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Plants for a Resilient City: The "Climate-Friendly Parks" Experiment in Reggio Emilia

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Received: 09-22-2025 **Revised:** 10-30-2025 **Accepted:** 11-14-2025

Citation: Zanardi, F., Santunione, G., Despini, F., & Sgarbi, E. (2025). Plants for a resilient city: The "climate-friendly parks" experiment in Reggio Emilia. *Chall. Sustain.*, *13*(4), 560–570. https://doi.org/10.56578/cis130407.

Abstract: Overurbanization poses environmental challenges that threaten human health and biodiversity. Nature-Based Solutions (NBS) enhance urban livability, restore biodiversity, and provide vital Ecosystem Services (ES), such as mitigating the Urban Heat Island (UHI) effect. This study evaluates environmental monitoring at Marco Biagi Park (Reggio Emilia, Italy) as part of the Life City AdapT3 project. Following the introduction of micro-forests, rural edges, tree rows, and a wetland, data were collected to assess local climate mitigation and carbon storage. Microclimatic effects were analyzed using satellite images (Landsat 8) and on-site measurements. Between 2021-2024, summer Land Surface Temperature (LST) decreased in post-intervention period by 2.1℃. Air temperature in urban forest areas averaged 1.2℃ lower, while humidity increased by 10% compared to built-up areas. Using the i-Tree model, it was estimated that Marco Biagi Park stored 332.20 kg of carbon in 2024 and 825.20 kg in 2025—representing a 148.4% increase in just one year. Species of the *Quercus genus*, *Prunus avium* and *Tilia platyphyllos* contributed 58.26% to this carbon storage in 2025. Findings highlight NBS effectiveness in improving urban microclimates and carbon sequestration, reinforcing their role in sustainable city planning.

Keywords: Nature-Based Solution; Microclimate; Urban Heat Island; Microforest; Carbon storage

1. Introduction

Urban areas occupy only 3% of Earth's surface but host about half the global population (Potere & Schneider, 2007). They account for roughly 70% of energy use and 75% of carbon emissions (https://unric.org/it/obiettivo-11-rendere-le-citta-e-gli-insediamenti-umani-inclusivi-sicuri-duraturi-e-sostenibili/). According to the United Nations (2018)'s World Urbanization Prospects, by 2050, nearly two-thirds of people will live or work in cities, intensifying environmental and health risks. This trend demands sustainable, multidisciplinary solutions balancing economic, social, and environmental needs. The IUCN's Nature-Based Solutions (NBS) framework promotes ecosystem restoration and sustainable resource use (Cohen-Shacham et al., 2016), aligning with UN 2030 SDG 11: creating inclusive, safe, resilient, and sustainable cities (https://sdgs.un.org/goals/goal11). Cities play a key role in addressing environmental challenges like intensifying summer heatwaves. Urban materials (e.g., concrete, asphalt) absorb and retain heat due to low albedo, while limited vegetation and dense structures amplify the Urban Heat Island (UHI) effect, raising urban temperatures and stressing public health, biodiversity, and energy demand (Li et al., 2019; Lopez-Cabeza et al., 2022). Land use changes—especially loss of green cover—further heighten this stress (Hussein & Osman, 2024; Jiang et al., 2015). Reggio Emilia, a mid-sized city in Emilia-Romagna, is advancing sustainable development through greening projects like the EU-funded Life City AdapT3 initiative. This includes "Climate Friendly Parks" with environmental features based on NBS: micro-forests (native, adaptive, edible), polyphyte meadows, hedgerows, and tree rows. These micro-forests follow the Miyawaki method—high-density planting to mimic natural succession. Parks were selected based on structure and public use, enabling assessments of local climate impacts and social perceptions. Plant diversity is central to NBS, supporting ecosystem services (ES) such as climate regulation, cultural benefits, and well-being (Isbell et al., 2011). Vegetation cools urban areas via shading and evapotranspiration, influenced by species, leaf traits, and seasonal factors (Escobedo et al., 2011; Givoni, 1991; Qiu et al., 2013; Schmidt, 2010). It also fosters social inclusion and physical activity (Haase et al., 2014). Recent studies increasingly quantify ES using satellite and bio-physical data, including Land Surface Temperature (LST), NDVI, and carbon stock (Haase et al., 2014). A Shanghai study found parks reduced summer air temperatures by 2.1–3.1°C and raised humidity by 1.8–3.8%, with effects declining with distance (Du et al., 2021). Similar findings are reported in cities like London (Vaz Monteiro et al., 2016), Glasgow (Ananyeva & Emmanuel, 2023), and Leipzig (Jaganmohan et al., 2016). Urban areas significantly contribute to greenhouse gas emissions (Dodman, 2011), mostly from energy use (Seto et al., 2014). Vegetation helps offset this by capturing CO_2 via photosynthesis and storing it as biomass (Nowak, 1993). Carbon storage can be estimated through direct (destructive) or indirect (non-destructive) methods using allometric models that link tree dimensions (e.g., height, DBH) to biomass (Apriantoro et al., 2024; Niklas, 2004; Vashum & Jayakumar, 2012). These models vary by species and region (Pilli et al., 2006; Williams et al., 2005), with larger trees sequestering more carbon due to greater leaf area and photosynthesis (Brack, 2002). Deciduous trees absorb more carbon seasonally, but evergreens remove pollutants year-round (Nowak et al., 2006). Tree cover's role in reducing urban CO_2 is well-documented. In Dhaka, 156 tree species sequester 33.24 tons of CO_2 annually (Shadman et al., 2022); a forested area in New York absorbs 0.044 Tg of carbon per year and stores 1.86 Tg (Pregitzer et al., 2022).

