

F.AIR
Fragile Air, Unfair Health

Guidelines for Healthier School Environments

Farah Makki



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Building on a research project by



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Publication curation and author
Farah Makki, Politecnico di Milano

**with the support for content and materials provided
by the F.AIR research team:**

Politecnico di Milano (PoliMi)
Department of Architecture and Urban Studies (DASTU)
Eugenio Morello, Farah Makki

Fondazione Transform Transport ETS (TT)
Giulia Ceccarelli, Andrea Gorrini, Lily Scarponi

Segantini Park Association (APS)
Christabel Burton, Gaetano Caia, Riccardo Casalegno, María Salomé Gachet

University of Milan-Bicocca
Department of Environmental and Earth Sciences (DISAT)
Luca Ferrero, Andrea Soldi

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Introduction

Unlocking transformative capacities for sustainable transitions in cities

Eugenio Morello

Laboratorio di Simulazione Urbana Fausto Curti
Department of Architecture and Urban Studies
Politecnico di Milano

Problem statement:

Injustice at distributional and procedural levels

In an era marked by urgent environmental and climate challenges, cities are particularly exposed. The impacts they experience are multiple, generating both material and immaterial damages, as well as environmental and social forms of injustice (e.g., right to access to healthy air, soil and water). Only recently has a more comprehensive understanding of these forms of injustice emerged, enabling a more integrated perspective on the interdependencies among issues that are typically addressed within siloed governance systems (Amorim-Maia et al., 2022). In particular, the boundaries between environmental and social stressors, together with their associated impacts, are becoming increasingly blurred. This growing overlap makes it difficult to operationalize and ensure the effectiveness of policies and strategies conceived within isolated thematic domains. Within this complex landscape of polycrisis, cities have revealed their fragility and limited capacity to respond to urgent societal challenges with adequate tools (Krueger et al., 2022).

Injustice manifests itself at both the distributional and procedural levels (Moroni, 2020). The first dimension, namely distributional injustice, emerges from the interaction between environmental and climate hazards and the exposed and vulnerable entities, as well as from their capacity to respond and enhance resilience. This perspective aligns with the risk equation, which integrates environmental and climate factors with social and societal dimensions, particularly in relation to the resources and assets that affected entities can mobilise. Air pollution provides a paradigmatic example*. Its distribution varies across space, resulting in uneven exposure among populations. This spatial variability is strongly influenced not only by atmospheric dynamics, but also by the location of pollution sources, such

as industrial settlements and major road infrastructures, which tend to concentrate emissions in specific urban areas (Thunis et al., 2021). The spatial distribution of exposure often reflects market-driven dynamics. Areas more affected by these sources typically experience lower real estate values, fewer green solutions, and limited access to protection and health measures (Stafoggia et al., 2019). This configuration contributes to a socio-economic divide, whereby more vulnerable populations are disproportionately located in high-exposure areas, thus facing higher environmental and health risks. Moreover, when environmental challenges are less visible, as in the case of the “invisible” nature of air pollution, their long-term health impacts are harder to perceive, reducing public awareness and sensitivity.

Distributional injustice is further exacerbated when considering the priorities and value systems of exposed and vulnerable populations, as well as their limited capacity to enhance healthy life conditions and resilience to various environmental shocks. This raises critical questions regarding responsibility. Who is in charge of responding to and supporting fragile communities? What role should public institutions play in empowering individuals and fostering transformations towards a more resilient society?

These questions lead to a second, equally critical dimension, which is procedural injustice. This concerns the tools available to enable sustainable societal transformation and the governance mechanisms that allow action to be carried out effectively and efficiently. In this regard, the boundaries of action and responsibility are often difficult to define. This is fundamentally a matter of trans-scalarity and involves the delineation of areas of influence, the organisation of deliberative processes, the identification of decision-makers and beneficiaries, the exercise of power, and the translation of strategies into actionable measures. It also includes monitoring and evaluation processes, as well as the question of who assesses the effectiveness of implemented actions and in what ways.

(*) This volume is situated at the intersection of environmental health, urban planning, citizen science, and environmental justice research. It draws on fine-grained air quality monitoring, spatial analysis of urban form, and participatory co-creation methods to address a largely invisible yet critical dimension of environmental injustice: the unequal exposure of children to air pollution in and around school environments. While climate dynamics, particularly the meteorological conditions of the Po Valley, influence ambient air quality, the primary focus of this work is on air pollution exposure and its governance, rather than on climate change mitigation.

For instance, local governments often have limited authority and capacity to address environmental and climate challenges through norms, regulations, and policies. Action is frequently determined at higher governance levels, such as regional, national, or international ones. However, the coherence and cumulative effects of multi-level governance remain difficult to assess. In the case of air quality regulation, this often generates frustration. Citizens demand stronger action from local governments, which may lack the mandate to enforce stricter regulations or to significantly influence pollution levels, especially when background pollution is driven by supra-local conditions. As a result, a complex geography of ‘response-abilities’ emerges, potentially discouraging action across different levels, from individuals and communities to cities and broader societal systems. When it becomes difficult to disentangle and assess the contributions of different actors operating at multiple scales, fostering accountability, care, and collaboration becomes even more challenging. These issues and questions constitute the foundation of the F.AIR project, which originates and operates within this complex landscape of multiple forms of injustice and diverse avenues for action.

Hypothesis: Addressing environmental inequalities through collective action, urban form and reliable knowledge

To address inequalities in exposure to environmental and climate challenges, as well as the evident shortcomings of current policies, and to more effectively contribute to sustainable urban transitions, we argue that a different posture is required. Focusing on inequalities related to air quality exposure, the F.AIR approach and its underlying hypotheses are articulated around three main standpoints, each suggesting directions for operationalizing responses to both distributional and procedural injustice. Firstly, local action plays a crucial role in sustainable transition processes. It is therefore necessary to explore ways of acting that interact with and connect different levels and spheres of influence shaping societal transformations (Gosnell et al., 2019). In this perspective, the co-production of solutions represents a key approach to raising awareness and contributing to the construction of a geography of response-abilities (Makki & Morello, 2025), through which capacities can be revealed and new forms of empowerment can emerge.

Secondly, urban form and, more broadly, the urban environment play a decisive role, as do urban planners and decision-makers. In the case of air quality, this implies moving beyond consolidated practices that focus primarily on reducing pollutant emissions, and expanding the scope of intervention to include other phases of air quality dynamics, such as air circulation and distribution, deposition processes, and patterns of human exposure (Wu et al., 2025). These dimensions are strongly influenced by urban form and material conditions, yet they are often neglected in existing policies. This gap can be traced back to a lack of integration between urban design and air quality governance. Urban planning regulations rarely incorporate air quality considerations, while air quality policies tend to overlook the role of urban form, underestimating its impact. In line with the risk equation, exposure to air pollution can be significantly reduced by acting on spatial configurations, for instance by relocating vulnerable populations away from hotspots or by modifying urban form to influence air flows and the circulation of air between buildings, echoing Gehl’s notion of “life between buildings” (Gehl, 2006).

Thirdly, building trust at both community and individual levels necessarily relies on the production of reliable knowledge, grounded in accessible information and data. Transforming data into meaningful knowledge is a delicate process that requires involvement and co-production. In this regard, co-monitoring approaches, which engage people directly in assessing and taking care of the air they breathe, represent a key strategy. Citizen science methods can therefore complement institutional approaches, enabling cities to collaborate more effectively with their inhabitants on environmental and climate challenges. A shift in perspective is needed to move beyond the tendency to evaluate citizen science primarily in terms of its compliance with official data standards. Rather, its value lies in fostering direct engagement, empowerment, and the co-construction of a shared knowledge base and collective vision to be sustained over time (Makki & Morello, 2025, 2026). For instance, air quality monitoring initiatives based on citizen science are often questioned or not fully supported by local governments and environmental agencies, due to concerns about scientific robustness and procedural compliance, as well as the risk of generating misleading information or alarmism.

However, the strong engagement and willingness to contribute demonstrated by citizens should be recognised as a critical resource. It can help build a broad base of informed and active participants, thereby supporting the adoption of more ambitious and stringent policies. In this sense, moving from niche practices to regime change, as suggested by transition theories (Geels, 2011), and leveraging shared challenges to overcome local frictions, are essential steps in strengthening the roles and capacities of multiple actors. This is key to sustaining co-production strategies within urban contexts.

Application: Testing co-production, Knowledge production, and the shaping of urban form through F.AIR

“F.AIR – Fragile AIR, Unfair Health, assessing access to healthy environments from schools to communities” is a project funded by Fondazione Cariplo under the 2024 Inequalities Research call. It represents the most recent initiative developed within the “Fausto Curti Urban Simulation Laboratory” (Labsimurb) at Politecnico di Milano. It builds on over a decade of research and experimentation focused on co-production approaches to support urban transitions towards sustainability. Over the years, a range of co-creation methods have been applied, targeting different audiences and stakeholders depending on the specific case study and on the environmental resource under investigation.

Working consistently within community-based urban settings, the Labsimurb research record has addressed multiple domains, including energy, water, air, soil, climate, and nature-based solutions. Across these experiences, a common assumption has guided the work: climate action can be more effectively implemented through a productive combination of evidence-based knowledge, derived from modelling and simulation as well as sensing and monitoring of environmental phenomena, and collective participation in deliberative processes. This also implies aligning proposed solutions with communities’ capacities, inclinations, and willingness to engage in their long-term management. In this perspective, building transformative capacities requires the integration of informed environments and co-governance models.

Within this trajectory, F.AIR adopts and further develops this posture by testing a set of complementary strategies. Firstly, it explores collective action through a variety of engagement methods targeting citizens, students, and policymakers. These activities are designed to foster awareness, participation, and shared responsibility in addressing air quality challenges.

Secondly, F.AIR investigates the production of knowledge, information, and data related to air quality through multiple channels. A key component is the use of distributed low-cost sensors, enabling the collection of spatially diffused data and their visualization through geo-referenced platforms.

This approach highlights both opportunities and challenges associated with citizen-generated data, including issues of measurement reliability, continuity of data collection, and maintenance over time. Long-term data accumulation is particularly valuable, as it allows for more robust interpretations of environmental dynamics. At the same time, important challenges emerge in relation to spatial representation. The density and distribution of sensors influence the quality of mapping outputs, affecting interpolation processes and potentially reducing precision when data granularity is insufficient.

