.

These findings support the proposed theoretical framework: urban environments are never neutral; they are active determinants of the ageing trajectory [10]. Consequently, achieving healthy longevity requires a paradigm shift—moving away from reductionist, technical "health fixes" toward a robust model of spatial justice. This model must empower the elderly not as passive recipients of care, but as active agents of change within their communities.

To foster truly age-friendly cities, it is imperative to move beyond the "one-size-fits-all" approach and address the "thin space" between individual needs and environmental affordances. When this gap widens, the environment ceases to be a resource and becomes a barrier, limiting autonomy and social participation. Moreover, for building a future "City for Longevity", it appears necessary to propose some strategic recommendations to urban planners and policy makers [71] to strongly support the development of ageing in place models.

Based on the empirical findings, four strategic pillars are proposed.

First, in order to implement new public policies focused on creating age-friendly cities and neighbourhoods, it is essential to rethink the way we observe, describe, and interpret the urban environment by adopting a transdisciplinary and multiscale perspective.

Second, it is important to implement spatial justice to combat neighbourhood "specialization". Public policies must address the horizontal inconsistency found in some neighbourhoods we have analyzed in Bergamo city (like Valverde-Valtesse). Urban planning should prioritize a "balanced affordance" model, ensuring that healthcare, commercial hubs, and green spaces are distributed equitably to prevent the formation of isolated service enclaves.

Third, there is an urgent need to adopt an integrated governance for thermal and social resilience. Governance must incorporate the environmental metrics—such as the Heat Island Index and ecosystem service scores—into the heart of urban design. As climate extremes become more frequent, these factors represent significant environmental barriers that can transform a city into an inaccessible space for old residents during climate extremes, limiting their autonomy and possibilities for open air socialization.

Finally, policy makers have to improve micro-interventions for supporting healthy AIP. Enhancing healthy longevity requires reducing the friction between individual capabilities and environmental demands through localized interventions. This includes improving walkability buffers, decentralizing social health services, and investing in high-quality "buffer infrastructures", such as, in Italy, "*Case di Comunità*" and "*Centri per Tutte le Età*". These spaces act as vital nodes for social cohesion and preventive care.

While these four pillars address the physical and social dimensions of the urban environment, it is important to acknowledge a limitation of the current study and the proposed VAL index. The index relies on a specific set of indicators and weighting choices, which constrain its generalisability. Moreover, some relevant dimensions for contemporary ageing in place—most notably digital connectivity, access to virtual services (such as telemedicine and home delivery) and digital literacy—were not included in the current version of the VAL index, even though they increasingly shape older adults' autonomy and social participation. In contemporary urban life, digital connectivity and access to virtual services, such as telemedicine, home delivery services, and digital social networks, are becoming increasingly critical affordances for older adults. The presence of robust digital infrastructure, coupled with the digital literacy required to navigate it, can act as a powerful facilitator for healthy longevity, often compensating for physical mobility barriers. Conversely, the "digital divide" can emerge as a significant negative affordance, exacerbating isolation and vulnerability. Future implementations of the VAL index should integrate digital accessibility and literacy as key spatial and social indicators, thereby providing an even more comprehensive model of the urban affordances available to ageing populations. These constraints mean that the present results should be interpreted as exploratory and context-specific, rather than as definitive benchmarks.

Future research should therefore extend the application of the VAL index to a larger number of territorial units and cities, test the robustness of the results to alternative normalization and weighting schemes, and systematically integrate indicators of digital accessibility and competences. Comparative studies across different urban systems could also explore how patterns of "specialized vulnerability" and "balanced affordances" vary according to planning traditions, welfare regimes and demographic trajectories. In parallel, longitudinal designs would make it possible to examine whether changes in neighbourhood affordances over time translate into measurable differences in ageing trajectories and healthy longevity outcomes.

In summary, the study contributes a place-based, operational perspective on how urban environments can either support or hinder healthy ageing in place, and offers a framework that can be refined and adapted in future work. By treating the city not as a neutral backdrop but as a dynamic partner in the longevity journey, planners and policy makers can better design interventions that sustain autonomy, social participation and a sense of agency for older residents across diverse neighbourhoods.

Ultimately, by moving beyond clinical liability and viewing the city as a dynamic partner in the longevity journey, medium-sized cities can be transformed into resilient landscapes of belonging and agency for all.

Fostering sustainable AIP requires a paradigm shift in urban planning and governance. They must move beyond purely technical or health-centred fixes and adopt person-centred strategies that prioritize autonomy, empowerment, and social inclusion. Only by aligning individual needs and environmental affordances can the lived realities of the cities and of its oldest citizens evolve into truly age-friendly possibilities that support not just a physical longevity, but a meaningful sense of agency throughout the entire lifespan, a sense of embodied agency in one's own life that constitutes the essential scaffolding for a healthy longevity [12,72].