This study aims to:

(1) Assess the microclimatic effects of greenery in Reggio Emilia;
(2) Identify heatwave-prone districts using 5 years of LST and NDVI data;
(3) Quantify tree and shrub carbon stock as a long-term ecosystem service.

2. Study Area

The present study focuses on Reggio Emilia and three of the four public parks included in the Life City AdapT3 project, developed in the municipality. The parks involved in the project are as shown in Table 1 and Figure 1.

Table 1. City district of the three urban parks involved in the life project

City District	Park	Park's Area	Total Area Involved
Santa Croce	Marco Biagi	13.000 m^2	8.760 m^2
San Prospero	Ferravilla	33.600 m^2	10.853 m^2
Codemondo	Grimaldi	31.500 m^2	9.414 m^2

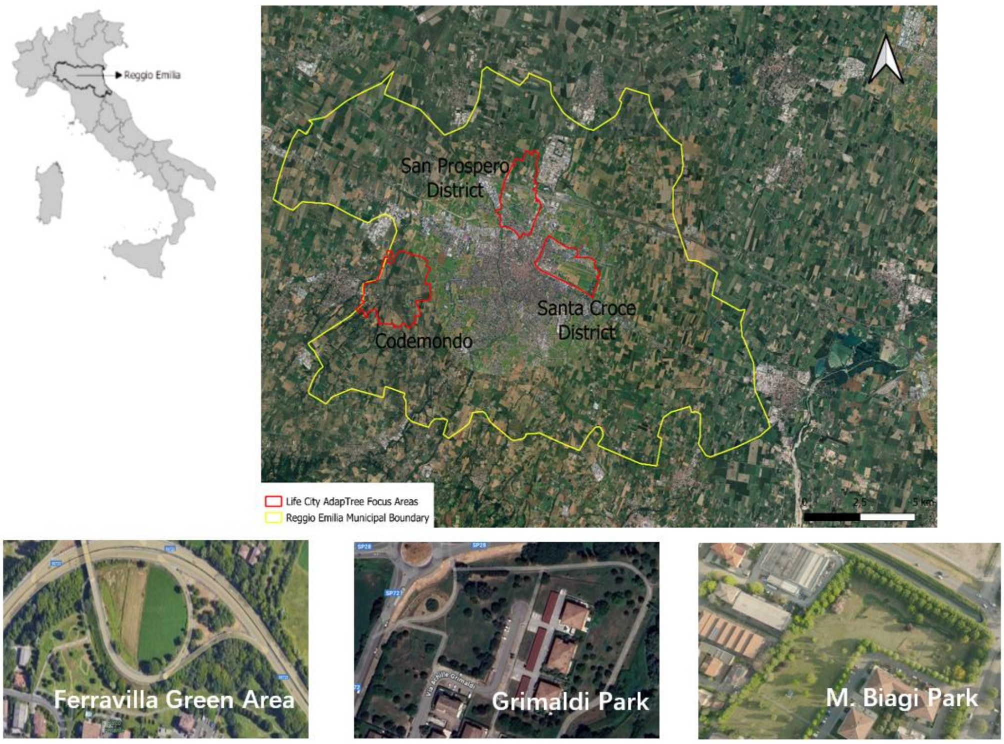


Figure 1. Reggio Emilia: Geographic location of the Life City AdapT3

3. Materials and Methods

3.1 Microclimatic Mitigation Evaluation

The microclimatic effects of urban greening project of Life City AdapT3 Parks were evaluated through:
(1) Remote Sensing - Satellite images analysis to assess LST;
(2) On-site measurements of air temperature and humidity (only Marco Biagi Park).

3.1.1 Satellite data

We used Landsat 8 OLI/TIRS data (Collection 2, Tier 1, Level 2 Surface Reflectance) for the period 2019–2024, focusing on the summer months (June–August) to capture peak LST and vegetation conditions (NDVI). Images were filtered by date, Region of Interest (ROI), and cloud cover (<8%). A custom masking function excluded cloud-contaminated and radiometrically saturated pixels. Thermal band ST_B10 was calibrated to derive LST, while NDVI was computed using SR_B5 (NIR) and SR_B4 (Red), following USGS guidelines.

