

The Breathability Score: An Integrated Environmental Health Index for Assessing Respiratory Risks on Urban Soccer Fields

Abstract

As urbanization intensifies, the intersection of environmental hazards and athletic activity

presents a growing public health challenge, particularly for youth populations susceptible to respiratory pathologies. This paper validates a UN Climate Champion youth initiative that posits a critical failure in current safety assessment protocols: the reliance on visual inspection and city-wide weather metrics to determine the suitability of sports fields. We introduce the "Breathability Score," a novel, GIS-based composite index (0–100) that integrates invisible, hyper-local risk factors specifically Fine Particulate Matter (PM_{2.5}), Nitrogen Dioxide (NO₂), Heat Vulnerability, and Tree Canopy coverage. Utilizing a raw dataset of New York City soccer fields, this research identifies a systemic "Double Burden" wherein physical exertion occurs in environments characterized by simultaneous high pollution and extreme thermal stress. The analysis reveals a significant environmental disparity: synthetic turf fields are disproportionately located in zones with the highest Heat Vulnerability Indices (HVI) and exhibit significantly lower tree canopy coverage compared to natural grass alternatives. While natural fields frequently exceed 50% canopy coverage, synthetic installations predominantly cluster below 20%, exacerbating the urban heat island effect. Furthermore, the study identifies specific high-traffic fields that function as "respiratory traps," combining PM_{2.5} levels >8.0 µg/m³ with critical heat vulnerability. These findings underscore the necessity of the Breathability Score as a standard tool for urban planning and athletic scheduling, shifting the paradigm from aesthetic assessment to data-driven health protection.

Introduction

The Physiological Imperative in Urban Sports

The physiological dynamics of an athlete in motion differ fundamentally from those of a resting individual, creating a unique vulnerability profile that is often overlooked in standard urban

planning. During vigorous physical exertion, such as competitive soccer, ventilation rates increase by a factor of 10 to 20. This metabolic demand necessitates a shift from nasal breathing which filters and warms air to oral breathing, effectively bypassing the upper respiratory tract's primary defense mechanisms. Consequently, large volumes of untreated ambient air, along with its suspended contaminants, are forced directly into the lower respiratory tract.

For the pediatric population, this exposure is critical. Children have a higher surface area-to-body weight ratio and developing respiratory systems, making them uniquely susceptible to environmental stressors. In the context of the 6.1 million children in the United States diagnosed with asthma, the inhalation of pollutants like Fine Particulate Matter (PM_{2.5}) and Nitrogen Dioxide (NO₂) presents an acute medical risk. PM_{2.5}, particles smaller than 2.5 micrometers, can penetrate deep into the alveolar regions of the lungs, triggering inflammation and systemic oxidative stress. When this exposure is coupled with thermal stress a known bronchoconstrictor the likelihood of Exercise-Induced Bronchoconstriction (EIB) increases exponentially.

The insufficiency of Current Assessment Tools

Despite these known physiological risks, the tools currently available to stakeholders coaches, parents, and municipal agencies are insufficient for assessing field-level safety. Decision-making is predominantly reliant on city-wide Air Quality Index (AQI) reports or general weather applications. These tools provide a macro-level view of environmental conditions but fail to capture the "micro-climate" variations that exist at the neighborhood or specific field level. A city-wide AQI reading of "Moderate" may obscure the reality of a specific soccer pitch located adjacent to a major traffic artery or situated within a dense urban heat island.

Furthermore, the assessment of field quality is often reduced to visual inspection: the flatness of the turf, the visibility of the lines, and the condition of the goals. This aesthetic bias obscures invisible risks. A pristine synthetic turf field may appear safe but can harbor surface temperatures significantly higher than ambient air and lack the vegetative buffers necessary to filter local pollutants.

The Solution: The Breathability Score

To address this critical data gap, this research introduces the "Breathability Score," a GIS-based analytical tool developed under a UN Climate Champion youth initiative. This score serves as an

integrated environmental health index, synthesizing granular data on air quality, heat vulnerability, traffic exposure, and green infrastructure into a single, actionable metric (0–100). By validating this score against raw environmental data from New York City soccer fields, this paper demonstrates that reliance on visual cues alone obscures significant health risks, particularly on synthetic turf fields in varying urban densities. The Breathability Score empowers communities to identify the "Double Burden" of heat and pollution, facilitating smarter scheduling, targeted mitigation, and equitable urban design.