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Abbreviations

AIP	Ageing in place (the ability of individuals to live in their own homes and communities safely, independently, and comfortably).
ALER	Azienda Lombarda Edilizia Residenziale (Lombard public housing agency).
AMPI	Adjusted Mazziotta–Pareto Index (a non-compensatory composite index methodology).
ATB	Azienda Trasporti Bergamo (the local public transport company in Bergamo).
CASA	Invecchiare nelle città-medie: come le Condizioni Abitative e gli spazi urbani possono ridurre o aumentare le opportunità per la longevità in Salute (Ageing in medium-sized cities: how housing conditions and urban spaces can reduce or increase opportunities for healthy longevity).
CTE	Centri per Tutte le Età (Centres for All Ages—Bergamo's social facilities designed to foster community gathering and intergenerational cohesion within neighbourhoods).
ERP	Edilizia Residenziale Pubblica (Public Residential Housing/Social Housing).
ISEE	Indicatore della Situazione Economica Equivalente (Equivalent Economic Situation Indicator—an Italian metric used to assess the economic condition of families).
LST	Land Surface Temperature (the temperature of the earth's surface).
NDBI	Normalized Difference Built-up Index (a spectral index used to map built-up areas).
NDVI	Normalized Difference Vegetation Index (a spectral index used in remote sensing to estimate live green vegetation).
NDWI	Normalized Difference Water Index (a spectral index used to monitor changes in water content).
PGT	Piano di Governo del Territorio (Territorial Government Plan—a municipal urban planning document in Italy).
PNRR	Piano Nazionale di Ripresa e Resilienza (National Recovery and Resilience Plan—an Italian national funding programme).
SE	Ecosystem Services (Servizi Ecosistemici—the benefits provided by natural ecosystems).
UHI	Urban Heat Island (a metropolitan area that is significantly warmer than its surrounding rural areas).
VAL INDEX	Vulnerability Index for ageing in place and Longevity (a multidimensional index measuring vulnerability for older adults in an urban context).

Appendix A

Table A1. List of all the variables used to define the VAL index and corresponding values in the 6 considered neighbourhoods of Bergamo. The Variable Short Name column provides a compact identifier for each indicator, in the form Vm.k, where m identifies the macro-areas (1 = demographic, 2 = economic, 3 = healthcare, 4 = social–relational and 5 = urban–environmental), and k indexes the indicators within each macro-area (e.g., V1.1 is the first indicator in the demographic macro-area 1).

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Borgo Palazzo	Old-age dependency ratio (pop. 65+/pop. 20–64)	V1.1	35.52	0.00
Borgo Palazzo	Ageing index (pop. 65+/pop. < 15)	V1.2	187.84	0.00
Borgo Palazzo	% of residents aged 65–74	V1.3	10.01	0.00
Borgo Palazzo	% of households with children	V1.4	29.30	0.00
Borgo Palazzo	% of residents aged 65+ living in social housing	V1.5	2.25	0.23
Borgo Palazzo	% of residents aged 75+	V1.6	12.00	0.00
Borgo Palazzo	% of foreign nationals or foreign-born residents	V1.7	24.61	0.55
Borgo Palazzo	% of 65+ adults who can access grocery retail services (bakery, fruit and vegetable shop, grocery store) within a 500 m walking distance	V2.1	95.65	0.06
Borgo Palazzo	% of 65+ adults who can access medium- and large-sized supermarkets within a 500 m walking distance	V2.2	99.18	0.00
Borgo Palazzo	Number of commercial services (grocery stores, bars, restaurants, markets) per older resident	V2.3	0.04	0.67
Borgo Palazzo	Number of medium- and large-sized supermarkets per older resident	V2.4	1.60	0.00
Borgo Palazzo	% of vacant dwellings	V2.5	17.92	0.28
Borgo Palazzo	% of social housing dwellings (over total dwellings)	V2.6	4.00	0.22
Borgo Palazzo	% of non-renovated or in poor-condition ALER dwellings	V2.7	13.01	0.13
Borgo Palazzo	% of residents with low educational attainment	V2.8	17.73	0.36
Borgo Palazzo	% of social households with ISEE < €10,000	V2.9	24.47	0.00
Borgo Palazzo	Employment rate	V2.10	70.30	0.00
Borgo Palazzo	% of social housing vacant dwellings	V2.11	3.66	0.00
Borgo Palazzo	% of 65+ adults who can access primary healthcare services (general practitioners and pharmacies) within a 300 m walking distance	V3.1	88.42	0.00
Borgo Palazzo	Number of private healthcare services (outpatient clinics and pharmacies) per 65+ resident	V3.2	0.01	0.35
Borgo Palazzo	Number of public healthcare services (general practitioners and other public services) per 65+ resident	V3.3	0.01	0.00
Borgo Palazzo	% of residents aged 65+ receiving home care services	V3.4	0.78	0.55
Borgo Palazzo	% of 65+ adults who can access cultural services (e.g., cinemas, theatres, museums) within a 300 m walking distance	V4.1	85.35	0.10