After preprocessing, image collections were merged by sensor and compiled into composite datasets. For LST, summer composites were used to calculate annual and image-level mean, min, and max temperatures. NDVI composites were analyzed for per-image and seasonal mean and extremum values. To assess the microclimatic effect of greening interventions, we created QGIS Shapefiles for three parks and four buffer zones around them, considering a progressive 50m distance (50, 100, 150, 200 m). These were imported into Google Earth Engine (GEE) and used as ROIs to analyze LST variations using ~16 Landsat images (4/year), comparing pre- (2021–2022) and post-intervention (2023–2024) periods.

We also calculated five-year (2019–2024) average summer LST and NDVI to identify districts most affected by the UHI and lacking vegetation using GEE for LST calculation. To determine LST anomalies, we created circular zones (10–15 km radius) from the city center and selected rural pixels at least 300 m from urban areas using Corine Land Cover data. Mean rural LST values were subtracted from urban LST values to calculate ΔLST, producing a city-wide anomaly map and zoning based on temperature differentials, using a modified methodology developed by the GIS Science Master's School of Padua University.

3.1.2 On-site measurement

The on-site assessment of microclimatic mitigation potential of urban greening was evaluated for the Marco Biagi Park only. The following parameters were measured:
Air temperature (Tair) at 150 cm height
Relative air humidity (RHair) at 150 cm height

Table 2. Environmental devices measuring point and relative codes

Environmental Devices	N° of Measurement Points	Code(s)
Adaptive forest	2, one internal and one external	AFint and AFext
Native forest	2, one internal and one external	NFint and NFext
Wetland	3, nord and south bank and pond	WETsud, WETnord, and WETpond
Rural hedges	1	Re
Tree row	1	Tr
Built-up area 1	1	AreaExt100 m
Built-up area 2	1	AreaExt200 m
Built-up area 3	1	AreaExt300 m

The measurements began on 05/28/2024 and were carried out two times per week until the beginning of September, taking advantage of days with clear skies and no (or poor) ventilation to avoid influences in the detection of the parameters. Furthermore, the parameters were obtained between 12:00 and 14:00, when the sun is at its zenith. Both temperatures and relative humidity were measured using portable instruments (PCE-320 InfraRed Psychrometer), at two points inside the micro-forests (one inside and one at the border), at one point inside the hedgerows, at three points near the wetland (reservoir, south bank and north bank) and at one point between the rows of trees. Air temperature and humidity were also obtained for three different points in the industrial and built-up area located east of the park, with buffers of ≈100 m, 200 m and 300 m away from the centroid of the park itself (defined with QGIS), to highlight any differences between the green area and the built-up area. For air temperature and relative humidity, data were collected at 150cm from ground level, taking care not to expose the sensor thermocouple to the sun. For each sampling point, three replicates were carried out in the measurements to ensure statistical robustness of the analyses. Table 2 presents the codes used to identify the different measurement point.

3.2 Carbon Sequestration and CO_2 Storage

Annual CO_2 storage and sequestration were estimated using the i-Tree Eco model (https://www.itreetools.org/), developed by the United States Department of Agriculture (USDA). The iTree model uses allometric parameters to estimate the amount of Carbon stored and sequestered by plants. The data relating to the height (H) and trunk diameter (DBH) of the tree and shrub species of all the environmental devices of Marco Biagi Park were therefore used. H was measured from the collar, the transition zone between roots and stem, up to the apical bud.

Since the plants were planted only three years ago and with a high planting density, some of them did not reach a height sufficient to allow the diameter measurement at 130 cm from the ground, as per literature (Chave et al., 2014) therefore, where necessary, this was carried out at two thirds of the total height of the plants. For shrubby and polycormic arboreal individuals, height and diameter were measured for at least three main branches. The data were elaborated through i-Tree Eco software to obtain the results, individual by individual, about the stored carbon and CO_2 sequestered by the species planted in the park using the species-specific allometric equations present in the literature.

