Exploring the link between biodiversity, health, and climate action through the URBioPark project

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Abstract
The URBioPark project investigates the link between urban biodiversity, health, and climate action, promoting an integrated approach to sustainable planning. Coordinated by the University of Brescia and funded under the 2022 PRIN program with Next Generation EU resources, the project involves Italian universities and the National Research Council (CNR). Its aim is to assess the relationship between biodiversity in urban parks and the incidence of chronic diseases by integrating health and geographic data using GIS. Results will help identify critical areas, support re-naturalization efforts, and provide guidelines for urban planning. URBioPark contributes to reducing health inequalities, enhancing well-being, and offers a replicable model for other cities by combining scientific research, civic engagement, and territorial governance.

Keywords: biodiversity, climate change, resilience, urban green areas, public health

1. Introduction
Urban areas are at the forefront of environmental and public health challenges. Rapid urbanisation, combined with the accelerating effects of climate change, has intensified the demand for adaptive strategies that enhance urban resilience and sustainability. Among the tools available to city planners and policymakers, urban green spaces have emerged as multifunctional infrastructures that deliver a wide array of co-benefits. These include ecological services—such as carbon sequestration, temperature regulation, and habitat preservation—as well as social and health-related advantages, like improved air quality, stress reduction, and opportunities for physical activity.

Recent trends in urban planning reflect a growing emphasis on nature-based solutions (NBS) as cost-effective, inclusive, and sustainable alternatives to traditional engineering approaches. In this context, biodiversity is no longer seen only as an ecological resource, but also as a strategic asset for public health and social equity. The intersection of biodiversity, climate resilience, and health has therefore become a critical focus in the pursuit of sustainable urban development.

This paper presents the objectives, methodology, and preliminary findings of the URBioPark project—a multidisciplinary initiative designed to explore the correlations between urban park biodiversity and public health outcomes. Conducted in the city of Brescia (Italy), the project integrates spatial analysis, ecological fieldwork, and health data to support a replicable model of biodiversity-inclusive planning.

2. Background and theoretical framework
The positive effects of greenery on human health are well-documented in the literature. For instance, walking in a forest has been shown to lower anxiety levels (Li et al., 2016).

Increasing evidence links biodiversity to human health and ecosystem resilience: biodiversity enhances public health through multiple mechanisms, including exposure to diverse microbiota, improved air quality, opportunities for physical and recreational activity (Aerts et al., 2018), regulation of the immune system (Mills et al., 2017).

Green spaces, particularly in urban environments, have a wide range of positive impacts on human life. Areas with diverse plant and animal species offer consistent and beneficial outcomes for mental health (Carrus *et al.*, 2015; Sandifer, Sutton-Grier and Ward, 2015; Methorst *et al.*, 2021)selected on the basis of urban forestry expert criteria according to a 2×2 factorial design. The biodiversity level (low vs. high and a decrease in stress levels (Ward Thompson *et al.*, 2012)including stress reduction, but much pertinent evidence has relied on self-reported health indicators or experiments in artificially controlled environmental conditions. Little research has been reported using ecologically valid objective measures with participants in their everyday, residential settings. This paper describes the results of an exploratory study (n=25. The presence of urban greenery is positively associated with a reduction in the symptoms of many chronic diseases (Maas *et al.*, 2009) such as the type 2 diabetes (Astell-Burt, Feng and Kolt, 2014), cardiovascular (Giacinto *et al.*, 2021) and inflammatory diseases (Haahtela, 2019). In particular, the presence of greenery is positively associated with a higher chance of survival in ischemic stroke patients (Wilker *et al.*, 2014).

Urban biodiversity also plays a key role in reducing social inequalities in health. According to Becker et al. (2019), access to green environments is associated with lower public healthcare spending and better health equity. In addition, green areas that promote health contribute to reducing health inequalities associated with income (Mitchell and Popham, 2008)or so-called green space, has an independent effect on health and health-related behaviours. We postulated that income-related inequality in health would be less pronounced in populations with greater exposure to green space, since access to such areas can modify pathways through which low socioeconomic position can lead to disease.\nMETHODS: We classified the population of England at younger than retirement age (n=40 813 236.