Thirdly, the project explicitly investigates the role of urban design and urban actors in addressing air quality. It questions whether and how urban form can be more systematically integrated into air quality policies. This involves reconsidering the role of planners and designers, and assessing the extent to which urban form can influence air circulation, pollutant distribution, deposition processes, and patterns of human exposure. Moving beyond approaches that focus exclusively on emission reduction, F.AIR explores the possibility of acting on multiple phases of air quality dynamics.

This also raises broader questions regarding the integration of policy domains. Can air quality policies effectively interact with urban planning and urban regeneration strategies? Are designers sufficiently aware of the environmental implications of their decisions when shaping urban spaces, selecting materials, and defining land-use distributions? To what extent do they recognise and address distributional inequalities embedded in the spatial configurations they contribute to produce?

By developing guidelines, F.AIR does not aim to provide definitive answers, but rather to open up critical questions and reveal multiple avenues for action. In doing so, it contributes to reframing urban air quality management as a multidimensional challenge, requiring the alignment of social engagement, knowledge production, spatial design and policy making.

Conclusion: reframing roles and capacities towards just transitions

The experience of F.AIR highlights the emergence of an increasingly complex picture of urban transitions. Addressing environmental inequalities, and air quality challenges in particular, requires moving beyond sectoral and fragmented approaches towards an integrated eco-socio-technological perspective. Transitions are not only technical or environmental processes, but are deeply embedded in social practices, spatial configurations, and governance structures. In this context, establishing and strengthening a dense and interconnected ecosystem, both temporally and spatially, becomes a key enabling condition for successful transitions. Such an ecosystem is constituted by a constellation of material and immaterial anchor points, including infrastructures, knowledge systems, institutional arrangements, and social practices, which together support continuity, coordination, and the capacity to act over time.

In this sense, the relevance of situated and place-based strategies becomes evident. Actions need to be grounded in specific contexts, close to people's everyday experiences, perceptions, and priorities. This proximity enhances visibility and recognition of environmental challenges, fostering awareness and, ultimately, a willingness to take care. Such processes are essential for the development of response-abilities, understood as the capacity of individuals and communities to engage with and respond to context-specific challenges. Through these dynamics, virtuous cycles of action can emerge, strengthening the ability of urban systems to adapt and transform. A key question concerns leadership in these processes. It is neither realistic nor desirable that research institutions alone take the lead in initiating and sustaining such transformations.

While they can play a crucial role in experimentation and knowledge production, these experiences point to the need for new professional figures within urban governance and design. These include intermediaries and hybrid practitioners capable of orchestrating and bridging across different domains of knowledge and action. Such roles require the ability to combine quantitative and qualitative forms of knowledge, to translate between technical and social languages, and to connect evidence-based approaches with participatory and deliberative processes. Moving beyond purely data-driven or technocratic solutions, the emphasis shifts towards informed, shared, and negotiated decision-making processes. In this perspective, the value of urban transformation lies not only in measurable project outcomes or performances, but increasingly in the processes that enable engagement, empowerment, and the collective construction of capacities within society. At the same time, several open challenges remain. A first issue concerns the mainstreaming of these approaches within the everyday routines of local governments. While many initiatives emerge as experimental or project-based activities, their long-term impact depends on their institutionalization and integration into standard practices.

A second challenge relates to continuity. Niche initiatives often rely on committed individuals or specific leadership configurations, which represent both a strength and a limitation. When these actors withdraw, there is a risk that processes of co-production and co-monitoring lose momentum. Ensuring continuity therefore requires the development of robust and resilient ecosystems of actors, capable of sustaining activities over time. In this sense, shared governance arrangements and co-production practices should be supported by redundant and distributed structures, so that the failure or withdrawal of one element does not compromise the entire system. Ultimately, advancing sustainable urban transitions requires not only new tools and knowledge, but also a reconfiguration of roles, responsibilities, and capacities across society. It is through the alignment of social engagement, spatial design, and governance and policy innovation that more just and effective responses to environmental challenges can be achieved.

F.AIR
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Guidelines for Healthier School Environments

Farah Makki

Laboratorio di Simulazione Urbana Fausto Curti
Department of Architecture and Urban Studies
Politecnico di Milano

Why these guidelines?

The context

Air quality inequalities around schools remain a largely invisible yet critical dimension of environmental injustice. While children and adolescents are among the most vulnerable to air pollution exposure—with over 1,200 deaths annually in Europe among youth under 18—they have little power to protect themselves or influence the policies that shape the air they breathe. The effects are particularly severe around educational settings, where daily exposure during critical developmental years can lead to increased risks of chronic diseases later in life. Yet despite growing recognition that place-based interventions around child-centric settings like schools fall within the direct mitigation sphere of local governments, a significant gap persists: we lack fine-grained knowledge about how air pollution exposure varies across different school environments, neighbourhoods, and everyday routes that children take.

These guidelines emerge from the F.AIR – Fragile AIR, Unfair Health research project, a multidisciplinary initiative that brings together research institutions and foundations (Politecnico di Milano, Transform Transport, Università degli Studi di Milano-Bicocca), civil society organisations (Associazione Parco Segantini), and public sector partners to address this knowledge gap. Working primarily in Milan's Districts 5 and 6, the project develops methodologies for improving fine-grained air quality monitoring through citizen science, mapping socio-environmental inequalities often overlooked by institutional data, and co-creating mitigation measures with school communities.



Spotlights

You'll see this lamp icon throughout the guidelines. It shines a light on some key facts and learnings from the F.AIR research.

Why these guidelines?

What will you find in these guidelines?

This document is structured to support practitioners, policymakers, school communities, and researchers in understanding and addressing air quality inequalities around educational environments:

We start by establishing the foundations for this work: why this issue matters, the growing attention to urban health and environmental justice, the F.AIR research questions, and the Milan context that makes this work both urgent and representative of broader challenges in the Po Valley region.

Monitoring & data (Part 1) guides you through the technical and conceptual work of making air quality visible at the scale that matters for children's exposure. It suggests how to combine citizen-sensing data, spatial analysis of urban forms and mobility patterns, and place-based observations to move from "data mosaics to sensemaking", revealing patterns of inequality that connect air quality measurements with the lived reality of school environments.

Urban form & inequalities in access (Part 2) explores how school environments differ in their spatial configurations, identifying six typical urban situations that shape exposure patterns differently. It shows how analysing these variations from compact urban fabrics along traffic corridors to peri-urban settings helps identify specific hotspots and context-sensitive intervention opportunities.

Design strategies for mitigation (Part 3) provides a practical framework for action, guiding you through identifying sensitive places, choosing intervention scales, and selecting from seven categories of measures from street space reallocation and green infrastructure to sustainable mobility options and air quality monitoring. These strategies emerge from extensive co-creation work with over 45 actors from school communities, civil society, and policy institutions.

Engagement & co-creation pathways (Part 4) offers concrete formats and tools for participatory processes that bring together diverse actors from future urban professionals and school communities to citizens and policymakers in co-producing knowledge and co-designing healthier school environments.

The final section **Policy Pockets for the Future** concludes with recommendations for building stable alliances, improving data practices, and scaling insights from the F.AIR pilot experience to inform broader urban health strategies.

Who are these guidelines for?

This resource is designed for multiple audiences working at the intersection of children's health, urban planning, and environmental justice: municipal officers responsible for environment, mobility, education, and urban planning; school communities including teachers, parents, and administrators seeking to improve their local environments; civil society organisations advocating for healthier cities; researchers and students exploring methods for addressing environmental inequalities; and policymakers developing strategies for clean air zones and child-friendly urban environments.

How to use these guidelines?

You can read this document linearly to understand the full F.AIR methodology, or navigate directly to specific sections relevant to your needs. Each chapter builds on evidence from the Milan pilot while offering transferable principles that can be adapted to other urban contexts facing similar challenges of air pollution, environmental inequality, and the need for healthier spaces for children to learn, play, and grow.

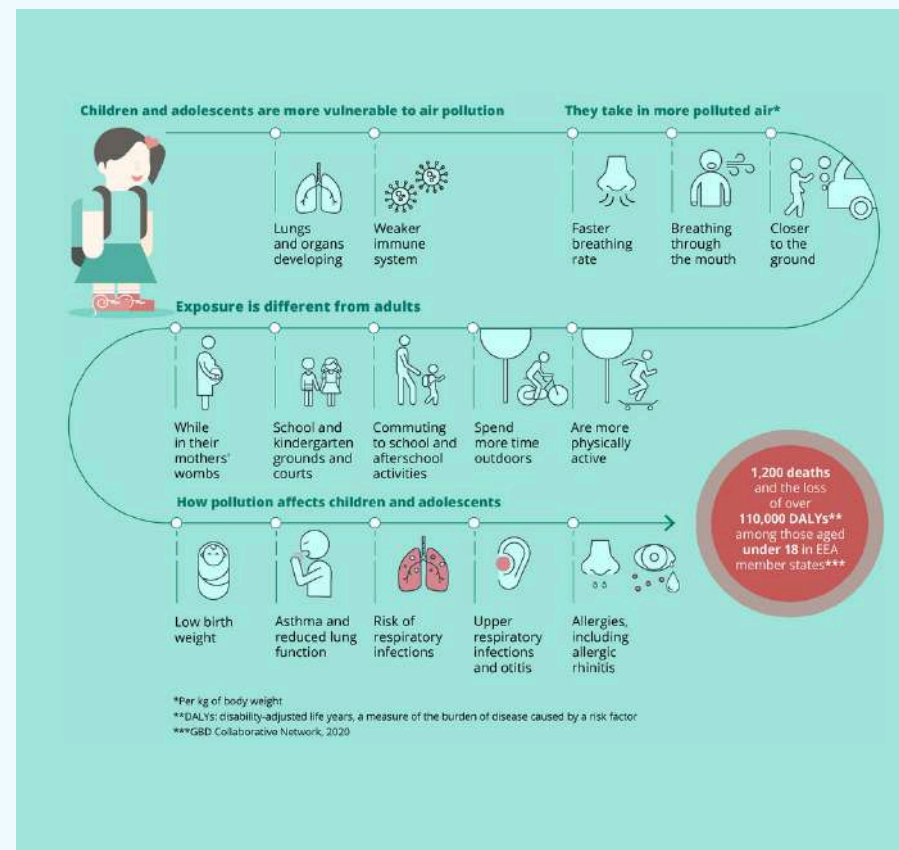
Research context

Right to environmental justice

Studies have shown that equal exposure to air pollutants does not translate into equal health impacts (EEA, 2023). The effects of air pollution are particularly harmful for children and adolescents, due to their developing bodies and immune systems (EEA, 2023). Every year in Europe, over 1,200 deaths and more than 110,000 disability-adjusted life years are estimated among people under 18. Asthma (over 9% of EU children), respiratory infections, and increased risks of chronic diseases in adulthood are all influenced by long-term exposure to pollution (EEA, 2023; Milligan et al., 2016; OECD, 2016).