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Borgo Palazzo	% of 65+ adults who can access religious services within a 300 m walking distance	V4.2	73.17	0.65
Borgo Palazzo	% of 65+ adults with a public transportation pass	V4.3	4.18	0.72
Borgo Palazzo	% of events organized by the educational service	V4.4	5.29	0.15
Borgo Palazzo	% of residents aged 65+ who are foreign-born and/or non-Italian citizens	V4.5	9.32	0.98
Borgo Palazzo	% of residents aged 65+ living alone	V4.6	37.36	0.59
Borgo Palazzo	% of residents aged 65+ enrolled in University of the Third Age courses	V4.7	2.75	0.24
Borgo Palazzo	% of intergenerational households: % of residents aged 65+ living in households with at least one co-resident under 30	V4.8	5.09	0.96
Borgo Palazzo	Number of cultural and religious services per 65+ resident	V4.9	0.95	0.95
Borgo Palazzo	Number of small urban parks (<1 ha) per 65+ resident	V5.1	98.72	0.04
Borgo Palazzo	% of the neighbourhood's total built-up area classified as low-density development	V5.2	0.90	0.04
Borgo Palazzo	% of the neighbourhood's total built-up area devoted to residential use	V5.3	64.80	0.53
Borgo Palazzo	% of the neighbourhood's total built-up area devoted to public/social housing	V5.4	0.44	0.09
Borgo Palazzo	Number of mobility service access points (tram stops, funicular, train stations, bus stops) per 65+ resident	V5.5	0.01	0.81
Borgo Palazzo	Linear metres of cycle lanes per 65+ resident	V5.6	1.53	0.74
Borgo Palazzo	Square metres of public green space per 65+ resident	V5.7	66.34	0.64
Borgo Palazzo	Heat island effect temperature index	V5.8	0.85	0.85
Borgo Palazzo	Average market price of commercial properties in 2024	V5.9	1273.91	0.17
Borgo Palazzo	Average market price of residential properties in 2024	V5.10	1469.00	0.26
Borgo Palazzo	Net migration rate among residents aged 65+	V5.11	4.19	0.53
Borgo Palazzo	Share of crashes involving heavy vehicles	V5.12	8.76	1.00
Borgo Palazzo	Share of crashes involving pedestrians or cyclists	V5.13	8.96	1.00
Borgo Palazzo	Ecosystem services index	V5.14	63.13	0.96
Borgo Palazzo	% of neighbourhood area covered by buildings	V5.15	19.48	0.48
Borgo Palazzo	% of neighbourhood area covered by green spaces	V5.16	40.00	0.98
Celadina	Old-age dependency ratio (pop. 65+/pop. 20–64)	V1.1	40.99	0.55
Celadina	Ageing index (pop. 65+/pop. < 15)	V1.2	190.15	0.02
Celadina	% of residents aged 65–74	V1.3	11.33	0.43
Celadina	% of households with children	V1.4	33.40	0.80
Celadina	% of residents aged 65+ living in social housing	V1.5	4.46	0.53
Celadina	% of residents aged 75+	V1.6	12.65	0.18
Celadina	% of foreign nationals or foreign-born residents	V1.7	33.10	1.00