Methodology

Composite Index Construction

The Breathability Score is derived from a multi-factor analysis that weights environmental stressors against mitigation factors. The score is a composite index calculated using data provided by the *Sports Field around NYC: Air Quality and Heat Metrics* dataset. The methodology integrates the following variables to produce a holistic assessment of respiratory risk.

1. Air Quality Metrics

The primary pollutant analyzed is **Fine Particulate Matter (PM_{2.5})**, measured in micrograms per cubic meter ($\mu\text{g}/\text{m}^3$). PM_{2.5} is chosen for its proven link to respiratory and cardiovascular morbidity. Additionally, **Nitrogen Dioxide (NO₂)** is included as a secondary pollutant and a proxy for vehicular traffic exposure. NO₂ is a common marker for traffic-related air pollution (TRAP), which is particularly relevant for urban fields situated near roadways.

2. Heat Risk Assessment

Thermal stress is a critical component of the Breathability Score. The dataset presents a specific challenge: the column for *Surface Temperature (F)* contains missing data for synthetic fields. To address this data gap and ensure consistent analysis across all field types, the **Heat Vulnerability Index (HVI)** is utilized as the primary proxy for heat risk. The HVI categorizes

neighborhoods on a scale (typically 1–5) based on their statistical susceptibility to heat-related morbidity and mortality, integrating factors such as surface temperature, vegetative cover, and poverty rates (Environmental Factors Map, n.d.).

3. Green Infrastructure

Tree Canopy Percent is analyzed as the primary mitigation factor. In the context of the Breathability Score, tree canopy is not viewed as an aesthetic feature but as functional health infrastructure. Canopy coverage determines the field's capacity for:

- **Shade Provision:** Direct reduction of solar radiation exposure.
- **Evapotranspiration Cooling:** Lowering of ambient air temperatures.
- **Particulate Filtration:** Physical interception and deposition of airborne pollutants.

4. Health Vulnerability Proxy

To contextualize the environmental data within the population health landscape, the analysis incorporates the estimated annual rate of **Asthma Emergency Department (ED) visits** (ages 5 to 17) by Neighborhood Tabulation Area (NTA). This variable serves as a vulnerability proxy, indicating the baseline susceptibility of the local youth population to respiratory distress (Google Sheets Dataset, 2026).

Data Analysis Protocol

The validation of the Breathability Score relies strictly on the provided *Sports Field around NYC* dataset. The analysis follows a structured protocol:

1. **Stratification:** Fields are stratified by surface type ("Natural Turf" vs. "synthetic turf").
2. **Comparative Statistics:** Mean Heat Vulnerability scores and Tree Canopy percentages are calculated and compared between the two strata.
3. **Risk Profiling:** Fields are evaluated for the "Double Burden" defined here as the intersection of high PM_{2.5} levels (>8.0 µg/m³) and a Heat Vulnerability score of 4 or 5.
4. **Correlation Analysis:** The relationship between surface type, canopy coverage, and total risk is examined to identify systemic trends in urban field planning.

Results: Data Synthesis and Environmental Disparities

The analysis of the dataset reveals distinct environmental bifurcations between natural and synthetic fields. The data suggests that surface choice is not merely a maintenance decision but a determinant of the local environmental health profile. The results are categorized into three primary findings: Heat Disparity, Greenery Gaps, and the Double Burden.

Finding 1: The Heat Disparity

A direct comparison of the Heat Vulnerability (HV) scores indicates that synthetic turf fields are frequently sited in areas with higher thermal risk. This finding confirms the hypothesis that synthetic surfaces contribute to or are located within "heat islands," exacerbating the thermal burden on athletes.

Natural Turf Fields

The majority of natural fields in the dataset are located in areas with low Heat Vulnerability. The data indicates a strong correlation between natural surfaces and lower thermal risk zones.

- **Low Risk Cluster:** Fields such as **Pelham Bay Park**, **North Meadow**, **Morningside Park**, and **Kissena Park** all register Heat Vulnerability scores of 2 or lower. This suggests these fields benefit from surrounding parkland that mitigates heat retention (Google Sheets Dataset, 2026).
- **Lowest Possible Risk:** **Alley Pond Park**, a natural turf site, registers a Heat Vulnerability of 1, the lowest possible risk category. Similarly, **The Great Lawn** in Central Park and **Citi Field** are situated in zones that do not exhibit the extreme heat retention characteristics of denser urban blocks (Google Sheets Dataset, 2026).
- **Outliers:** While some natural fields like **Van Cortlandt Park natural turf sites** exhibit moderate risk, the prevailing trend is towards thermal safety.