Yet, although children and adolescents are among the most vulnerable, they can do little to protect themselves or to influence air-quality policies. Mitigating exposure through place-based interventions around child-centric settings such as schools and kindergartens has therefore been promoted as both effective and firmly within the action sphere of local governments (EEA, 2023). However, inequalities in access to healthy environments often remain under-examined in spatial research, particularly in the everyday spaces of exposure at the local scale and around school facilities.

This research responds to that gap by generating knowledge about this overlooked dimension of inequality and by developing methodologies to improve fine-grained air-quality monitoring and mitigation policy through citizen science. It focuses on identifying local vulnerable hotspots of exposure and on creating healthier access to school environments, thereby contributing to the growing attention to urban health and environmental justice.



Infographic on children's exposure to air pollution. Source: European Environment Agency (EEA), 2023

In recent years, there has been an increased commitment to promoting citizens' rights to live in a healthy environment, to be informed, and to actively participate in addressing environmental challenges. The Aarhus Convention (UNECE, 2018) and EU Directive 2003/35/EC (European Parliament et al., 2003) have strengthened the right of access to environmental information and public participation in decision-making on environmental plans and programmes.

Building on this rights-based framework, the European Commission's "Pathway to a healthy planet for all" (EU Monitor, 2021) aims to achieve zero pollution for air, water, and soil by 2050.

The new Ambient Air Quality Directive (AAQD) (European Union, 2024) is expected to support local authorities' efforts to enhance air-quality monitoring and modelling, raise public awareness about health effects, and encourage changes that minimise harmful exposure.

These evolving rights and policy frameworks reinforce the view that unequal exposure to pollution—especially for children in highly exposed school environments—is a matter of environmental injustice and must be addressed through informed, participatory action.

Cities: an “underestimated” arena of influence

In this changing context, cities are becoming key playgrounds for testing solutions and activating public efforts to increase fine-grained air-quality monitoring through processes of knowledge co-production for non-harmful lifestyles and environments. Local actions at the city scale can, for example, improve PM_{2.5} and NO₂ concentrations (Thunis et al., 2021; Crosignani et al., 2021). Yet cities often underestimate their responsibility in governing the generation of air pollution due to gaps in methodological choices and underlying assumptions. Recognising cities as central sites of responsibility and experimentation is, however, crucial for translating these rights into concrete changes in children's everyday places.

Citizen sensing has also emerged as a form of active participation in “challenging traditional allocations of responsibilities” (Berti et al., 2023) and in monitoring local environmental problems. At the same time, translating citizen-generated air-quality data into robust evidence for policy remains challenging, due to issues of data quality, reliability, and legitimacy (Mahajan et al., 2022).

This publication acknowledges areas of ongoing debate. The policy relevance of citizen-generated air quality data remains contested: while low-cost sensors can reveal spatial inequalities invisible to sparse official networks, their precision is lower than reference instruments, and their integration into formal regulatory processes remains limited (Berti et al., 2023). Co-monitoring networks require calibration, maintenance, and clear protocols if they are to complement institutional monitoring rather than be dismissed as anecdotal.

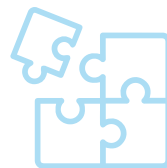
Moreover, local urban interventions, however well-designed, can only address a fraction of air quality dynamics, since regional background pollution – driven by heating, agriculture, industrial emissions and traffic – largely determines ambient concentration levels (INEMAR-ARPA Lombardia, 2025; Thunis et al., 2021). These limits clarify where schools and municipalities can act and where coordinated action at higher governance levels remains essential.

Against this background, F.AIR approaches citizen sensing and co-creation not just as technical tools but as vehicles for environmental citizenship, shared ownership, and co-produced evidence that can inform local decisions about school environments. The project therefore experiments with ways of strengthening the credibility and usability of citizen-generated data in dialogue with public authorities.

Objectives

These guidelines build on the F.AIR research findings*, which explore how social, environmental and spatial inequalities shape access to healthy educational settings and to clean air around them, focusing first on the school-age population as a starting point for a broader population-wide approach in future studies. It seeks to fill key methodological gaps by improving how we map fine-grained exposure, involve affected communities, and strengthen the use of citizen-generated evidence to support local decision-making and the design of context-sensitive mitigation measures. More specifically, it aims to:

(*) Limitations and Transferability
The findings presented in the following pages are grounded in a pilot study in Milan's Districts 5 and 6. Conclusions are indicative rather than statistically generalisable. Future research should test these approaches in other urban contexts, with larger school samples and more developed citizen-science infrastructure, to build a stronger evidence base for policy action. These guidelines offer a replicable framework and an invitation to extend this work beyond its pilot origins



Top up

a knowledge gap on children's access to healthy school environments and clean air.



Promote

citizen science for more widespread environmental monitoring.



Map

socio-environmental inequalities often overlooked by institutional data.



Involve

new generations and future urban planners in action-research processes on the urban determinants of environmental injustice.



Strengthen

the role of school communities and public decision-makers, promoting policies and guidelines for more equitable access to school spaces.

Milan Pilot Process

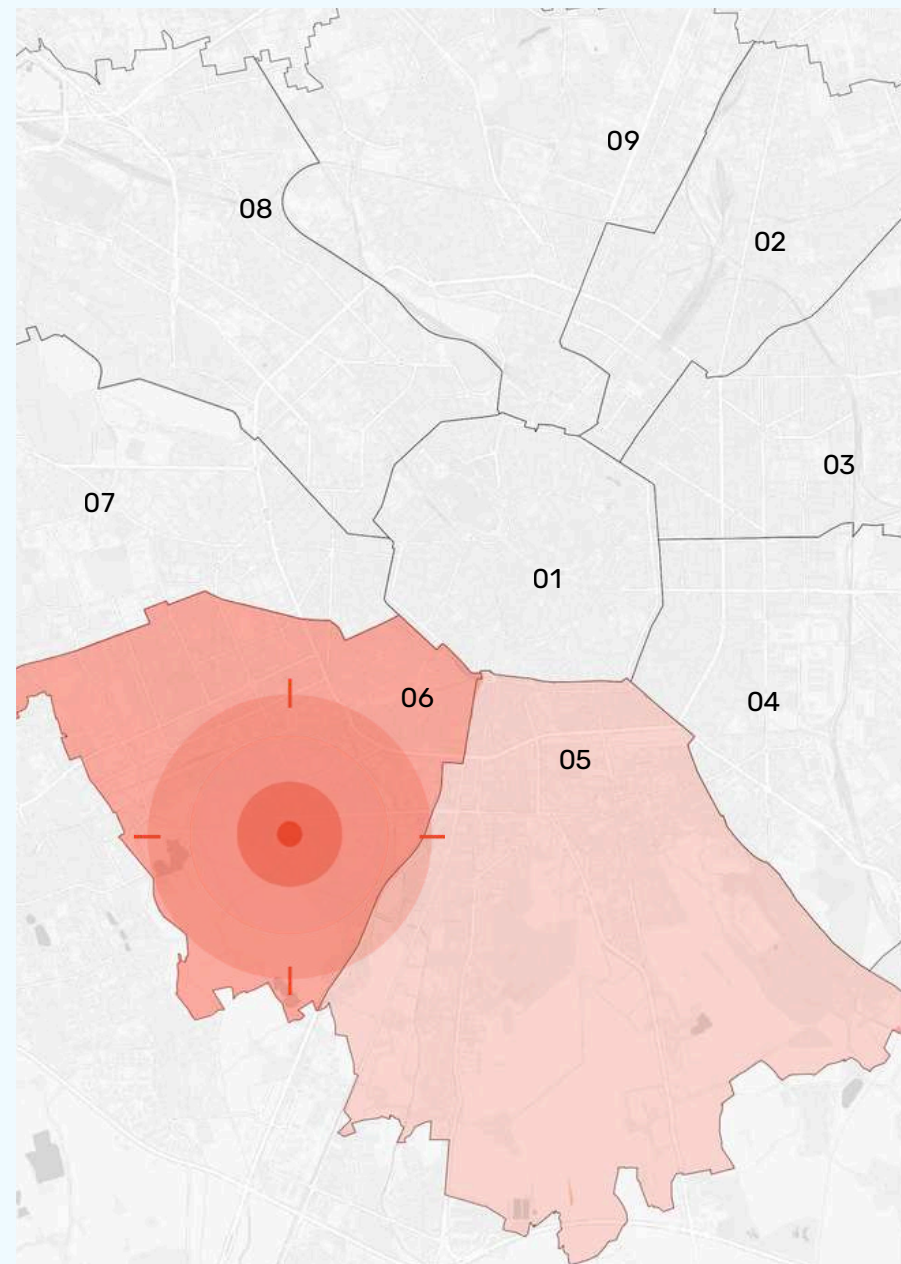
The findings, shared here, mainly build on a pilot experimentation in the City of Milan, which combines fine-grained environmental mapping with sustained engagement of local school communities and institutions.