3.3 Statistical Analysis

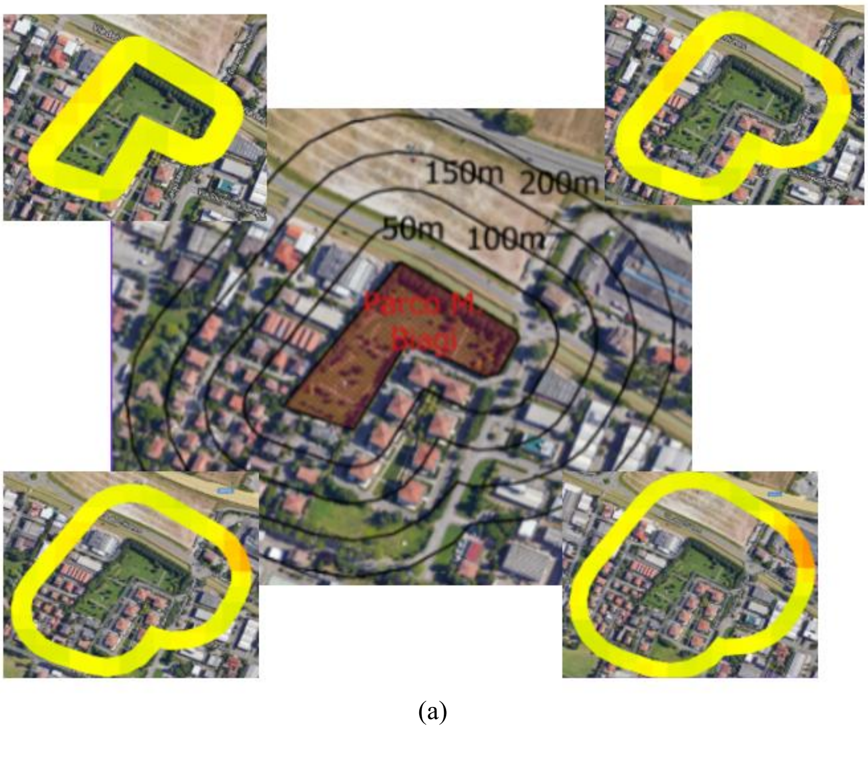
All the statistical analyses were carried out with R software 4.3.3. After checking for normality and homoscedasticity of the data, we proceeded with parametric two-way ANOVA followed by a post-hoc analyses (TukeyHSD) to evaluate whether the greening project had an impact on LST pre- and post-intervention. A one-way ANOVA was used to assess differences in air and soil temperature and humidity at various environmental devices at Marco Biagi Park. We considered a significance level of $\alpha = 0.05$.

4. Results

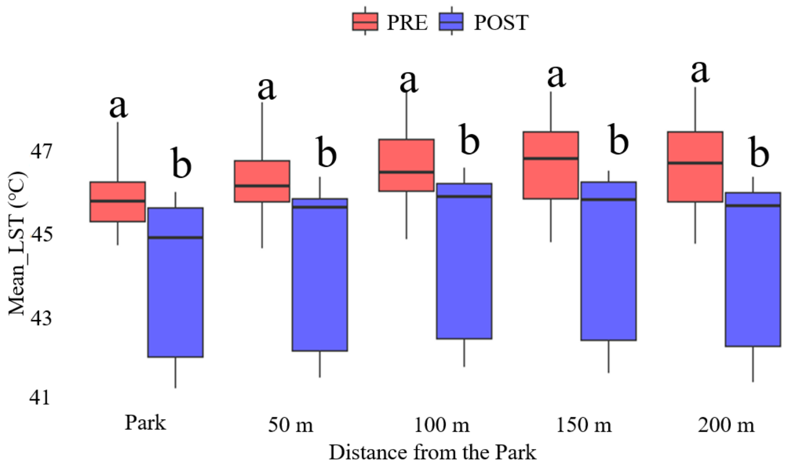
4.1 Remote Sensing

The two-way ANOVA used to assess whether the three parks in Reggio Emilia have a microclimatic mitigation effect on the surrounding areas revealed no statistically significant differences (P-value > 0.05) between the LST of the three parks and the respective four adjacent buffer zones. Additionally, no combined effect of the factors 'distance' and 'pre- vs. post-intervention' was observed (P-value > 0.05). Nevertheless, LST differed significantly between the pre- and post-intervention periods for each park evaluated (P-value < 0.05, Figure 2, Table 3).

Marco Biagi Park recorded the highest average summer LST, with 46.01 ± 1.10°C in the pre-intervention period and 43.87 ± 2.11°C in the post-intervention period. In comparison, Ferravilla Green Area had LSTs of 41.75 ± 2.53°C and 35.21 ± 11.9°C, while Grimaldi Park recorded 42.41 ± 3.62°C and 34.88 ± 11.83°C in the same periods.



(a)



(b)

Figure 2. (a) Marco Biagi Park and buffer areas, and (b) boxplot with statistical differences

Table 3. Mean summer LST value in the Pre and Post period for each park and the relative ΔLST

Park	Mean Summer LST (Pre)	Mean Summer LST (Post)	ΔLST
Marco Biagi	46.01°C	43.87°C	2.15°C
Ferravilla	41.75°C	35.21°C	6.54°C
Grimaldi	42.41°C	34.88°C	7.54°C