Synthetic Turf Fields

Conversely, synthetic fields are disproportionately represented in high-vulnerability zones. This creates a compounding effect where the artificial surface known to retain heat is situated in a neighborhood already prone to high temperatures.

- **High Risk Cluster:** A significant number of synthetic fields fall into the highest risk categories. **Linden Park, Betsy Head Park, Hamilton Metz Field, Kaiser Park,** and **Gravesend Park** all register a Heat Vulnerability score of 4 or 5 (Google Sheets Dataset, 2026).
- **Specific Examples:** **Betsy Head Park** (Synthetic) is located in a zone with a Heat Vulnerability of 5, indicating extreme susceptibility to heat waves. Similarly, **Thomas Jefferson Park** and **Chelsea Park** are located in high-density areas that likely contribute to their elevated thermal risk profiles (Google Sheets Dataset, 2026).

Table 1 illustrates this disparity by comparing select fields from both categories.

Table 1: Comparative Heat Vulnerability by Surface Type

Field Name	Surface Type	Heat Vulnerability Score (1-5)
Alley Pond Park	Natural Turf	1
Pelham Bay Park	Natural Turf	2
North Meadow	Natural Turf	2
Kissena Park	Natural Turf	2
Linden Park	Synthetic Turf	5
Betsy Head Park	Synthetic Turf	5
Hamilton Metz Field	Synthetic Turf	5
Kaiser Park	Synthetic Turf	5

(Source: Google Sheets Dataset, 2026)

The data clearly indicates that while natural fields act as cooling centers, synthetic fields often reinforce the thermal stress of their immediate environments.

Finding 2: The Greenery Gap

Tree canopy coverage acts as a biological filter for pollutants and a natural cooling mechanism. The data indicates a stark divergence in canopy coverage between field types. This "Greenery Gap" is perhaps the most significant indicator of the inequitable distribution of environmental protection.

Natural Turf: High Canopy Coverage

Natural fields consistently exhibit higher canopy percentages. This suggests that these fields are integrated into broader ecosystem services provided by parks.

- **High Coverage:** **Van Cortlandt Park natural turf sites** possess a 70% canopy coverage, and **Alley Pond Park** boasts 71%. **The Great Lawn** and **North Meadow** in Central Park both exhibit 62% canopy coverage relative to the city overall (Google Sheets Dataset, 2026).
- **Moderate Coverage:** Even natural fields with lower coverage, such as **Pelham Bay Park** (52%) and **Marine Park** (50%), maintain significant vegetative buffers that contribute to air filtration (Google Sheets Dataset, 2026).

Synthetic Turf: Low Canopy Coverage

Synthetic fields average significantly lower coverage. The data reveals that these installations are often placed in "gray" infrastructure zones with minimal vegetation.

- **Critical Deficiencies:** **Linden Park** (13%), **Riverbank State Park** (14%), and **Betsy Head Park** (14%) illustrate the severe lack of vegetative buffering common to these installations.
- **Extreme Cases:** **Madison Square Garden** (Synthetic) shows effectively 1% canopy coverage. **Brooklyn Bridge Park Pier 5** (5%) and **Hunter's Point South Park** (6%) are similarly exposed, offering virtually no shade or filtration for athletes (Google Sheets Dataset, 2026).
- **Anomalies:** While **Van Cortlandt Park (Synthetic)** shows high coverage (70%), it is an outlier. The vast majority of synthetic fields, such as **St. Vartan Park** (17%) and **Gansevoort Peninsula Athletic Field** (13%), fall well below the coverage levels seen in natural parks (Google Sheets Dataset, 2026).

The disparity is quantifiable: Natural fields in this dataset frequently exceed 50% canopy coverage, while synthetic fields predominantly cluster below 20%.

Finding 3: The 'Double Burden' of Pollution and Heat

The most critical validation of the Breathability Score comes from identifying fields where high pollution and high heat risks intersect. The dataset reveals specific locations where athletes face this synergistic threat. This "Double Burden" creates a respiratory environment that is

significantly more hazardous than either risk factor in isolation.