Mapping

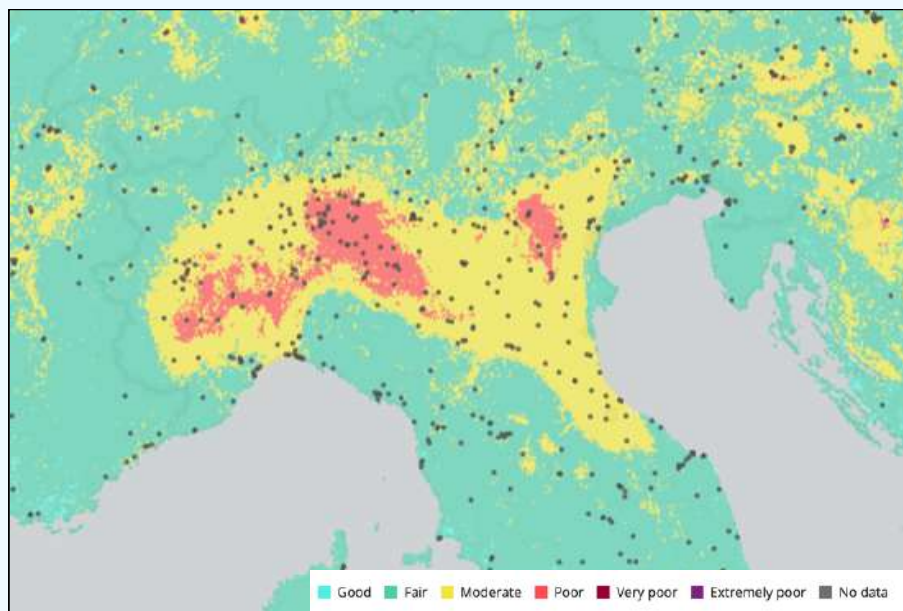
The pilot project focused on the southern districts of Milan (5 and 6), where schools are embedded in dense urban fabrics and along major mobility corridors. In this area, the project analysed data from a distributed network of citizen-sensing devices and GIS mapping to monitor air quality and relate measured concentrations to spatial variables and socio-demographic vulnerabilities. The sensor network was expanded where needed to achieve higher spatial resolution and to identify exposure hotspots, creating a shared evidence base for local action.

Engaging

Within this broader perimeter, District 6 was selected as the core Urban Living Lab, concentrating fieldwork, co-monitoring, and educational and participatory activities with schools, communities and decision-makers. The district serves as a testbed where actors jointly build knowledge about critical exposure periods, everyday mobility patterns and mitigation measures around school micro-environments and commuting routes. Through the Urban Living Lab, these experiments are connected to policy dialogues and citizen-science infrastructures, so that the results can inform strategies capable of being scaled city-wide.



This local experimentation offers a concrete entry point into a much wider regional air-quality problem that is particularly acute in Milan and the Po Valley. Recent reports by the European Environment Agency highlight a significant gap in access to healthy environments, both in terms of how air pollution is distributed and how it affects environmental quality and human health, particularly in critical urban areas of the Po Valley where vulnerable populations such as children are at high risk (EEA, 2023).



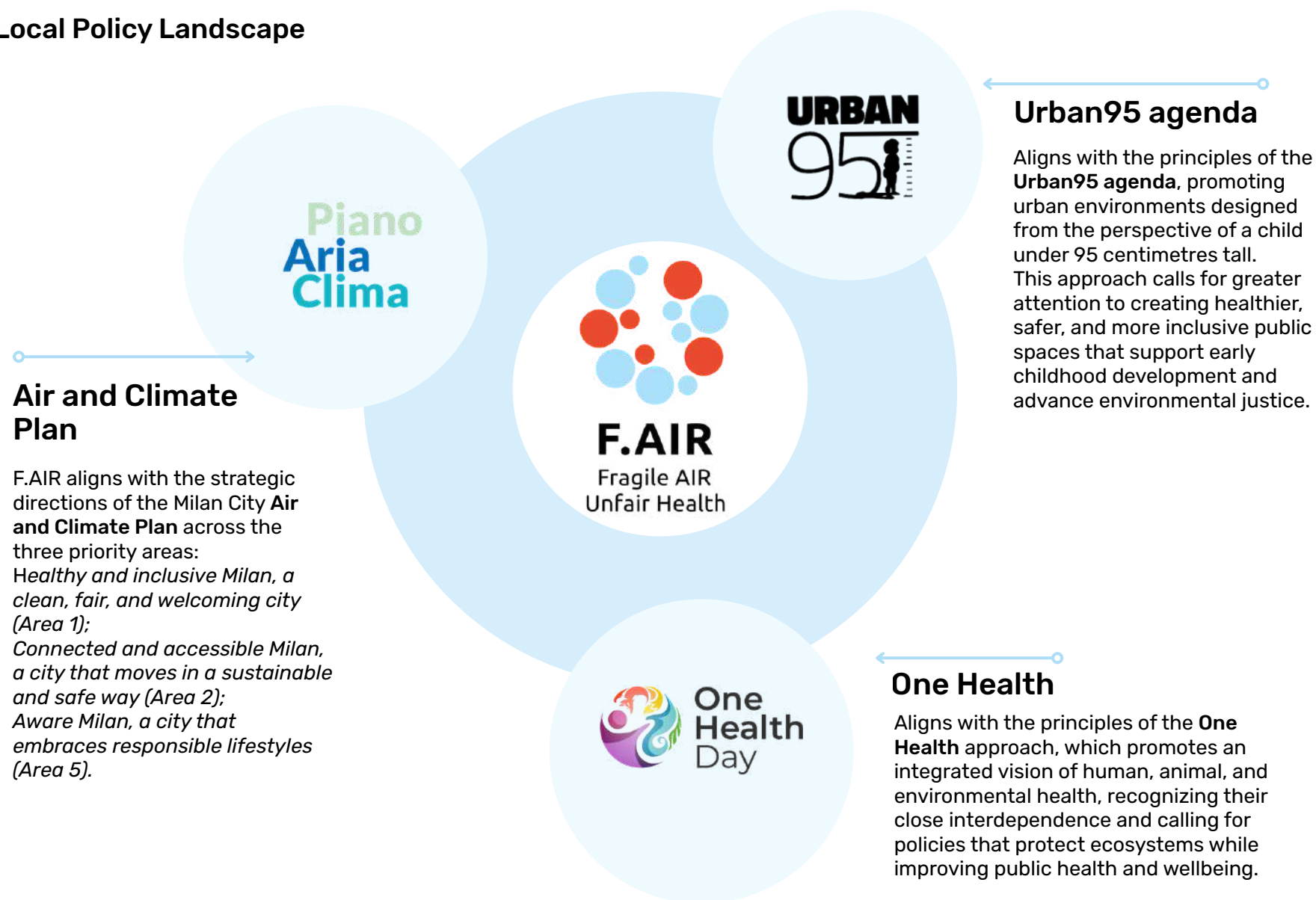
The Po Valley and Lombardy region on the European Air Quality Index Map (European Environmental Agency)

In Lombardy, air quality is especially poor because major emission sources are concentrated within the Po Valley, whose orographic and meteorological conditions limit the dispersion of pollutants. Within this regional hotspot, Milan stands out: an estimated 1,178 deaths each year are attributed to long-term exposure to air pollution. If the city's mean annual particulate matter concentration were reduced by just 10%, mortality from natural causes would fall immediately by 31 deaths per year and by about 210 deaths per year after 3 to 4 years (Crosignani, 2010).

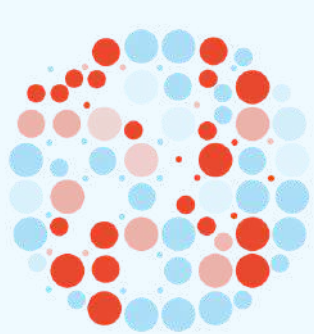
These avoidable health impacts underline the urgency of coordinated action at city level and the need to connect experimental projects like F.AIR with existing policy frameworks that aim to transform Milan into a healthier and more just city. Indeed, the City of Milan is strengthening policies to tackle the air-pollution challenge among which the Air and Climate Plan, Urban95 and One Health.

Situated within this local policy ecosystem (see p. 17), F.AIR translates its objectives into a concrete methodological approach (see p. 18) that can generate usable evidence and support action in school environments. The pages that follow turn this research context into four operational guidelines. Each one corresponds to one of F.AIR's main research questions and moves from evidence to action, offering tools, frameworks, measures and examples that practitioners, school communities, and policymakers can adapt to their own contexts.

Local Policy Landscape



The F.AIR pathway

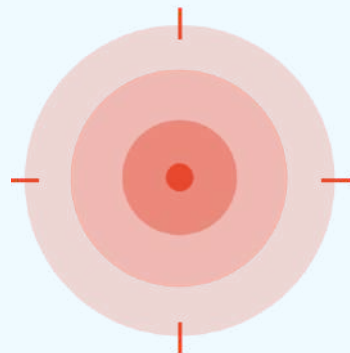


CRITICAL MAPPING

High-resolution mapping of the distribution of urban air quality, demographic data, and factors related to the built environment and accessibility to services, in districts and critical reading of social inequalities linked to environmental factors and accessibility to services, through GIS-based (WebGIS) data processing and a widespread monitoring network.

F.AIR FACTS

Data from 16 low-cost sensors monitoring PM2.5, active between 2020 and 2024 and located in Districts 5 and 6, were analysed. Data and maps are accessible through an open WebGIS.*



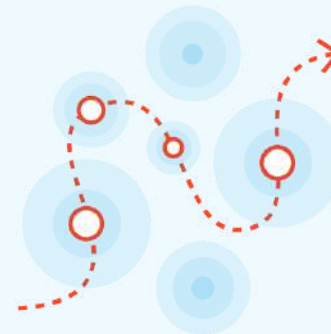
IDENTIFY THE AREA OF RESPONSE-ABILITY

Investigation of school contexts in districts involving future urban planners and designers in action-research processes focused on the new dynamics of socio-environmental inequalities and urban determinants.

F.AIR FACTS

Inquiry in 16 primary schools and early care facilities in the southern districts of Milan (6, 5) > 80 university students

The F.AIR pathway for co-shaping environmental justice unfolds through four interconnected phases:

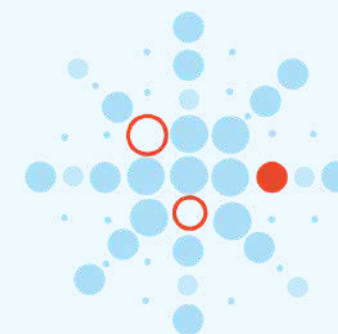


ADOPT A DESIGN STRATEGY

Activation of an Urban Living Lab in District 6 to co-design scenarios of soft and hard measures to improve accessibility to healthy school environments, through dialogue between institutions and school communities.

F.AIR FACTS

Co-creation and policy dialogue events involved more than 80 actors. Six typical school situations have been identified, with tailored measures presented in these guidelines.