The maps of Reggio Emilia, zoned by districts based on the average summer values of LST and NDVI, are presented in Figure 3. Regarding LST, the colour gradient indicates increasing temperature differences, with the darkest red zones experiencing the most warming (3.6–5.8°C) and white areas showing little to no change. In contrast, the NDVI map uses a green gradient to depict vegetation cover. Dark green areas indicate the districts with higher vegetation density, while light green and white areas represent regions with sparse or minimal vegetation. Marco Biagi Park is located in a district where average summer LST values are 2.4–3.6°C higher than those of rural areas, corresponding to an average NDVI of 0.46–0.55. Among the three parks, this district has the lowest vegetation cover and the highest LST differential compared to rural areas. In contrast, Ferravilla Green Area and Grimaldi Park exhibit lower temperature increases compared to rural areas, with average summer LST values of 1.2–2.4°C and 0–1.2°C higher, respectively. These temperature differences are also reflected in the NDVI values, which range from 0.461 to 0.546 for Ferravilla Green Area (similar to Marco Biagi Park), and from 0.59 to 0.65 for Grimaldi Park, indicating a higher vegetation density in the latter.

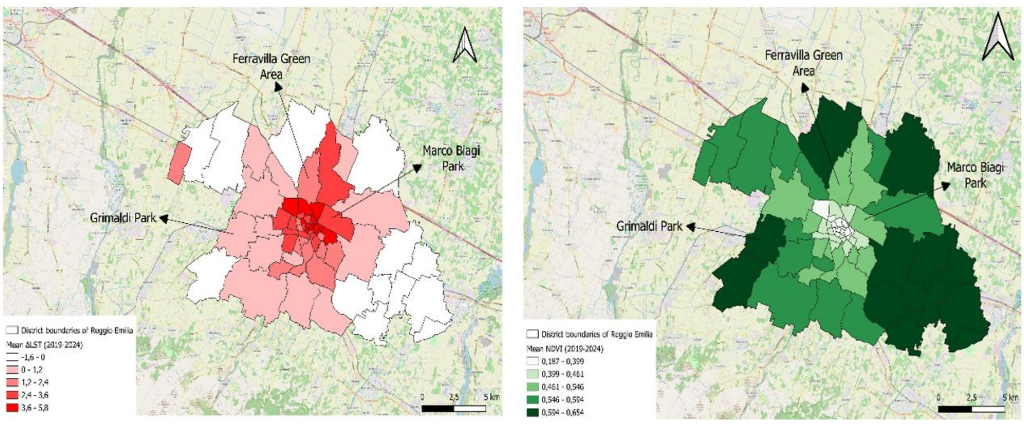


Figure 3. Map of Reggio Emilia districts showing the mean summer LST change (ΔLST) (left) and the mean summer NDVI (right) from 2019 to 2024

4.2 On-Site Analysis

The results of the ANOVA applied to air temperature and humidity data (Tair and Uair) are shown in Figure 4. The different "sampling points" were grouped per environmental devices type, divided based on the presence or absence of statistically significant differences in the measured parameters. Specifically, Tair and Uair, the groupings were as follows:

- AFint and AFext = AF, as no differences were found between the internal and external points.
- NFint and NFext = NF, same as above.
- Wetsud, Wetnord, and Wetpond = Wet.
- Re + Te = Re_Tr.
- AreaExt100 m.
- AreaExt200 m.
- AreaExt300 m.

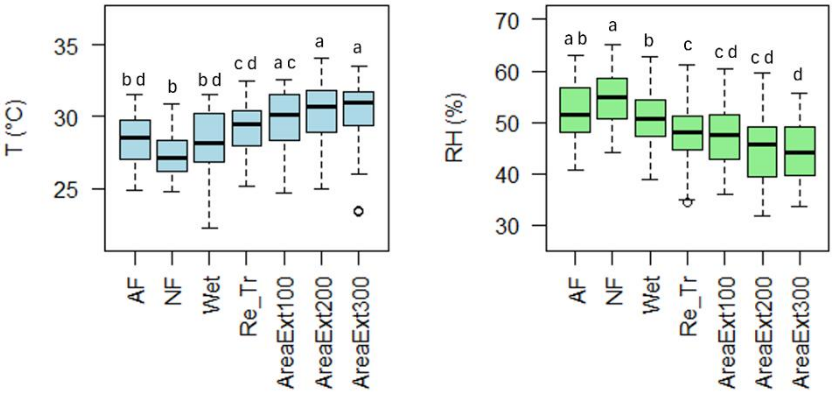


Figure 4. Boxplot of air temperature and humidity with letters indicating the statistical differences