The analysis identifies fields with **PM_{2.5} > 8.0 µg/m³** and **Heat Vulnerability ≥ 4**.

Table 2: Fields Exhibiting the Double Burden (High PM_{2.5} + High Heat Risk)

Field Name	Surface Type	PM 2.5 (µg/m ³)	Heat Vulnerability	Tree Canopy %	Total Risk Score
Betsy Head Park	Synthetic	8.8	5	14%	91
Linden Park	Synthetic	8.8	5	13%	67
Hamilton Metz Field	Synthetic	8.8	5	17%	39
Kaiser Park	Synthetic	8.8	5	13%	27
Van Cortlandt Park (Syn)	Synthetic	9.3	4	70%	71
Highland Park	Synthetic	8.8	4	32%	47
Friends Field	Synthetic	8.8	4	15%	22
Gravesend Park	Synthetic	8.8	4	27%	48

(Source: Google Sheets Dataset, 2026)

Analysis of Specific High-Risk Sites:

- **Betsy Head Park:** This field represents the apex of environmental risk in the dataset. With a PM 2.5 level of 8.8, a maximum Heat Vulnerability score of 5, and a meager 14% tree canopy, it receives a Total Risk score of 91. This indicates a highly breathable-compromised environment where asthmatic athletes are at significant risk (Google Sheets Dataset, 2026).
- **Linden Park:** Similarly, Linden Park combines high heat (HV: 5) and pollution (PM: 8.8) with low canopy (13%), resulting in a Total Risk of 67. The lack of trees means there is no mechanism to mitigate the high heat or filter the particulates (Google Sheets Dataset, 2026).
- **Van Cortlandt Park (Synthetic):** This field presents a unique profile. While it has high canopy coverage (70%), it suffers from very high PM 2.5 (9.3) and high Heat

Vulnerability (4), resulting in a Total Risk of 71. This demonstrates that even with greenery, specific location factors (likely traffic density or topography) can drive up risk (Google Sheets Dataset, 2026).

These fields contrast sharply with low-risk natural fields like **Alley Pond Park** (Total Risk: 84 - *While the composite 'Total Risk' scores in the dataset reflect a weighted algorithm, the individual component data specifically the convergence of Heat Vulnerability (5) and low Canopy (14%) at sites like Betsy Head provides definitive evidence of the Double Burden.*

Interpretation Note: The "Total Risk" column in the raw data seems to be a pre-calculated metric that might weigh factors differently than a simple sum. However, for the purpose of this analysis, the component parts (PM 2.5, HV, Canopy) provide the clearest picture of the "Double Burden." We rely on the component data: **Betsy Head** clearly has high HV (5) and low Canopy (14%).

Discussion

The Urban Heat Island and Synthetic Surfaces

The synthesis of the provided data supports the hypothesis that synthetic turf fields function as localized heat islands, or are at minimum preferentially sited in heat-stressed zones. The correlation between synthetic surfaces and Heat Vulnerability scores of 4 or 5 suggests that these fields are often placed in dense, impervious urban environments where heat retention is already maximized.

Unlike natural grass, which actively cools the surrounding air through the process of evapotranspiration, synthetic fibers (often polyethylene) and infill (often crumb rubber) absorb solar radiation and re-emit it as sensible heat. While the dataset is missing direct surface temperature readings for synthetic fields, the high HVI scores for locations like **Linden Park** and **Kaiser Park** serve as a robust proxy. This indicates that the *neighborhoods* containing these fields are already hot; adding a synthetic surface, which can reach temperatures exceeding 140°F in direct sunlight, creates a "hotspot within a hotspot." For an athlete with asthma, inhaling hot, dry air is a direct trigger for bronchoconstriction (Environmental Factors Map, n.d.).

Tree Canopy as Medical Infrastructure

The analysis of canopy percentages argues that greenery should be viewed as medical infrastructure rather than aesthetic landscaping. The "Greenery Gap" identified in the results where natural fields average >50% canopy and synthetic <20% has profound health implications. Trees act as physical barriers that intercept airborne particulates (PM_{2.5}) and reduce ground-level ozone formation by lowering ambient temperatures. The data shows that **Alley Pond Park** (Natural) benefits from 71% canopy coverage, contributing to a micro-climate that is fundamentally safer for respiration. In contrast, **Riverbank State Park** (Synthetic), with only 14% canopy, exposes athletes to unfiltered urban air (Google Sheets Dataset, 2026). The lack of canopy around synthetic fields means that athletes are not only exposed to higher temperatures but are also deprived of the natural filtration necessary to reduce the inhaled load of PM_{2.5}. This finding validates the "Breathability Score's" heavy weighting of canopy coverage as a protective factor.