EXTEND GRANULAR SENSING ABILITY

Promoting citizen science and expanding the environmental co-monitoring network of Milano Smart Park sensors, of open source data.

F.AIR FACTS

The co-monitoring network of Milano Smart Park sensors has been expanded with the installation of additional 6 outdoor and 8 indoor sensors in primary schools. In parallel, the development of educational labs has engaged 10 classrooms, over 180 children and 20 teachers.

For clarifications on sensing units and school involvement, see appendix pp. 86-88.

Practical Guidelines for Healthier School Environments

In this work, we try to provide some initial answers and guidelines on how to improve access to healthier school environments through cleaner air and fairer representation of those most affected. As you turn the page, these guidelines unfold into four sections: monitoring & data, urban form & inequalities in access, design strategies for mitigation, and engagement & co-creation pathways.

These guidelines follow F.AIR's four main research questions, with each one addressing a specific inquiry in depth and weaving in the key lessons learnt from the F.AIR – Fragile AIR, Unfair Health research project, hoping to inspire further experiments and initiatives.

1 Monitoring & data

What is the most effective way to collect, process and finally map air pollution at a granular scale?

And, relatedly, how should this information be linked to environmental risk in order to provide useful evidence for local decision makers, urban professionals and citizens on the distribution of vulnerability at a granular scale?

Does spatial mapping reveal new patterns of environmental inequality and variations in their distribution across city neighbourhoods and schools' microenvironments?

If so, what are the socio-economic, cultural, urban and environmental factors involved, and the underlying sources at different times of the day and seasons that contribute to such disparities?

2 Urban form & inequalities in access

3 Design strategies for mitigation

Is it possible to design effective and context sensitive strategies that both monitor and mitigate air pollution around locations, where exposure risks are critical?

How can these actions be implemented effectively and sustained over time, with adequate sources of monitoring by competent institutions and/or citizen groups?

How should active participation be structured to co-produce knowledge, and encourage informed mitigation actions?

How can these processes support evidence-based policies to reduce exposure and promote clean air zones, especially around schools and other identified sensitive areas?

4 Engagement & co-creation pathways

1

Monitoring & data

What is the most effective way to collect, process and finally map air pollution at a granular scale?

And, relatedly, how should this information be linked to environmental risk in order to provide useful evidence for local decision makers, urban professionals and citizens on the distribution of vulnerability at a granular scale?

Air, urbanscapes, people

In cities, information about air, space, and everyday life often comes in fragments: a sensor reading here, a traffic count there, a map layer, or a story from a school community. Taken alone, each piece is partial and sometimes misleading; taken together, they form a data mosaic that can reveal how environmental inequalities actually play out in children's lives. Because no single dataset can capture the complexity of children's exposure to air pollution, it is necessary to combine different types of data. In this guideline, we invite you to move from "data mosaics to sensemaking" by working across scales—from the city to neighbourhoods and to everyday places such as school gates, courtyards, and routes to school—and deliberately stitching these heterogeneous pieces—high-resolution air-quality measurements, spatial data on urbanscapes and mobility flows, and situated observations around schools—into a shared reading of places and patterns. Through this process, numbers become situated in context, maps become stories of exposure and vulnerability, and evidence becomes a basis for dialogue and action towards fairer, healthier environments for children.



Air quality

Citizen Sensing Data

Why air data matters

Access to healthy air at school is a fundamental condition for children's right to learn, play, and grow in safe environments. Ambient air quality data with sufficiently high spatial resolution is essential to reveal environmental inequalities that remain invisible in coarse, city-level averages.

Multiplying and strategically placing outdoor sensing units makes it possible to capture local variations, detect hotspots, and show how pollution patterns overlap with social and spatial vulnerabilities.

FAIR FACTS

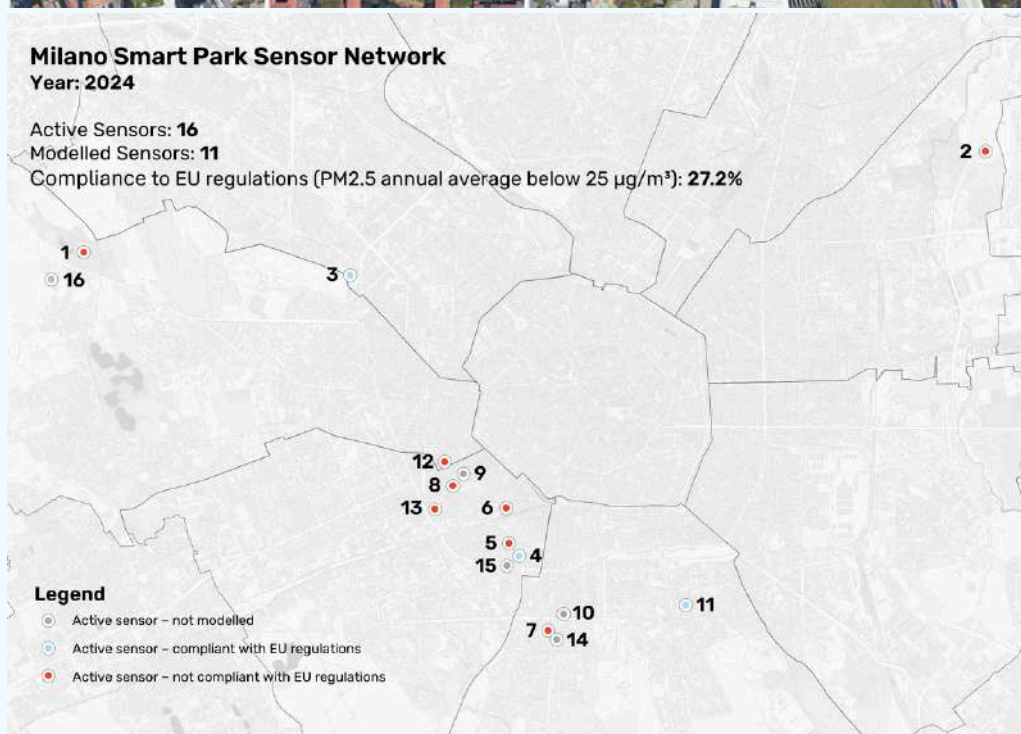


List of sensors*

1. *Bosco*
2. *Cascina Biblioteca*
3. *WAU*
4. *Segantini2*
5. *Segantini1*
6. *Valenza*
7. *Montegani*
8. *Solari40*
9. *Bergognone*
10. *Cermenate*
11. *FCUB*
12. *Moisè Loria*
13. *Savona*
14. *Battisti*
15. *I.T. Giorgi*
16. *Frutta in Campo*

In the figure above:
Location of the 16 Milano Smart Park (MSP) PM2.5 outdoor sensing units in Districts 5 and 6 of Milan, active between 2020 and 2024. Each sensor is numbered according to the list on the right. Of these, sensors 9, 13 and 14 are located at school sites directly engaged in F.AIR: G. Oberdan C.A. Porzi & Foppette (see appendix pp. 86–88 for the full list of MSP sensing units and their relationship to F.AIR schools.

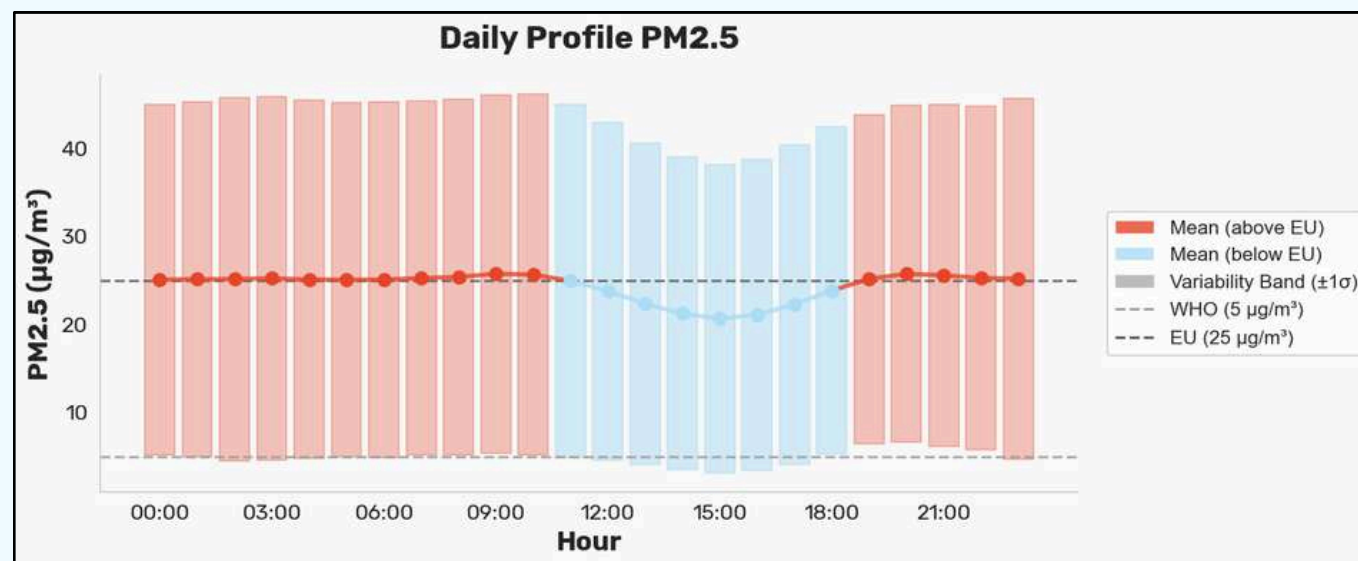
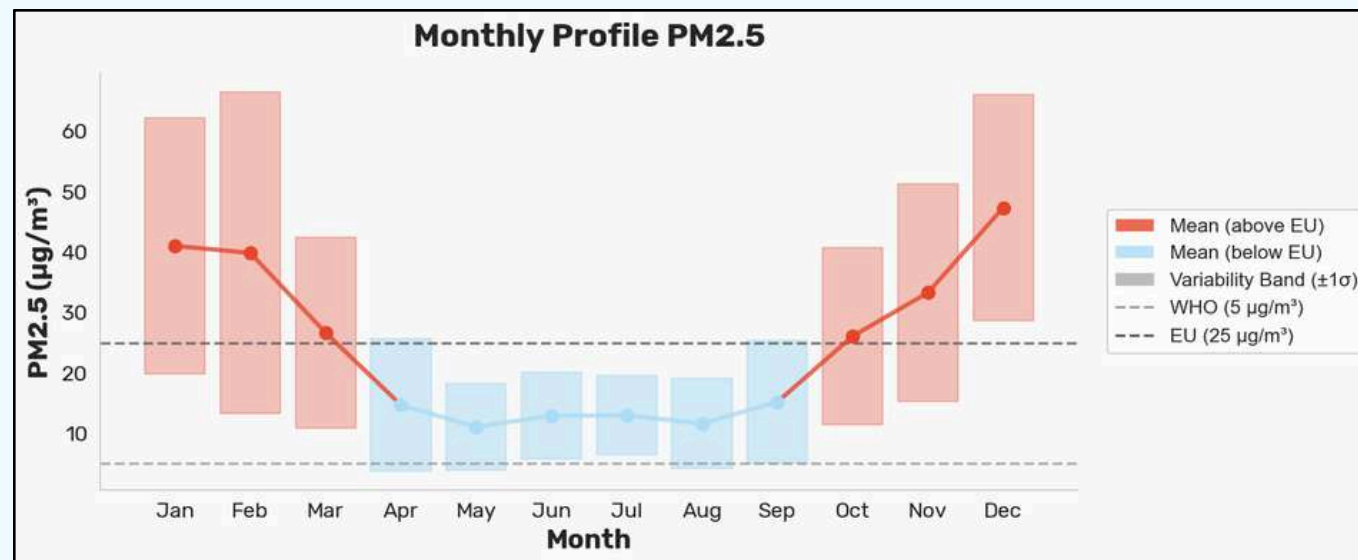
(*) Sensing Units Milano Smart Park: an OpenSource, OpenData, OpenStandard participatory science project for environmental data collection and environmental awareness.
<https://milanosmartpark.info/>