The statistical analysis conducted for these groups indicates the presence of statistically significant differences (P-value < 0.05). In particular, the Native Forest (NF) recorded the lowest average air temperature (27.34 ± 1.55°C). In contrast, the External Areas at 100m, 200m, and 300m from the park were the warmest, with mean temperatures of 29.71 ± 2.11°C, 30.21 ± 2.13°C, and 30.27 ± 2.22°C, respectively. These external areas do not show significant differences among themselves (P-value > 0.05). The average temperature difference between the NF and the External Areas is 2.73°C, while the difference between the AF and the same areas is slightly lower at 1.73°C. Notably, there is no significant difference between the Tair of AF and that of the Wetland Area (considered as a whole: south, north, and pond). Additionally, Hedgerows and Tree Rows (29.10 ± 1.79°C) are, on average, warmer than afforested areas and the wetland but show a significant difference of 0.96 °C compared to the External Areas. These results align with those observed for relative humidity (RHair). As expected, due to the lower recorded temperatures, Native Forest exhibits the highest humidity values (54.63 ± 5.15%) and is the area with the highest relative humidity (P-value < 0.05) compared to other environmental settings. Conversely, the three External Areas show the lowest humidity values (on average, 45 ± 6.13%) with a difference of 9.40% compared to NF, 7.07% compared to AF, and 5.36% compared to Wet. The average humidity values for Re_Tr do not differ from those observed in the 100m buffer zone (P-value > 0.05).

4.3 Carbon Storage and Sequestration

The data provided by the i-Tree Eco software allowed for the estimation of the amount of carbon stored (in kg) and sequestered annually (in kg/year) by the tree component of the environmental devices (Figure 5). For the year 2024 and considering the devices (micro-forests, hedgerows, and trees in rows), the annual carbon sequestration is approximately 76.7 kg/year. The species most effective in removing carbon from the atmosphere are those that have experienced significant growth in the past two years: *Fraxinus excelsior*, *Quercus frainetto*, *Tilia platyphyllos*, *Quercus robur*, *Morus alba*, and *Prunus avium*.

Furthermore, it is estimated that the trees introduced to the park store approximately 332 kg (at May 2024). In this case, the most effective species are those that are numerically more abundant: *Q. frainetto*, *Q. robur*, *T. platyphyllos*, *F. excelsior*, *P. avium*, *M. alba* and *Spartium junceum*. By 2025, the total carbon stored by park trees increased to 825.8 kg, and the annual carbon sequestration rose to 133.8 kg/year. These figures represent an increase of 148.4% in carbon storage and 73.5% in annual carbon sequestration compared to 2024.

Additionally, the most effective species in 2025 remained the same as those identified in 2024: *Q. frainetto*, *Q. robur*, *P. avium*, and *T. platyphyllos* together accounted for 58.3% of the total carbon stored and 36.6% of the total carbon sequestered.

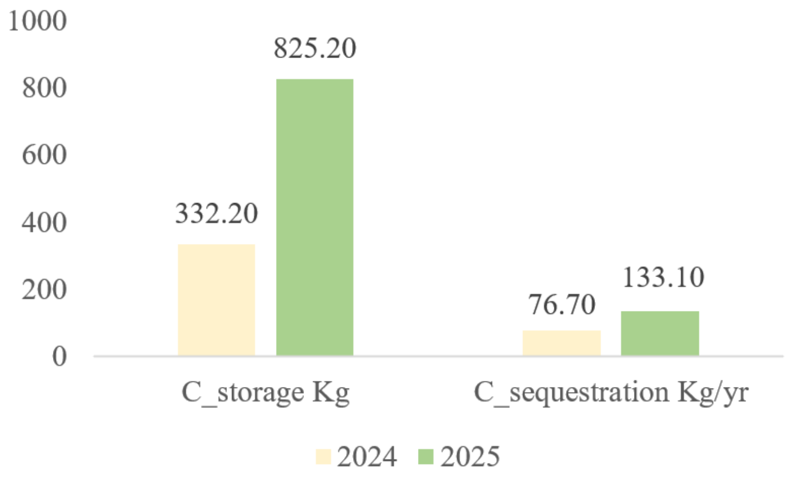


Figure 5. Barchart of carbon storage and sequestration by environmental devices in Marco Biagi Park for the years 2024 and 2025

5. Discussion

Despite the absence of statistically significant differences across the distance buffers for every park analyzed, they exhibit a lower LST in the post-intervention period. This localized cooling is noteworthy, especially given that air temperature recorded at 2 m in the urban meteorological station (Meteorological Station of Reggio Emilia, Reggio Emilia Urban, ARPAE, lat = 44.697809, lon = 10.633698) showed no significant variation (P-value > 0.05) over the same four-years period, suggesting that while overall summer air temperature remained stable through the years and at the city scale, surface-level microclimatic improvements occurred in response to the greening interventions. The absence of a measurable temperature gradient across buffer zones may be attributed to the complexity of the urban environment. Built-up surfaces, street configurations, and the thermal inertia of materials may diffuse or dampen localized cooling effects, making it difficult to detect sharp differences between park interiors and adjacent areas. Furthermore, the presence of small, scattered green patches surrounding each park may contribute to a more uniform temperature distribution, thereby reducing thermal contrast between zones. These factors likely contributed to the lack of a clear distance-based effect, despite the overall success of the interventions in reducing surface temperatures.