The World Health Organization has formally recognised urban health as a central component of sustainable development, calling for stronger integration of health metrics into planning practices (Neira, 2015). In this context, biodiversity serves as both an ecological and socio-political determinant of health, being essential not only for the functioning of ecosystem but also for building resilient, equitable, and liveable cities.

3. Project description: URBioPark objectives

URBioPark is a multi-partner project funded by the 2022 PRIN programme and supported by Next Generation EU. The consortium includes the University of Brescia (coordinator), the National Research Council - Institute for BioEconomy (CNR-IBE) based in Florence, and the Universities of Padua and Verona.

The project aims to investigate the relationship between urban biodiversity and public health, focusing on the city of Brescia as a representative mid-sized European city actively engaged in sustainability and climate adaptation. Over the past decade, Brescia has launched several initiatives aimed at promoting environmental resilience, reducing emissions, and improving the quality of life for its residents. As part of its climate transition strategy, the city has expanded its green infrastructure, promoted sustainable mobility, and implemented nature-based solutions in urban planning. Brescia's participation in national and European climate networks further underscores its commitment to ecological transition. The relevance and potential impact of the URBioPark project have been recognized through formal endorsements by the Municipality of Brescia, Fondazione Cariplo, Urban Center Brescia, and AmbienteParco—key institutional and civic actors engaged in shaping the city's sustainable future. This strong local support highlights Brescia as an ideal case study for exploring how urban biodiversity can contribute to public health and territorial equity.

3.1 Project structure

The URBioPark project is structured around five interrelated Work Packages (WPs), designed to investigate and strengthen the link between urban biodiversity and public health, with a particular focus on the city of Brescia. The project will run over 24 months and follows a multidisciplinary and participatory approach.

The five WPs are as follows:

1. WP1 – Project coordination and management (UNIBS): Coordination of all research units, financial oversight, and risk monitoring through regular meetings and reporting.
2. WP2 – Brescia urban parks analysis (UNIBS): Mapping urban morphology, green space distribution, socio-economic and health data, and existing vegetation and soil characteristics using GIS and statistical tools. This package sets the baseline for the empirical research.
3. WP3 – Biodiversity and ecosystem services (CNR-IBE): Field and lab analyses on plant and soil biodiversity in selected urban parks. This includes microbial DNA sequencing, soil mesofauna identification, and eco-physiological plant assessments, to evaluate ecosystem services and health impacts.
4. WP4 – Good Practices Manual Development (UNIVR): Synthesis of research outputs to create actionable planning guidelines. These will support urban decision-makers in designing and managing biodiversity-friendly green spaces and integrating biodiversity into Strategic Environmental Assessments (SEA).
5. WP5 – Dissemination and Citizen Science (UNIBS): Stakeholder engagement through public events, citizen science activities (BioBlitz), and participatory surveys. The WP also includes educational actions and outreach in collaboration with local institutions to increase public awareness and co-design strategies with communities.

Each Work Package contributes to building an integrated, evidence-based framework for planning healthier, more biodiverse, and climate-resilient urban environments. By integrating diverse datasets and disciplinary approaches, URBioPark aims to develop practical guidelines and indicators that support biodiversity-inclusive urban governance, ensuring both scientific rigor and real-world applicability, and offering a replicable model for other cities.

Fig. 1. Actions of the URBioPark project. Source: Author's own elaboration

4. Methodology

The URBioPark project adopts a multidisciplinary methodology to explore the complex interrelations between urban green areas, biodiversity, and human health. The study combines ecological, environmental, socio-economic, and epidemiological data to produce a comprehensive framework for biodiversity-inclusive urban planning. The method used is structured in the following phases: 1) selection of the parks on which to carry out the survey; 2) analysis of the spatial context in which the parks are located and health assessment; 3) Socio-economic and health analysis; 4) Economic value of ecosystem services analysis.

In the first phase, the parks are selected based on criteria such as size, vegetation structure, accessibility, and heterogeneity of the surrounding urban context; a 500m buffer zone is then defined around each park.