In the figure below:
Compliance of modelled sensor values with the EU annual PM2.5 limit (25 $\mu\text{g}/\text{m}^3$) for the reference year 2024.
Source: Transform Transport / Milano Smart Park

Mapping air quality at fine scale

Traditional monitoring networks often provide a limited number of reference stations, which are not enough to describe conditions around schools and everyday routes. Expanding monitoring through additional fixed and mobile sensors allows for more granular maps that reflect the actual air children breathe on their way to and from school, in courtyards, and in nearby public spaces. This finer grain supports more accurate assessment of exposure and helps compare conditions between neighbourhoods that are differently served in terms of green infrastructure, traffic regulation, and public transport.



The graphs present daily and monthly PM2.5 patterns for Sensor 6 – Via Valenza (2021–2024). The sensor is located in a dense urban area near Porta Genova railway station. Lines show daily and monthly multi-year averages (2021–2024); shaded bands indicate year-to-year variability. Dashed horizontal lines mark the EU annual limit (25 $\mu\text{g}/\text{m}^3$, dark grey) and the WHO guideline value (5 $\mu\text{g}/\text{m}^3$, light grey). PM2.5 consistently exceeds the EU limit in autumn and winter (October–March) and during early morning, evening, and night hours (00:00–11:00 and 19:00–00:00). Seasonal variability is marked in autumn and winter and more limited in spring and summer, while the daily profile remains stable.

Disclaimer: Graphs were generated from raw data collected from the Milano Smart Park sensing network and processed by Transform Transport. Source: Transform Transport

Sound processing of Low-Cost Sensors (LCSs) data

Building on this expanded picture of everyday exposure, additional citizen-science sensors can reveal consistent patterns across seasons, months and times of day. At the same time, their data quality is not automatically sufficient to support strong conclusions, so co-monitoring networks require regular maintenance of low-cost sensing units, and information on robustness – such as uptime, gaps and anomalies – should be openly documented.

With standardised procedures for cleaning, validating and aggregating measurements, this richer monitoring layer can become a reliable basis for analysing air pollution dynamics of exposure in school environments and informing decisions on how to mitigate them.



F.AIR's project multi-sensor PM2.5 forecasting methodology:

Cleaning & normalization

PM2.5 time series are standardized and cleaned by removing outliers (e.g., rolling Z-score on a daily window). Anomalous hours are excluded and gaps are kept as NaN; PM2.5 is not interpolated.

Continuity & robustness checks

Data availability and gap structure are assessed to quantify sensor robustness and flag unreliable periods. These quality indicators guide when reconstruction and analysis are appropriate.

PM2.5 prediction for complete series

An algorithm is developed to predict PM2.5, producing continuous hourly series for analysis. The predictive dataset includes lags, rolling features, cyclical time variables, continuity flags and similarity features.

Aggregated temporal pattern mapping

With consistent series, PM2.5 is aggregated at annual, monthly, and daily scales to highlight recurring dynamics (seasonality, diurnal cycles) and compare patterns across locations.

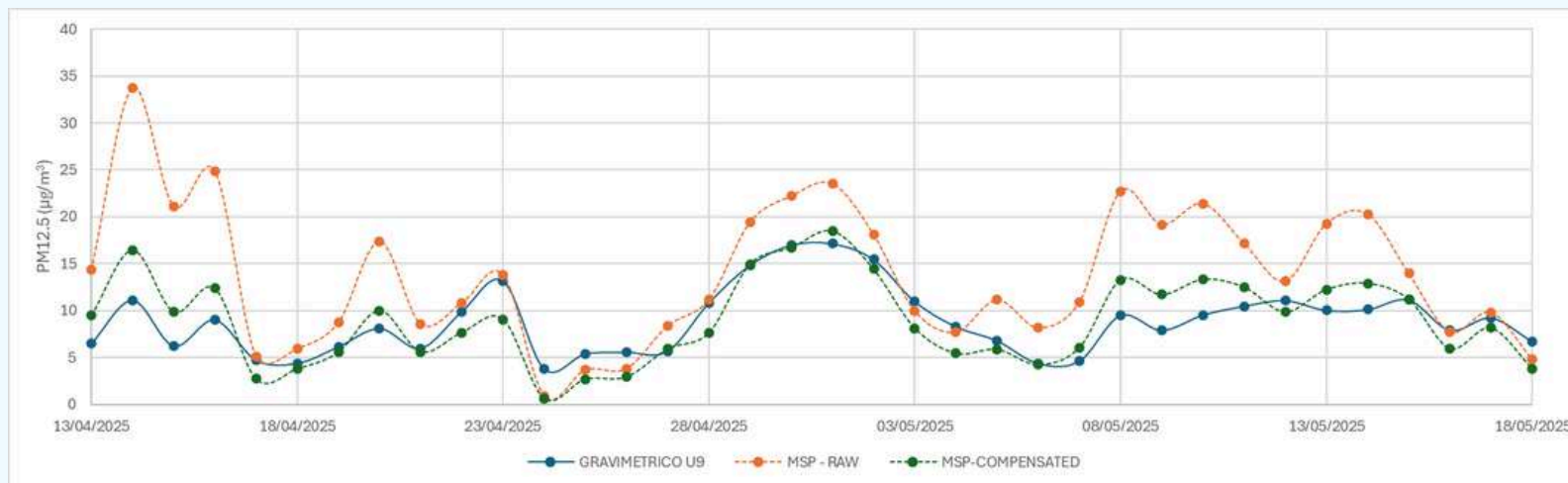
Critical periods & potential exceedances

Critical episodes are identified by comparing aggregated concentrations with relevant thresholds (e.g., EU), highlighting when and where higher-risk conditions tend to occur.

Takeaways

To make PM2.5 data truly readable, aggregation helps reveal recurring patterns and enables clear comparison with regulatory thresholds. At the same time, it's just as important to keep an eye on daily and hourly dynamics to pinpoint when action matters most.

Forecasting method source: Transform Transport



In the figure above, the graph shows the comparison between the PM 2.5 data collected by DISAT and MSP sensing units (raw and humidity adjusted) in Milan.
Source: DISAT and APS

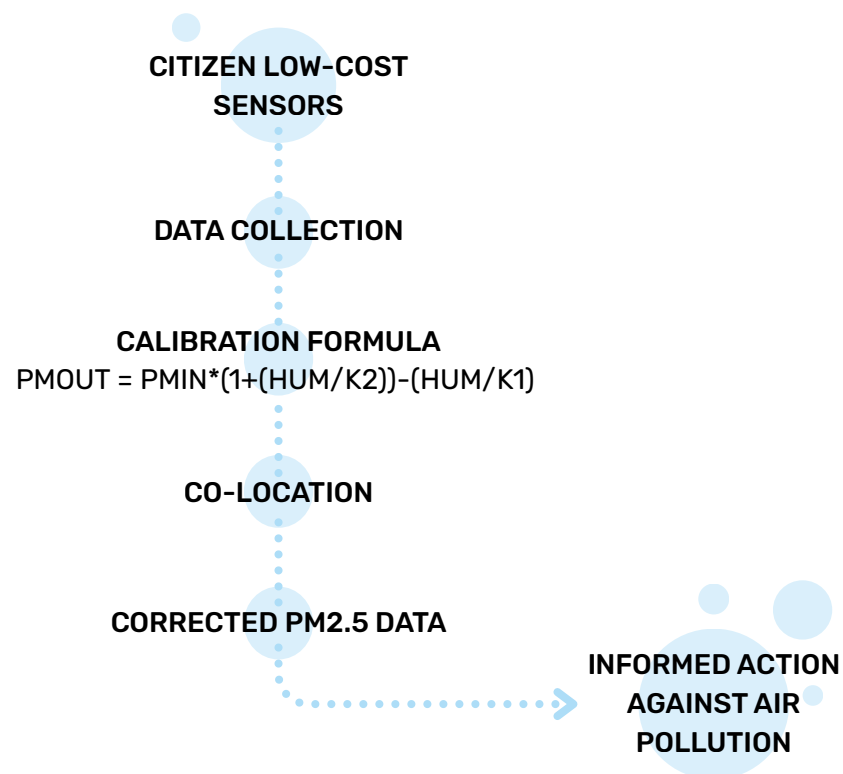


In F.AIR, three calibration campaigns were carried out in collaboration with DISAT - University of Milano-Bicocca. The results show that, once humidity is corrected, PM2.5 becomes more accurate. Moreover, these interventions enable both firmware and hardware improvements.