The reduced surface area of Marco Biagi Park (see Table 1) likely results in a weaker cooling effect, as smaller parks could be more influenced by adjacent impervious surfaces and could receive proportionally more heat input from their surroundings. This is consistent with previous findings indicating that park size is positively correlated with cooling intensity and spatial extent (Algretawee, 2022; Zhang et al., 2024).

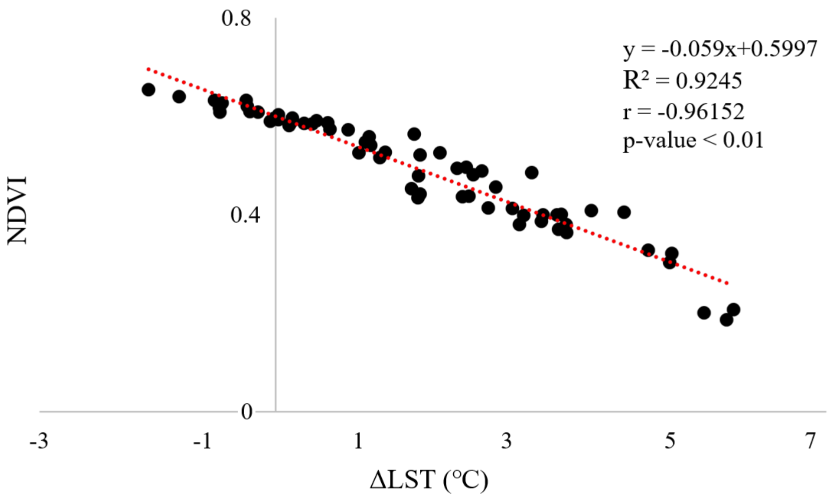


Figure 6. Scatterplot showing the strong negative correlation (r, R^2, $P < 0.01$) between ΔLST and NDVI across Reggio Emilia districts (2019–2024), higher vegetation density is associated with lower surface temperature differentials

The zoned map of the city clearly shows that the urban core exhibits the highest ΔLST, confirming the presence of an UHI effect, where built-up areas retain more heat than the rural surroundings. This pattern is also reflected in the NDVI zoned map, which shows that areas with lower vegetation cover correspond to the highest LST differentials, further supporting the inverse relationship between vegetation density and surface temperature. A strong negative correlation between NDVI and ΔLST (P-value < 0.01, Figure 6) was found, suggesting statistical significance. Similar correlations have been reported in studies conducted in various Italian cities, including Rome (Marando et al., 2019), Modena (Barbieri et al., 2018) and Padua (Todeschi et al., 2022), highlighting the effectiveness of plant-based infrastructure in microclimate mitigation across different urban configurations. However, it is important to recognize that NDVI values are biologically driven and are inherently seasonal (e.g. peak greenness in summer and senescence in autumn), reflecting variations in the phenological cycle of vegetation, as noted by (Eastman et al., 2013). Thus, while vegetation plays a key role in climatic mitigation, the urban configuration and land use within urban districts also exert a strong influence on surface temperature. In Reggio Emilia, areas with low NDVI and high ΔLST—primarily associated with anthropogenic activities, commercial development, and industrial land use—appear to contribute to the observed spatial distribution of surface temperatures. For instance, the Santa Croce district includes a densely built-up residential area in its western section, adjacent to a former third-class airport. Similarly, the Mancasale area hosts a large industrial zone, as well as the city's high-speed rail station. In general, the districts in the greenest category (NDVI > 0.59) are predominantly rural or peri-urban, likely with agricultural or low-density residential use. On the other hand, the hottest zones (ΔLST > 3.6) correspond to dense urban cores, suggesting a concentration of imprevious surfaces and limited tree cover. Districts like Duomo, S. Pietro and Porta S. Croce, reflect central business or historical centres, with lower vegetation due to space constraints or architectural heritage. Some areas in the mid ΔLST range (1.2–2.4 and 2.4–3.6) with moderate NDVI values may offer opportunities for targeted greening strategies — like urban parks, green roofs, or tree-lined streets. In this scenario, districts like Baragalla, San Pellegrino, or Bell'Albero Premuda could be prioritized for intervention, given their balance between density and green potential. These findings are consistent with previous research; for instance, Wang et al. (2023) identified a positive correlation between LST and the expansion of built-up areas in Chongqing (China), as well as a negative correlation between LST and street-level vegetation cover.

Based on these findings, the areas where new greening interventions would be most beneficial include the city center, along with the districts located directly at south and north to the city center, as they exhibit the highest LST differentials and the lowest vegetation cover in the summer period of the last six years (2019–2024).