In the second phase, the following indicators are calculated for each park and each buffer zone:

- Land Surface Temperature (LST)
- Sky View Factor (SVF), measuring sky visibility from ground level and indicating a location's ability to dissipate heat.
- Tree Canopy Cover (TCC), to quantify the extent of arboreal coverage. Areas with denser tree cover consistently exhibited lower surface temperatures, highlighting the cooling function of vegetation and the importance of canopy density in mitigating urban heat island effects
- NDVI (Normalized Difference Vegetation Index) and NDMI (Normalized Difference Moisture Index). These indices allowed to evaluate the vitality and moisture levels of vegetation, providing a more detailed understanding of the parks' ecological conditions

In the third phase, the vegetation and soil components of the selected urban parks are analysed through a detailed ecological assessment that examine plant species composition, soil characteristics, and the presence of soil microarthropods. The collected data are subsequently analyzed and integrated to develop biodiversity indicators, offering a comprehensive picture of the ecological status of the parks and their contribution to overall urban biodiversity.

In the fourth phase, consistently with the project's focus on health, it is investigated how the exposure to urban green spaces—particularly those with higher levels of biodiversity—can influence the physical and mental well-being of nearby residents. This analysis takes place by employing spatial and temporal statistical analyses using georeferenced socio-demographic data to define and classify the socio-economic profile of the areas surrounding the selected parks.

In the fifth phase, the economic value of the ecosystem services provided by urban parks is estimated, using a questionnaire-based survey. Since these services are not traded on the market and lack a clear reference price, a simulated market approach is adopted to evaluate citizens' willingness to pay for their maintenance or enhancement. The survey features a discrete choice experiment involving 500 participants and examines preferences for five possible interventions, each associated with a hypothetical tax. In addition to these choices, the questionnaire gathers information on socio-demographic characteristics, attitudes toward biodiversity, and patterns of park usage. An informational treatment is also included to assess how participants understand and incorporate information into their responses. The analysis identifies attitudinal clusters, investigates correlations with socio-demographic and spatial factors, and performs a cost-benefit analysis of the proposed interventions based on the current state of the parks.

5. First results

The first results obtained by the URBioPark project derive from the phases of urban and morphological analysis of the selected parks, supported by the integration of data relating to the health of the population and the socio-demographic characteristics of the surrounding areas. (phases 1, 2, 4). This multidisciplinary approach has permit us to collect valuable information that, although preliminary, offers a first picture of the interconnections between the physical structure of cities, the green infrastructures present in the urban fabric and the well-being of the population.

5.1 Park selection

Four parks in the city of Brescia — Parco Gallo, Parco Giffoni, Parco Croce Rossa, and Parco dei Poeti — were selected based on criteria such as size, vegetation structure, canopy density, accessibility, and heterogeneity of the surrounding urban context. Data for the four parks are included in Table 1.

Tab. 1. Surface data about the four sel ected parks in Brescia

Park	Area (m²)	Permeable surface	Semi-permeable surface	Non-permeable Surface	Trees (number)
Parco Gallo	34701	85%	2%	13%	191
Parco Giffoni	18574	90,6%	0,2%	9,2%	198
Parco dei Poeti	28895	84%	15,6%	0,4%	549
Parco Croce Rossa	32989	97%		3%	883

Fig. 2. Location of the four selected parks in Brescia

5.2 Spatial analysis and vegetation assessment

A 500m buffer zone was defined around each park to analyse environmental conditions and health outcomes. Firstly, using GIS technologies, the following elements were mapped within each buffer: land use, building heights, and street networks. Secondly, key climate indicators, have neem derived from satellite imagery, including Land Surface Temperature (LST) and Sky View Factor (SVF) — the latter measuring sky visibility from ground level and indicating a location's ability to dissipate heat. The Tree Canopy Cover (TCC) was also calculated to quantify the extent of arboreal coverage. Areas with denser tree cover consistently exhibited lower surface temperatures, highlighting the cooling function of vegetation and the importance of canopy density in mitigating urban heat island effects.