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Celadina	% of 65+ adults who can access grocery retail services (bakery, fruit and vegetable shop, grocery store) within a 500 m walking distance	V2.1	45.82	1.00
Celadina	% of 65+ adults who can access medium- and large-sized supermarkets within a 500 m walking distance	V2.2	67.01	0.32
Celadina	Number of commercial services (grocery stores, bars, restaurants, markets) per older resident	V2.3	0.02	0.89
Celadina	Number of medium- and large-sized supermarkets per older resident	V2.4	1.27	0.21
Celadina	% of vacant dwellings	V2.5	10.88	0.00
Celadina	% of social housing dwellings (over total dwellings)	V2.6	8.26	0.50
Celadina	% of non-renovated or in poor-condition ALER dwellings	V2.7	73.16	0.73
Celadina	% of residents with low educational attainment	V2.8	24.63	0.97
Celadina	% of social households with ISEE < €10,000	V2.9	38.38	0.33
Celadina	Employment rate	V2.10	65.79	1.00
Celadina	% of social housing vacant dwellings	V2.11	14.29	0.86
Celadina	% of 65+ adults who can access primary healthcare services (general practitioners and pharmacies) within a 300 m walking distance	V3.1	46.69	1.00
Celadina	Number of private healthcare services (outpatient clinics and pharmacies) per 65+ resident	V3.2	0.00	0.69
Celadina	Number of public healthcare services (general practitioners and other public services) per 65+ resident	V3.3	0.00	0.56
Celadina	% of residents aged 65+ receiving home care services	V3.4	1.12	0.91
Celadina	% of 65+ adults who can access cultural services (e.g., cinemas, theatres, museums) within a 300 m walking distance	V4.1	63.35	0.46
Celadina	% of 65+ adults who can access religious services within a 300 m walking distance	V4.2	58.96	1.00
Celadina	% of 65+ adults with a public transportation pass	V4.3	4.30	0.68
Celadina	% of events organized by the educational service	V4.4	4.78	0.24
Celadina	% of residents aged 65+ who are foreign-born and/or non-Italian citizens	V4.5	9.40	1.00
Celadina	% of residents aged 65+ living alone	V4.6	29.40	0.00
Celadina	% of residents aged 65+ enrolled in University of the Third Age courses	V4.7	1.20	0.72
Celadina	% of intergenerational households: % of residents aged 65+ living in households with at least one co-resident under 30	V4.8	5.58	0.73
Celadina	Number of cultural and religious services per 65+ resident	V4.9	0.98	0.98

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Celadina	Number of small urban parks (<1 ha) per 65+ resident	V5.1	92.27	0.26
Celadina	% of the neighbourhood's total built-up area classified as low-density development	V5.2	1.13	0.04
Celadina	% of the neighbourhood's total built-up area devoted to residential use	V5.3	40.07	0.00
Celadina	% of the neighbourhood's total built-up area devoted to public/social housing	V5.4	4.63	1.00
Celadina	Number of mobility service access points (tram stops, funicular, train stations, bus stops) per 65+ resident	V5.5	0.02	0.40
Celadina	Linear metres of cycle lanes per 65+ resident	V5.6	3.89	0.35
Celadina	Square metres of public green space per 65+ resident	V5.7	50.31	0.88
Celadina	Heat island effect temperature index	V5.8	0.89	0.89
Celadina	Average market price of commercial properties in 2024	V5.9	1001.67	0.00
Celadina	Average market price of residential properties in 2024	V5.10	1131.67	0.00
Celadina	Net migration rate among residents aged 65+	V5.11	2.94	0.11
Celadina	Share of crashes involving heavy vehicles	V5.12	2.40	0.08
Celadina	Share of crashes involving pedestrians or cyclists	V5.13	1.93	0.02
Celadina	Ecosystem services index	V5.14	62.44	1.00
Celadina	% of neighbourhood area covered by buildings	V5.15	14.11	0.26
Celadina	% of neighbourhood area covered by green spaces	V5.16	45.72	0.82
Centro Pignolo	Old-age dependency ratio (pop. 65+/pop. 20–64)	V1.1	41.35	0.58
Centro Pignolo	Ageing index (pop. 65+/pop. < 15)	V1.2	218.13	0.21
Centro Pignolo	% of residents aged 65–74	V1.3	11.39	0.45
Centro Pignolo	% of households with children	V1.4	31.05	0.34
Centro Pignolo	% of residents aged 65+ living in social housing	V1.5	0.59	0.00
Centro Pignolo	% of residents aged 75+	V1.6	13.06	0.30
Centro Pignolo	% of foreign nationals or foreign-born residents	V1.7	16.44	0.12
Centro Pignolo	% of 65+ adults who can access grocery retail services (bakery, fruit and vegetable shop, grocery store) within a 500 m walking distance	V2.1	98.83	0.00
Centro Pignolo	% of 65+ adults who can access medium- and large-sized supermarkets within a 500 m walking distance	V2.2	54.40	0.45
Centro Pignolo	Number of commercial services (grocery stores, bars, restaurants, markets) per older resident	V2.3	0.06	0.38
Centro Pignolo	Number of medium- and large-sized supermarkets per older resident	V2.4	0.89	0.45
Centro Pignolo	% of vacant dwellings	V2.5	26.78	0.63
Centro Pignolo	% of social housing dwellings (over total dwellings)	V2.6	0.63	0.00
Centro Pignolo	% of non-renovated or in poor-condition ALER dwellings	V2.7	100.00	1.00
Centro Pignolo	% of residents with low educational attainment	V2.8	13.63	0.00