The statistical analysis conducted on the environmental parameters measured on-site shows a clear trend, as outlined in Figure 4. In both micro-forests, lower temperature values and higher humidity levels were recorded compared to other environmental devices and external areas. The mitigating effect of tree cover on air temperature can be explained by both the direct shading effect generated by the canopy's development and the indirect effect through the process of transpiration. Despite comparable plant growth over the past two years in both micro-forests, the presence of a higher number of species in the native micro-forest has led to more interwoven canopies, allowing it to reach lower Tair values and higher RHair values compared to the adaptive micro-forest. The greater canopy development in the native micro-forest likely contributed to reducing wind speed and, consequently, increasing evapotranspiration, which led to higher relative humidity and lower temperature at a micro-local scale, as previously observed in (Gu et al., 2022; Wu et al., 2022; Zhang & Dai, 2022). The wetland area, thanks to the thermoregulatory action of water, shows values comparable to those of the adaptive micro-forest, both in terms of temperature and air humidity. It also represents a highly functional landscape element with considerable environmental value, demonstrating that even small bodies of water, like the one present in Biagi Park, could mitigate the local climate. Evaporation is the main mechanism through which water performs its thermoregulatory function. This process, favored by the high thermal capacity of water, draws heat from the water body and increases the relative humidity of the air, contributing to cooling the surrounding environment (Manteghi et al., 2015; Syafii et al., 2016). The areas of field hedges and rows of trees are characterized by temperature and humidity values that are comparable to each other, although they are higher and lower, respectively, compared to the micro-forests and the wetland area. This difference is likely related to the different structures of the vegetation, planted using a traditional layout where the plants are spaced apart (in rows and not at the same planting density as micro-forests). It should also be noted that both the *T. platyphyllos* specimens in the tree row and the tree-shrub species in the field hedges are still small, with separated crowns, and thus not yet able to create significant shading.

Nevertheless, the recorded temperatures are lower compared to the surrounding completely built-up areas, highlighting the thermoregulatory potential that these environmental features exert on the local climate.

Based on the data trends, the measurement period (summer 2024) can be divided into three main periods:

- A late spring period (28/05/2024–11/06/2024): During this period, with moderate temperatures (25–27°C), the relative humidity of the air is higher compared to the central summer period.
- A central summer period (18/06/2024–17/08/2024): This period is characterized by higher temperatures and lower humidity. The highest temperature (34.1°C) was recorded on 11/07/2024, in the built-up area 200 m from the park.

- A late summer period (22/08/2024–02/09/2024): This period shows a decrease in temperature and an increase in the relative humidity of the air.

Regarding Carbon storage and sequestration, *Quercus* species (*Q. frainetto* and *Q. robur*) are the tree's species that are the most effective at storing and sequestering carbon from the atmosphere, being the predominant genus for both the year evaluated. This trend is not solely attributable to the numerical abundance of these species, but also to the DBH relative growth rates. The most effective species in terms of carbon capture have shown significant growth over the monitored period, further enhancing their contribution to carbon storage and sequestration. While a few species dominate in carbon terms, maintaining a diverse species composition remains essential for promoting ecological resilience, supporting biodiversity, and ensuring the delivery of a broader range of ecosystem services.

6. Conclusion

This study demonstrated the effectiveness of NBS in enhancing urban microclimatic conditions and carbon storage capacity in Reggio Emilia. Despite the absence of a clear spatial gradient in temperature reduction across buffer zones, all three parks showed statistically significant surface temperature decreases post-intervention. On-site measurements further confirmed that tree-covered areas—especially native micro-forests in Marco Biagi Park, exhibit lower air temperatures and higher humidity levels compared to surrounding built-up zones, highlighting the localized cooling potential of targeted green infrastructure. Carbon sequestration estimates obtained through the i-Tree Eco model, although modest due to the young age of plantings, illustrate the potential for cumulative carbon storage in the long term. *Quercus* and *Prunus* species emerged as the most effective carbon sinks for both 2024 and 2025 evaluation.

Overall, the findings underscore the importance of integrating NBS into urban planning to counteract the UHI effect, support climate resilience, and foster sustainable, healthy cities. These results support further expansion of greening interventions in the most heat-stressed districts, as identified through combined LST and NDVI analysis. Future work should monitor the long-term ecological performance of these interventions and explore their co-benefits, including biodiversity enhancement, social inclusion, and health outcomes.

Author Contributions

Conceptualization, E.S., G.S., and F.Z.; methodology, G.S. and F.Z.; software, F.Z. and F.D.; validation, G.S. and F.Z.; investigation, G.S. and F.Z.; resources, E.S.; data curation, F.Z. and G.S.; writing—original draft preparation, F.Z. and G.S.; writing—review and editing, F.Z., G.S., and E.S.; visualization, F.Z. and G.S.; supervision, E.S. All authors have read and agreed to the published version of the manuscript.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Acknowledgements

The authors would like to thank the LARMA Lab of the "Enzo Ferrari" Department of Engineering and Dr. Sofia Costanzini for her valuable assistance with GGE coding. The Authors are also grateful to Daniela Mordacci and all the technical staff of the Municipality of Reggio Emilia for involving us in this project and for their availability and support during the experimental data collection.

Conflicts of Interest

The authors declare no conflict of interest.

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