Low-Cost Sensors (LCSs) do not replace reference monitoring stations; but, when carefully calibrated and regularly maintained, they can reliably track trends, compare different areas, and support local analyses around schools. Clear, accessible visualizations of calibrated datasets can enable residents, teachers, and students to better understand the air they breathe and to communicate concerns in an informed and constructive way.

By transforming raw measurements into understandable evidence, these tools foster environmental literacy and strengthen community engagement. At the same time, institutions can draw on this shared evidence base to prioritise interventions, refine air-quality strategies, and develop regulations or incentives that reflect actual exposure patterns. In this collaborative framework, citizen monitoring networks, and public agencies complement each other: communities contribute dense, place-based measurements, while technical authorities ensure validation, calibration, and rigorous interpretation.

Scheme source: DISAT and APS



Urbanscapes

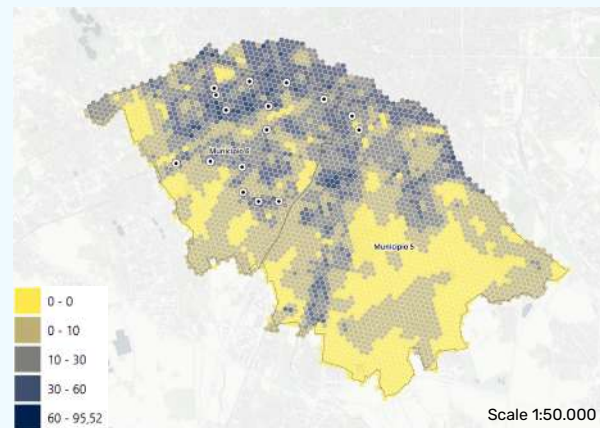
Beyond data mosaics to sensemaking

Air quality is not only a matter of emissions; it is also shaped by the urbanscape and the ways people live, move, and meet within it. Street canyons, open squares, school districts, and mobility corridors create everyday patterns of exposure, concentrating some groups in polluted micro-environments while offering others better access to cleaner, greener spaces. The distribution of income, age, and services influences who lives near busy roads, who relies on public transport, and who can retreat to quieter places. Sidewalks, and transit stops channel daily routines, like walking to school or commuting to work, so that social life and traffic flows constantly intersect. Understanding these spatial and social configurations is crucial to connect measured concentrations with the lived experience of the city.

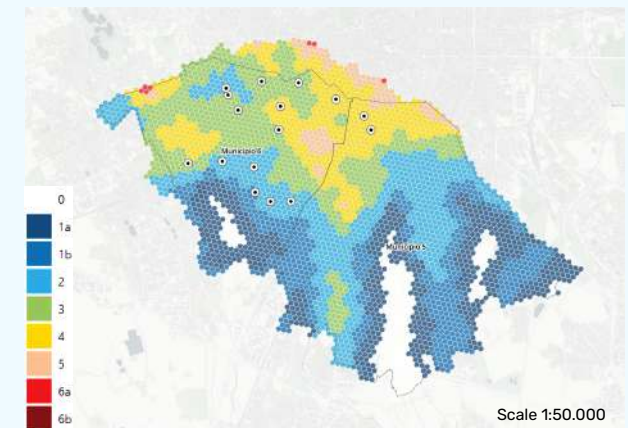
Maps by Transform Transport.
Methodology and data sources
in p. 27 and appendix p. 89.

F.AIR FACTS

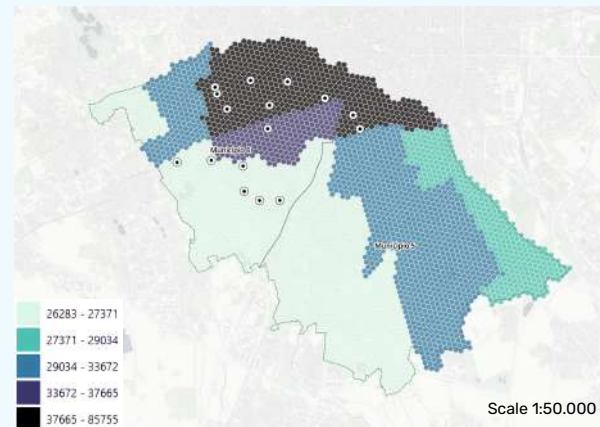
RESIDENTS UNDER 15 YEARS OF AGE



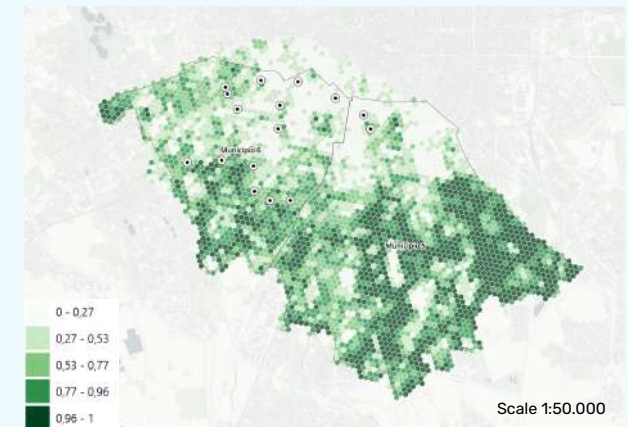
PUBLIC TRANSPORT ACCESSIBILITY LEVEL



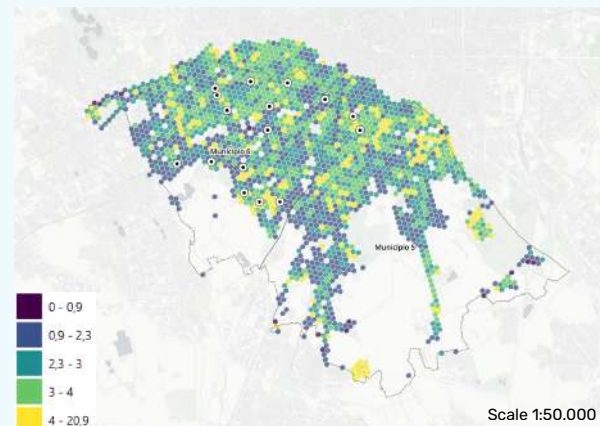
AVERAGE INCOME [€]



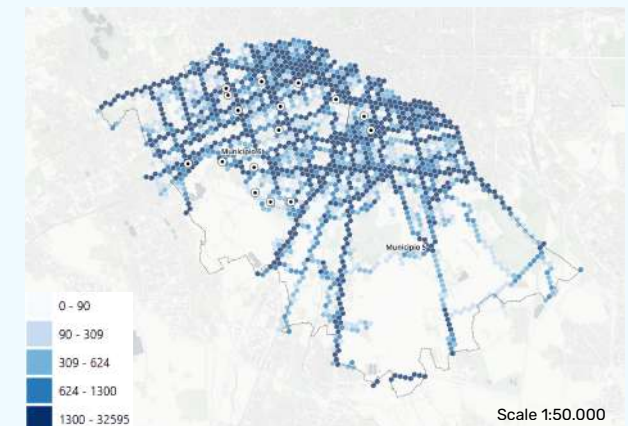
VEGETATION AVERAGE [%]



SIDEWALK WIDTH [m]

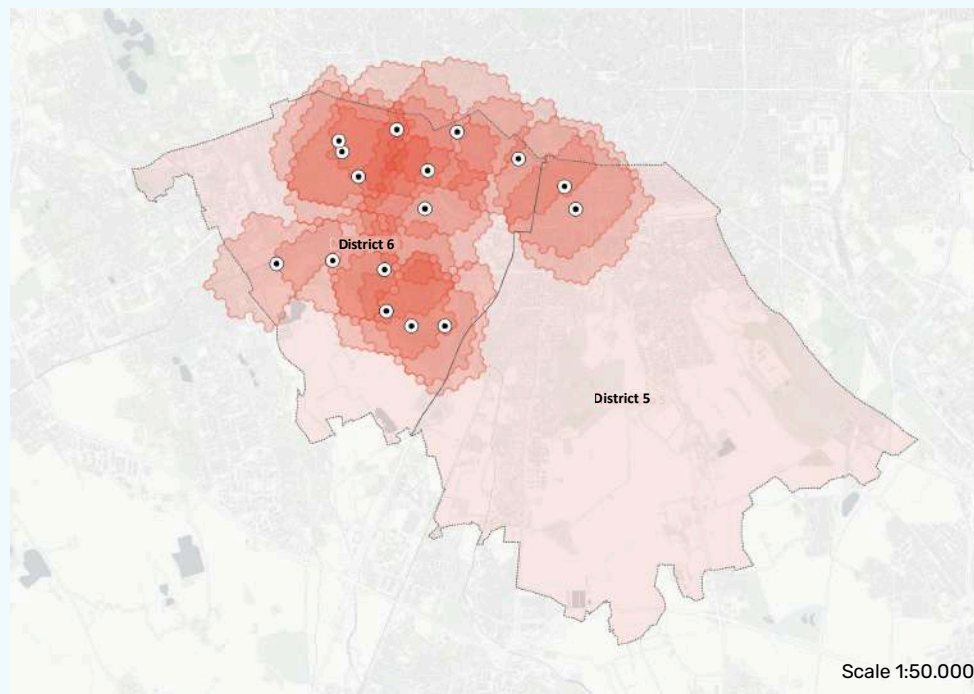
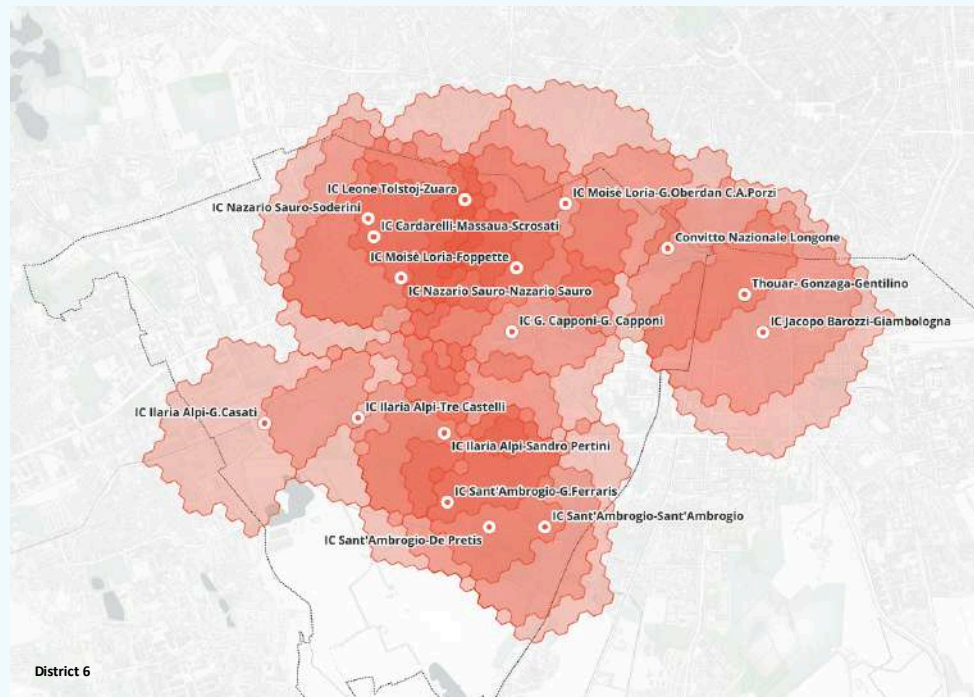