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Centro Pignolo	% of social households with ISEE < €10,000	V2.9	66.67	1.00
Centro Pignolo	Employment rate	V2.10	69.32	0.22
Centro Pignolo	% of social housing vacant dwellings	V2.11	16.00	1.00
Centro Pignolo	% of 65+ adults who can access primary healthcare services (general practitioners and pharmacies) within a 300 m walking distance	V3.1	48.11	0.97
Centro Pignolo	Number of private healthcare services (outpatient clinics and pharmacies) per 65+ resident	V3.2	0.01	0.00
Centro Pignolo	Number of public healthcare services (general practitioners and other public services) per 65+ resident	V3.3	0.00	0.43
Centro Pignolo	% of residents aged 65+ receiving home care services	V3.4	0.25	0.00
Centro Pignolo	% of 65+ adults who can access cultural services (e.g., cinemas, theatres, museums) within a 300 m walking distance	V4.1	85.08	0.10
Centro Pignolo	% of 65+ adults who can access religious services within a 300 m walking distance	V4.2	99.66	0.00
Centro Pignolo	% of 65+ adults with a public transportation pass	V4.3	3.95	0.80
Centro Pignolo	% of events organized by the educational service	V4.4	NA	NA
Centro Pignolo	% of residents aged 65+ who are foreign-born and/or non-Italian citizens	V4.5	7.81	0.51
Centro Pignolo	% of residents aged 65+ living alone	V4.6	38.87	0.71
Centro Pignolo	% of residents aged 65+ enrolled in University of the Third Age courses	V4.7	3.53	0.00
Centro Pignolo	% of intergenerational households: % of residents aged 65+ living in households with at least one co-resident under 30	V4.8	6.21	0.44
Centro Pignolo	Number of cultural and religious services per 65+ resident	V4.9	0.70	0.70
Centro Pignolo	Number of small urban parks (<1 ha) per 65+ resident	V5.1	96.31	0.12
Centro Pignolo	% of the neighbourhood's total built-up area classified as low-density development	V5.2	0.00	0.00
Centro Pignolo	% of the neighbourhood's total built-up area devoted to residential use	V5.3	77.91	0.81
Centro Pignolo	% of the neighbourhood's total built-up area devoted to public/social housing	V5.4	0.00	0.00
Centro Pignolo	Number of mobility service access points (tram stops, funicular, train stations, bus stops) per 65+ resident	V5.5	0.02	0.60
Centro Pignolo	Linear metres of cycle lanes per 65+ resident	V5.6	3.11	0.48
Centro Pignolo	Square metres of public green space per 65+ resident	V5.7	42.50	1.00
Centro Pignolo	Heat island effect temperature index	V5.8	0.92	0.92
Centro Pignolo	Average market price of commercial properties in 2024	V5.9	1956.14	0.60
Centro Pignolo	Average market price of residential properties in 2024	V5.10	1944.22	0.64
Centro Pignolo	Net migration rate among residents aged 65+	V5.11	2.60	0.00