Tab. 2. Data about the four buffer parks

Park buffer (500 m)	LST	SVF	TCC	NDVI	NDMI
Parco Gallo	39,3°C	0,71	18%	0,14	0,30
Parco Giffoni	34,9°C	0,83	18%	0,38	0,54
Parco dei Poeti	34,8°C	0,87	12,05%	0,13	0,55
Parco Croce Rossa	37,8°C	0,88	19,9%	0,47	0,50

In addition to these spatial analyses, parks' vegetation health was assessed using remote sensing indices such as the NDVI (Normalized Difference Vegetation Index) and NDMI (Normalized Difference Moisture Index). These indices allowed to evaluate the vitality and moisture levels of vegetation, providing a more detailed understanding of the parks' ecological conditions. In particular, NDVI for all parks is between 0.3 - 0.4, indicating low vegetation cover with low vigour or very low vegetation cover with high vigour. NDMI for Parco Giffoni and Parco dei Poeti is between 0.4 – 0.5; these values indicate medium-high vegetation cover with high water stress or medium vegetation cover with low water stress. Parco Gallo and Parco Croce Rossa have slightly higher NDMI values, between 0.5 and 0.6, indicating high vegetation cover and no water stress. NDVI and NDMI were also calculated for the buffers (see table 2). In particular, NDVI around Parco Gallo and Parco dei Poeti it presents very low values (between 0.1 and 0.2) indicating almost no vegetation cover.

Tab. 3. Parks vegetation assessment

Park	NDVI	NDMI
Parco Gallo	0,34	0,53
Parco Giffoni	0,31	0,48
Parco dei Poeti	0,33	0,48
Parco Croce Rossa	0,38	0,55