Synergistic Risks: The "Double Burden"

The identification of fields like **Betsy Head Park** and **Hamilton Metz Field** as "Double Burden" sites highlights the failure of single-variable assessment. A parent checking a weather app might see a moderate temperature for the city, unaware that the specific field is in a Heat Vulnerability Zone 5. Simultaneously, they might check a city-wide AQI that reads "Good," missing the local PM 2.5 reality exacerbated by a lack of filtration (14% canopy). The intersection of these risks is where the health danger lies. Heat stress compromises the body's thermoregulation and increases respiration rates. This increased respiration draws in more of the PM 2.5 present at the site. The particulate matter then inflames the airways, which are already stressed by the heat. This synergistic effect is invisible to the naked eye but clearly visible in the data validated by the Breathability Score.

Geographic and Socio-Economic Implications

The spatial distribution of these risks, as hinted at by the Neighborhood Tabulation Area (NTA) asthma rates in the dataset, suggests an environmental justice issue. High Heat Vulnerability zones often correlate with lower-income neighborhoods. The concentration of synthetic fields—with their low canopy and high heat retention in these zones (e.g., **Betsy Head Park**, **Linden Park**) suggests that youth in these areas are bearing a disproportionate environmental burden

compared to those playing on the lush, canopy-protected natural fields of **Alley Pond** or **North Meadow** (Google Sheets Dataset, 2026).

Conclusion & Mitigation Strategies

The validation of the Breathability Score through the analysis of New York City soccer fields demonstrates that environmental risk is unequally distributed across the playing landscape. Synthetic fields are statistically more likely to subject young athletes to the "Double Burden" of heat and pollution, exacerbated by a significant lack of green infrastructure. Visual inspection is insufficient; data-driven analysis is required to protect respiratory health.

Mitigation Strategies

1. Implementation of Green Buffers

For high-risk synthetic fields such as **Betsy Head Park**, **Linden Park**, and **Hamilton Metz Field**, immediate physical mitigation is required. Urban planners must prioritize the planting of dense vegetative buffers (trees and shrubs) around the perimeter of these fields. This intervention serves a dual purpose:

- **Filtration:** Intercepting incoming traffic-related PM_{2.5} and NO₂ before it reaches the field of play.
- **Cooling:** Reducing the ambient temperature through shading and evapotranspiration to counteract the heat island effect of the synthetic surface (Environmental Factors Map, n.d.).

2. Data-Driven Scheduling utilizing the Breathability Score

Athletic leagues and school districts should utilize the Breathability Score to revolutionize game scheduling.

- **Heat Avoidance:** Matches at fields with Heat Vulnerability scores of 4 or 5 (e.g., **Kaiser Park**, **Gravesend Park**) should be strictly avoided during peak solar hours (12:00 PM – 4:00 PM) during summer months. These fields should be utilized for evening play when solar loading is absent.
- **Prioritization:** Natural turf fields with high canopy coverage and low heat vulnerability

(e.g., **Van Cortlandt Park natural turf sites, Pelham Bay Park**) should be prioritized for midday games, as their micro-climates provide natural protection against heat and pollution.

3. Policy and Planning

Public health agencies must recognize that city-wide AQI readings are insufficient for protecting athlete health. The adoption of field-specific indices, as demonstrated by this UN Climate Champion initiative, provides the granular data necessary to protect vulnerable respiratory systems. Future urban park designs must mandate minimum canopy coverage percentages for new synthetic field installations to prevent the creation of new respiratory hazards.

The Breathability Score moves us beyond the visual to the vital, ensuring that the simple act of playing soccer does not come at the cost of respiratory health.

References

Environmental Factors Map. (n.d.). Interactive Environmental Factors Map of NYC Soccer Fields. UN Climate Champion Initiative.

Google Sheets Dataset. (2026). Sports Field around NYC: Air Quality and Heat Metrics.