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Centro Pignolo	Share of crashes involving heavy vehicles	V5.12	6.77	0.71
Centro Pignolo	Share of crashes involving pedestrians or cyclists	V5.13	8.31	0.91
Centro Pignolo	Ecosystem services index	V5.14	72.78	0.38
Centro Pignolo	% of neighbourhood area covered by buildings	V5.15	31.53	1.00
Centro Pignolo	% of neighbourhood area covered by green spaces	V5.16	39.19	1.00
Città Alta	Old-age dependency ratio (pop. 65+/pop. 20–64)	V1.1	43.74	0.82
Città Alta	Ageing index (pop. 65+/pop. < 15)	V1.2	332.86	1.00
Città Alta	% of residents aged 65–74	V1.3	13.06	1.00
Città Alta	% of households with children	V1.4	29.43	0.03
Città Alta	% of residents aged 65+ living in social housing	V1.5	1.43	0.11
Città Alta	% of residents aged 75+	V1.6	13.48	0.42
Città Alta	% of foreign nationals or foreign-born residents	V1.7	15.91	0.09
Città Alta	% of 65+ adults who can access grocery retail services (bakery, fruit and vegetable shop, grocery store) within a 500 m walking distance	V2.1	79.49	0.36
Città Alta	% of 65+ adults who can access medium- and large-sized supermarkets within a 500 m walking distance	V2.2	0.00	1.00
Città Alta	Number of commercial services (grocery stores, bars, restaurants, markets) per older resident	V2.3	0.09	0.00
Città Alta	Number of medium- and large-sized supermarkets per older resident	V2.4	0.00	1.00
Città Alta	% of vacant dwellings	V2.5	36.27	1.00
Città Alta	% of social housing dwellings (over total dwellings)	V2.6	1.59	0.06
Città Alta	% of non-renovated or in poor-condition ALER dwellings	V2.7	100.00	1.00
Città Alta	% of residents with low educational attainment	V2.8	16.48	0.25
Città Alta	% of social households with ISEE < €10,000	V2.9	58.82	0.81
Città Alta	Employment rate	V2.10	66.18	0.91
Città Alta	% of social housing vacant dwellings	V2.11	5.56	0.15
Città Alta	% of 65+ adults who can access primary healthcare services (general practitioners and pharmacies) within a 300 m walking distance	V3.1	72.08	0.39
Città Alta	Number of private healthcare services (outpatient clinics and pharmacies) per 65+ resident	V3.2	0.00	0.91
Città Alta	Number of public healthcare services (general practitioners and other public services) per 65+ resident	V3.3	0.00	1.00
Città Alta	% of residents aged 65+ receiving home care services	V3.4	1.14	0.93
Città Alta	% of 65+ adults who can access cultural services (e.g., cinemas, theatres, museums) within a 300 m walking distance	V4.1	91.45	0.00

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Città Alta	% of 65+ adults who can access religious services within a 300 m walking distance	V4.2	99.57	0.00
Città Alta	% of 65+ adults with a public transportation pass	V4.3	4.86	0.49
Città Alta	% of events organized by the educational service	V4.4	0.51	1.00
Città Alta	% of residents aged 65+ who are foreign-born and/or non-Italian citizens	V4.5	6.15	0.00
Città Alta	% of residents aged 65+ living alone	V4.6	42.78	1.00
Città Alta	% of residents aged 65+ enrolled in University of the Third Age courses	V4.7	0.29	1.00
Città Alta	% of intergenerational households: % of residents aged 65+ living in households with at least one co-resident under 30	V4.8	6.44	0.33
Città Alta	Number of cultural and religious services per 65+ resident	V4.9	0.00	0.00
Città Alta	Number of small urban parks (<1 ha) per 65+ resident	V5.1	92.88	0.24
Città Alta	% of the neighbourhood's total built-up area classified as low-density development	V5.2	0.00	0.00
Città Alta	% of the neighbourhood's total built-up area devoted to residential use	V5.3	69.83	0.64
Città Alta	% of the neighbourhood's total built-up area devoted to public/social housing	V5.4	0.29	0.06
Città Alta	Number of mobility service access points (tram stops, funicular, train stations, bus stops) per 65+ resident	V5.5	0.03	0.00
Città Alta	Linear metres of cycle lanes per 65+ resident	V5.6	0.00	1.00
Città Alta	Square metres of public green space per 65+ resident	V5.7	103.67	0.07
Città Alta	Heat island effect temperature index	V5.8	0.48	0.48
Città Alta	Average market price of commercial properties in 2024	V5.9	2595.00	1.00
Città Alta	Average market price of residential properties in 2024	V5.10	2408.00	1.00
Città Alta	Net migration rate among residents aged 65+	V5.11	4.58	0.66
Città Alta	Share of crashes involving heavy vehicles	V5.12	2.04	0.03
Città Alta	Share of crashes involving pedestrians or cyclists	V5.13	2.16	0.06
Città Alta	Ecosystem services index	V5.14	68.46	0.64
Città Alta	% of neighbourhood area covered by buildings	V5.15	22.58	0.62
Città Alta	% of neighbourhood area covered by green spaces	V5.16	57.16	0.52
Colognola	Old-age dependency ratio (pop. 65+/pop. 20–64)	V1.1	45.55	1.00
Colognola	Ageing index (pop. 65+/pop. < 15)	V1.2	232.54	0.31
Colognola	% of residents aged 65–74	V1.3	10.76	0.25
Colognola	% of households with children	V1.4	32.16	0.56
Colognola	% of residents aged 65+ living in social housing	V1.5	7.41	0.93
Colognola	% of residents aged 75+	V1.6	15.52	1.00
Colognola	% of foreign nationals or foreign-born residents	V1.7	26.56	0.65