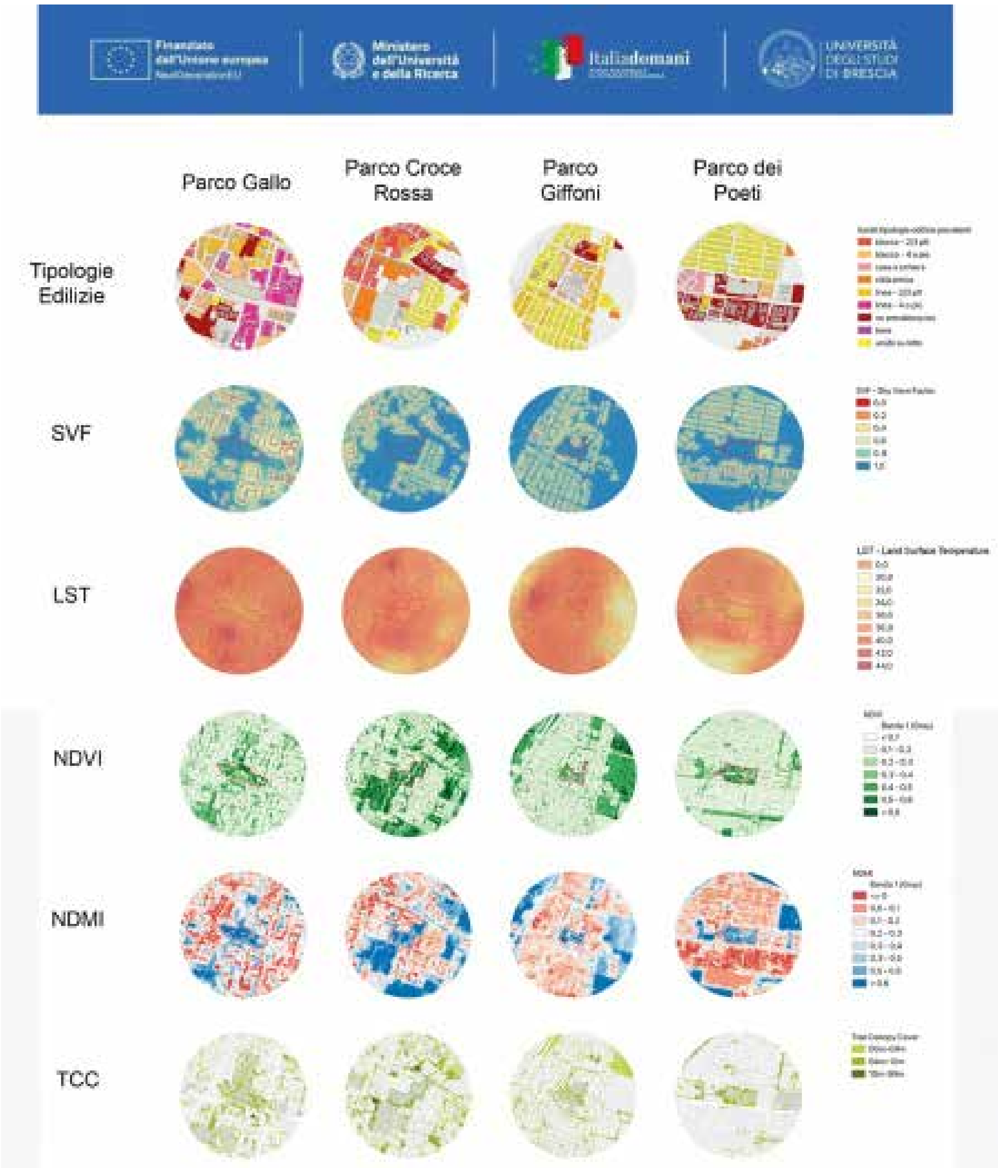

Fig. 4. Analysis of the urban fabric surrounding urban parks within a 500-meter buffer zone. Comparison of indices: Building Typologies, Sky View Factor (SVF), Land Surface Temperature (LST); Normalized Difference Vegetation Index (NDVI), Normalized Difference Moisture Index (NDMI), and Tree Canopy Cover. Source: Author's own elaboration.

5.3 Socio-economic and health analysis

To identify potential correlations between health outcomes and both proximity to and use of green spaces, aggregated data on health conditions and medication have been used. The source is the health database (BDA) of the Brescia Local Health Protection Agency (ATS). To capture these dynamics, disease frequencies are calculated for residents living within two defined buffer zones—250 meters and 500 meters—around each park. For each area, the Standardised Prevalence Rate (SPR) is computed by comparing the number of observed cases of chronic diseases to the expected number based on citywide averages. This methodology enables a robust comparison across different neighborhoods and helps assess whether variations in health status may be associated with environmental and ecological conditions, including biodiversity levels.

Tab. 4. Chronic disease cases in the observed buffers

Park buffer	Observed cases	Expected cases	SPR
250 m			
Parco Gallo	520	542.67	0.96
Parco Giffoni	570	520.88	1.09
Parco dei Poeti	375	342.17	1.10
Parco Croce Rossa	322	280.42	1.15
500 m			
Parco Gallo	2,754	2,808.02	0.98
Parco Giffoni	1,484	1,404.49	1.06
Parco dei Poeti	1,522	1,480.75	1.03
Parco Croce Rossa	1,091	1,069.04	1.02

Tab. 5. Demographic characteristic of the population within the 250 m. buffers

Park buffer (250m)	Population	Females (%)	Foreigners (%)	Median Age
Parco Gallo	1,250	54.2	29.3	48,9
Parco Giffoni	1,178	53.2	18.8	50,0
Parco dei Poeti	766	54.2	13.8	51,5
Parco Croce Rossa	619	54.8	2.9	50,6
Brescia (total)	**192,322**	**51,9**	**19,9**	**48,8**

6. Discussion

The first results of the URBioPark project are based on the urban and morphological analysis of the selected parks and the integration of health and socio-demographic data. These preliminary findings provide an initial understanding of the relationships between urban structure, green infrastructure, and public health.

The ecological assessments related to vegetation and soil biodiversity—crucial for establishing detailed biodiversity indicators—are still ongoing. Their integration will offer a more complete picture of how different components of urban biodiversity contribute to residents' well-being and health outcomes.

Preliminary analyses conducted across the four selected urban parks in Brescia reveal insightful correlations between urban biodiversity, socio-demographic factors, and public health outcomes.

From a demographic standpoint, the population distributions in the four park areas are broadly comparable to the rest of the city in terms of age and male/female ratio. However, significant differences emerge in the percentage of foreign residents: for example, the area surrounding Parco Gallo shows a notably higher share (29.3%) compared to the city average (19.9%), while the Parco Croce Rossa area registers just 2.9%.

In terms of environmental indicators, parks with higher NDVI values and greater canopy density were associated with lower Land Surface Temperatures (LST) and improved microclimatic comfort. Notably, areas with low Sky View Factor (SVF)—indicating a denser urban form—still benefited from significant heat mitigation when supported by robust green infrastructure. These findings confirm the essential role of vegetation and tree coverage in regulating urban temperatures.