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Colognola	% of 65+ adults who can access grocery retail services (bakery, fruit and vegetable shop, grocery store) within a 500 m walking distance	V2.1	65.91	0.62
Colognola	% of 65+ adults who can access medium- and large-sized supermarkets within a 500 m walking distance	V2.2	52.19	0.47
Colognola	Number of commercial services (grocery stores, bars, restaurants, markets) per older resident	V2.3	0.01	0.99
Colognola	Number of medium- and large-sized supermarkets per older resident	V2.4	1.17	0.27
Colognola	% of vacant dwellings	V2.5	13.15	0.09
Colognola	% of social housing dwellings (over total dwellings)	V2.6	15.87	1.00
Colognola	% of non-renovated or in poor-condition ALER dwellings	V2.7	62.32	0.62
Colognola	% of residents with low educational attainment	V2.8	24.96	1.00
Colognola	% of social households with ISEE < €10,000	V2.9	35.59	0.26
Colognola	Employment rate	V2.10	67.14	0.70
Colognola	% of social housing vacant dwellings	V2.11	5.41	0.14
Colognola	% of 65+ adults who can access primary healthcare services (general practitioners and pharmacies) within a 300 m walking distance	V3.1	66.12	0.53
Colognola	Number of private healthcare services (outpatient clinics and pharmacies) per 65+ resident	V3.2	0.00	0.69
Colognola	Number of public healthcare services (general practitioners and other public services) per 65+ resident	V3.3	7×10^{-4}	0.91
Colognola	% of residents aged 65+ receiving home care services	V3.4	0.96	0.74
Colognola	% of 65+ adults who can access cultural services (e.g., cinemas, theatres, museums) within a 300 m walking distance	V4.1	59.60	0.52
Colognola	% of 65+ adults who can access religious services within a 300 m walking distance	V4.2	89.85	0.24
Colognola	% of 65+ adults with a public transportation pass	V4.3	3.36	1.00
Colognola	% of events organized by the educational service	V4.4	4.61	0.27
Colognola	% of residents aged 65+ who are foreign-born and/or non-Italian citizens	V4.5	7.82	0.51
Colognola	% of residents aged 65+ living alone	V4.6	31.14	0.13
Colognola	% of residents aged 65+ enrolled in University of the Third Age courses	V4.7	1.85	0.52
Colognola	% of intergenerational households: % of residents aged 65+ living in households with at least one co-resident under 30	V4.8	5.01	1.00
Colognola	Number of cultural and religious services per 65+ resident	V4.9	0.90	0.90

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Colognola	Number of small urban parks (<1 ha) per 65+ resident	V5.1	99.79	0.00
Colognola	% of the neighbourhood's total built-up area classified as low-density development	V5.2	6.05	0.24
Colognola	% of the neighbourhood's total built-up area devoted to residential use	V5.3	46.59	0.14
Colognola	% of the neighbourhood's total built-up area devoted to public/social housing	V5.4	1.60	0.35
Colognola	Number of mobility service access points (tram stops, funicular, train stations, bus stops) per 65+ resident	V5.5	0.01	0.94
Colognola	Linear metres of cycle lanes per 65+ resident	V5.6	4.10	0.31
Colognola	Square metres of public green space per 65+ resident	V5.7	72.37	0.54
Colognola	Heat island effect temperature index	V5.8	0.74	0.74
Colognola	Average market price of commercial properties in 2024	V5.9	1023.75	0.01
Colognola	Average market price of residential properties in 2024	V5.10	1150.00	0.01
Colognola	Net migration rate among residents aged 65+	V5.11	3.87	0.42
Colognola	Share of crashes involving heavy vehicles	V5.12	4.09	0.33
Colognola	Share of crashes involving pedestrians or cyclists	V5.13	3.02	0.18
Colognola	Ecosystem services index	V5.14	64.75	0.86
Colognola	% of neighbourhood area covered by buildings	V5.15	8.14	0.00
Colognola	% of neighbourhood area covered by green spaces	V5.16	70.30	0.16
Valverde-Valtesse	Old-age dependency ratio (pop. 65+/pop. 20–64)	V1.1	44.86	0.93
Valverde-Valtesse	Ageing index (pop. 65+/pop. < 15)	V1.2	231.93	0.30
Valverde-Valtesse	% of residents aged 65–74	V1.3	12.20	0.72
Valverde-Valtesse	% of households with children	V1.4	34.44	1.00
Valverde-Valtesse	% of residents aged 65+ living in social housing	V1.5	7.94	1.00
Valverde-Valtesse	% of residents aged 75+	V1.6	13.84	0.52
Valverde-Valtesse	% of foreign nationals or foreign-born residents	V1.7	14.26	0.00
Valverde-Valtesse	% of 65+ adults who can access grocery retail services (bakery, fruit and vegetable shop, grocery store) within a 500 m walking distance	V2.1	84.41	0.27
Valverde-Valtesse	% of 65+ adults who can access medium- and large-sized supermarkets within a 500 m walking distance	V2.2	47.08	0.53
Valverde-Valtesse	Number of commercial services (grocery stores, bars, restaurants, markets) per older resident	V2.3	0.01	1.00
Valverde-Valtesse	Number of medium- and large-sized supermarkets per older resident	V2.4	0.00	1.00
Valverde-Valtesse	% of vacant dwellings	V2.5	12.32	0.06
Valverde-Valtesse	% of social housing dwellings (over total dwellings)	V2.6	12.13	0.75
Valverde-Valtesse	% of non-renovated or in poor-condition ALER dwellings	V2.7	0.00	0.00
Valverde-Valtesse	% of residents with low educational attainment	V2.8	20.88	0.64

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Valverde-Valtesse	% of social households with ISEE < €10,000	V2.9	35.06	0.25
Valverde-Valtesse	Employment rate	V2.10	68.32	0.44
Valverde-Valtesse	% of social housing vacant dwellings	V2.11	8.39	0.38
Valverde-Valtesse	% of 65+ adults who can access primary healthcare services (general practitioners and pharmacies) within a 300 m walking distance	V3.1	52.31	0.87
Valverde-Valtesse	Number of private healthcare services (outpatient clinics and pharmacies) per 65+ resident	V3.2	0.00	1.00
Valverde-Valtesse	Number of public healthcare services (general practitioners and other public services) per 65+ resident	V3.3	0.00	1.00
Valverde-Valtesse	% of residents aged 65+ receiving home care services	V3.4	1.21	1.00
Valverde-Valtesse	% of 65+ adults who can access cultural services (e.g., cinemas, theatres, museums) within a 300 m walking distance	V4.1	30.48	1.00
Valverde-Valtesse	% of 65+ adults who can access religious services within a 300 m walking distance	V4.2	88.93	0.26
Valverde-Valtesse	% of 65+ adults with a public transportation pass	V4.3	6.33	0.00
Valverde-Valtesse	% of events organized by the educational service	V4.4	6.14	0.00
Valverde-Valtesse	% of residents aged 65+ who are foreign-born and/or non-Italian citizens	V4.5	6.23	0.02
Valverde-Valtesse	% of residents aged 65+ living alone	V4.6	35.08	0.42
Valverde-Valtesse	% of residents aged 65+ enrolled in University of the Third Age courses	V4.7	2.41	0.35
Valverde-Valtesse	% of intergenerational households: % of residents aged 65+ living in households with at least one co-resident under 30	V4.8	7.14	0.00
Valverde-Valtesse	Number of cultural and religious services per 65+ resident	V4.9	0.91	0.91
Valverde-Valtesse	Number of small urban parks (<1 ha) per 65+ resident	V5.1	70.42	1.00
Valverde-Valtesse	% of the neighbourhood's total built-up area classified as low-density development	V5.2	25.18	1.00
Valverde-Valtesse	% of the neighbourhood's total built-up area devoted to residential use	V5.3	86.77	1.00
Valverde-Valtesse	% of the neighbourhood's total built-up area devoted to public/social housing	V5.4	3.21	0.69
Valverde-Valtesse	Number of mobility service access points (tram stops, funicular, train stations, bus stops) per 65+ resident	V5.5	0.01	1.00
Valverde-Valtesse	Linear metres of cycle lanes per 65+ resident	V5.6	5.97	0.00
Valverde-Valtesse	Square metres of public green space per 65+ resident	V5.7	107.93	0.00
Valverde-Valtesse	Heat island effect temperature index	V5.8	0.00	0.00
Valverde-Valtesse	Average market price of commercial properties in 2024	V5.9	1568.75	0.36
Valverde-Valtesse	Average market price of residential properties in 2024	V5.10	1967.59	0.65

Table A1. *Cont.*

Neighbourhood	Variable	Variable Short Name	Raw Value	Normalized Value
Valverde-Valtesse	Net migration rate among residents aged 65+	V5.11	5.61	1.00
Valverde-Valtesse	Share of crashes involving heavy vehicles	V5.12	1.83	0.00
Valverde-Valtesse	Share of crashes involving pedestrians or cyclists	V5.13	1.76	0.00
Valverde-Valtesse	Ecosystem services index	V5.14	79.14	0.00
Valverde-Valtesse	% of neighbourhood area covered by buildings	V5.15	9.47	0.06
Valverde-Valtesse	% of neighbourhood area covered by green spaces	V5.16	76.30	0.00

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