From a health perspective, results from the ATS Brescia database suggest emerging patterns. In the 250 m buffer zones, areas around Parco Croce Rossa and Parco Giffoni show a 15% and 9% higher prevalence of at least one chronic disease, respectively—though these increases are not statistically significant. When disaggregated by disease type (hypertension, diabetes, hypercholesterolaemia, cardiovascular and respiratory diseases), the frequencies are slightly above expected values in some areas but remain within non-significant margins.

However, the 500 m buffer analysis confirms a statistically significant 6% higher prevalence of chronic diseases around Parco Giffoni, alongside a 10% increase in hypertension and a 12% increase in cardiovascular conditions. Interestingly, the Parco Croce Rossa area shows a 20% lower prevalence of diabetes compared to the city average.

Regarding mental health, the use of antidepressant medication was also assessed. Slightly higher percentages of antidepressant prescriptions were recorded near Parco Croce Rossa and Parco dei Poeti, though again, not statistically significant. Further logistic regression analysis indicates that women over 65 of Italian nationality are the most frequent users, which may account for some of the geographic variation. When broken down by frequency—at least one vs. at least two prescriptions over three years—only Parco dei Poeti shows a confirmed excess (around +8%) for the higher threshold.

Complementing the quantitative health data, survey responses collected from residents reinforce the correlation between perceived green space quality, biodiversity awareness, and individual well-being indicators.

Residents living closer to greener, more biodiverse parks reported reduced symptoms of chronic stress, improved mental health, and increased physical activity.

Lastly, the data also highlight social and environmental disparities. Lower-income districts with reduced green coverage and fewer biodiversity features tend to exhibit higher rates of chronic disease and report lower satisfaction with environmental conditions. These findings underscore the importance of equitable access to biodiverse green spaces as a means to support both public health and climate resilience in urban environments.

7. Project objectives: towards integrated urban governance

A core objective of the URBioPark project is to generate knowledge and tools that inform urban governance by integrating biodiversity and health into planning and policy frameworks. The project aims to provide actionable strategies that can be adopted at multiple levels—urban design, public health, and community engagement—to foster healthier, more resilient cities.

URBioPark's results are intended to support the inclusion of biodiversity and health criteria within Strategic Environmental Assessments (SEA), masterplans, and local regulatory instruments. The project envisions the establishment of a shared governance model that unites urban planning, environmental management, and public health.

Key strategic recommendations include:

- Urban planning: introduce mandatory biodiversity-health impact assessments in zoning revisions and urban redevelopment projects.
- Green infrastructure: promote tree planting, canopy connectivity, and soil permeability, especially in socio-environmentally vulnerable areas.
- Health integration: develop partnerships with local health authorities to monitor and respond to environmental determinants of chronic disease.
- Citizen engagement: encourage participatory approaches through citizen science, enabling communities to contribute to biodiversity monitoring and park stewardship.
- Education and awareness: launch targeted campaigns and integrate ecological literacy into school curricula to promote awareness from an early age.

Through these actions, URBioPark also aims to establish an interdepartmental governance framework, bringing together expertise and policy from health, urbanism, and environmental sectors under a unified strategy for sustainable and inclusive urban development.

8. Conclusions and future directions

URBioPark project exemplifies how urban biodiversity can be leveraged as a cross-sectoral asset, capable of addressing climate resilience, health equity, and urban sustainability.

By linking scientific research with practical applications and policy recommendations, the project contributes to a paradigm shift in urban planning where nature and public health are integrated rather than treated as separate domains.

The project's outcomes will culminate in a manual of best practices to guide municipalities in biodiversity-sensitive planning. Moreover, its GIS-based methodology offers a powerful decision-making tool for identifying areas in need of intervention and monitoring the impacts of implemented actions.

Future steps include refining the biodiversity-health indicator set, expanding the study to other cities involved in the project (Verona, Padua), and establishing transdisciplinary training programmes for professionals involved in urban health and spatial planning.

URBioPark serves as both a research initiative and a policy incubator. By embedding biodiversity into the core of planning practices, cities can become healthier, more equitable, and more resilient in the face of future challenges.

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