TRAFFIC FLOWS [Vehicle/h]



From neighbourhoods to everyday places

Environmental inequalities become more visible when analysis moves from the neighborhood scale to concrete everyday places such as school gates, playgrounds, bus stops, and walking routes. Scaling down from aggregated neighborhood indicators to micro-local observations around schools helps identify specific conditions that may increase exposure, such as narrow sidewalks along busy roads, congested intersections at drop-off time, or lack of protective buffers. This place-based perspective makes it possible to see how the same neighborhood can contain both safer and more critical micro-environments for children.



For each school complex, a 15-minute walking isochrone was considered, representing the area reachable on foot within 15 minutes using the actual road and path network. The red colour indicates the isochrone areas (above: District 6; below: Districts 5 and 6 combined).

The analysis area is defined by the intersection of Districts 5 and 6 with the 16 school isochrones.

Seven descriptive indicators were analysed: resident population under 15 years of age, income, vegetation, accessibility to public transport, width of sidewalks, NO₂ concentration, and traffic flow (as shown in pp. 26, 28).

These indicators were analysed using the H3 hexagonal spatial index at resolution 10 – a uniform grid with a cell area of 0.015 km² (see following page for school-level detail).

All data sources can be found in the appendix p. 89.

Red tones carry no analytical meaning; transparency is used to show the overlap between isochrone edges.

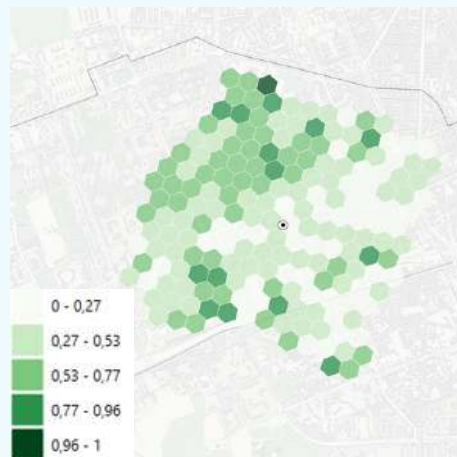
Maps source: Transform Transport



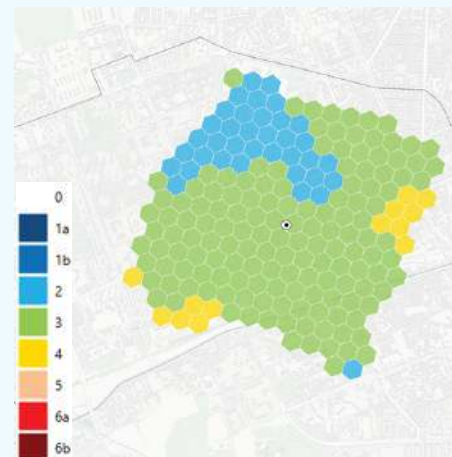
GETTING MORE GRANULAR

School-based reading of
urbanscape, flow and social life
<15min: the case of I.C. Nazario
Sauro

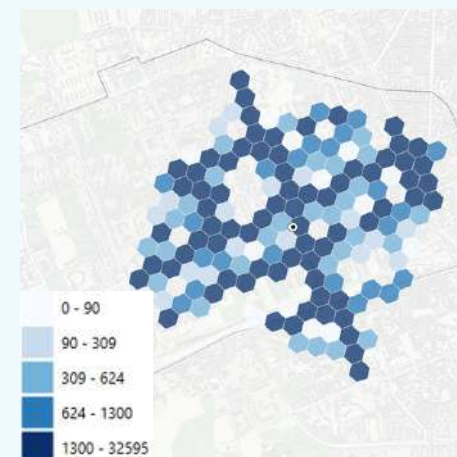
VEGETATION = 0.43%



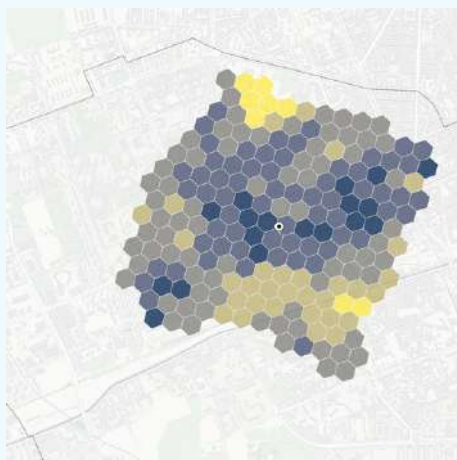
PUBLIC TRANSPORT ACCESSIBILITY
LEVEL = 3



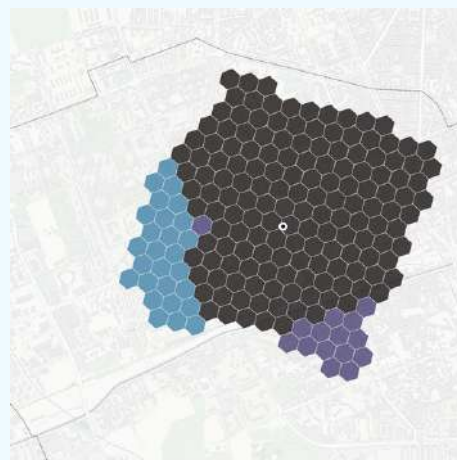
TRAFFIC FLOW = 403152 VEH/H



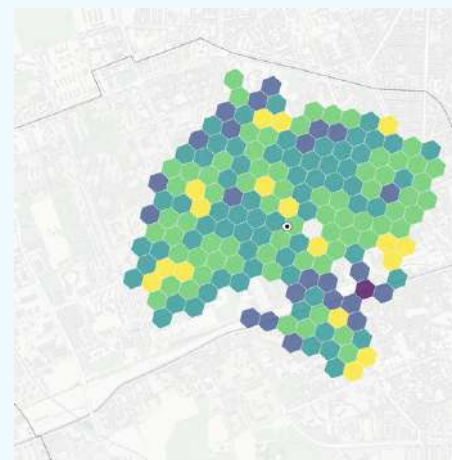
RESIDENTS < 15 YEARS AGE = 5687



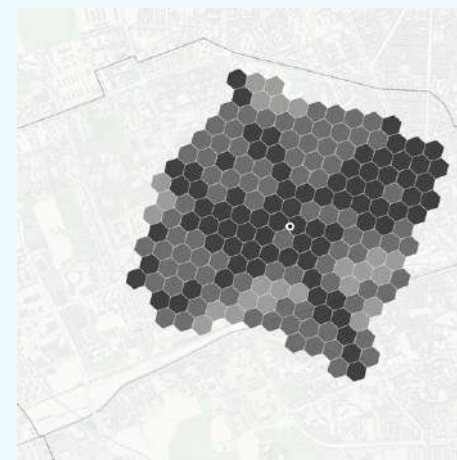
AVERAGE INCOME = 40130 €



SIDEWALK WIDTH = 3.0 M



NO₂ /MONTH = 44.7 MG/M3*



Maps by Transform Transport. Methodology and
data sources in p. 27 and appendix p. 89. Key
terms are defined in the glossary pp. 84-85.

*Monitoring data from the citizen science campaign "NO₂, No Grazie!" (2023) - Source: Boniardi L, Nobile F, Stafoggia M, Michelozzi P, Ancona C. Assessing the impact of traffic restriction interventions on school air quality: a citizen science-based modelling study. Environ Res. 2025 Jul 15;277:121562.

People

Children and adults' interaction in everyday places

Standard GIS datasets may not be enough to capture the practices, routines, and micro-features that shape exposure around schools, and this limitation needs to be explored as a working hypothesis. Fieldwork can therefore be used to test and enrich spatial data with place-based observations of hotspots and everyday life, documenting pick-up and drop-off behaviours, informal routes, temporary uses of space, and small but relevant elements such as informal parking, delivery zones, or entrances used by pupils with special needs.

Images source: PoliMi students' fieldwork. For the full list of schools, see appendix p. 87.

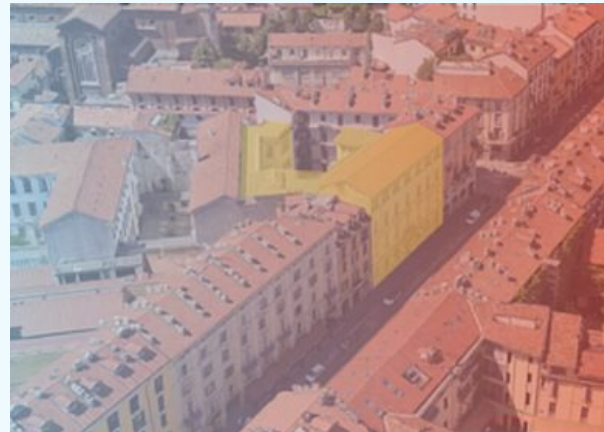
Red and blue tones are aesthetic photo filters and carry no analytical meaning.

FAIR FACTS

Thouar-Gonzaga Gentilino



Convitto nazionale Longone



IC Moisé Loria - Foppette



IC Ilaria Alpi, G. Casati



IC Capponi



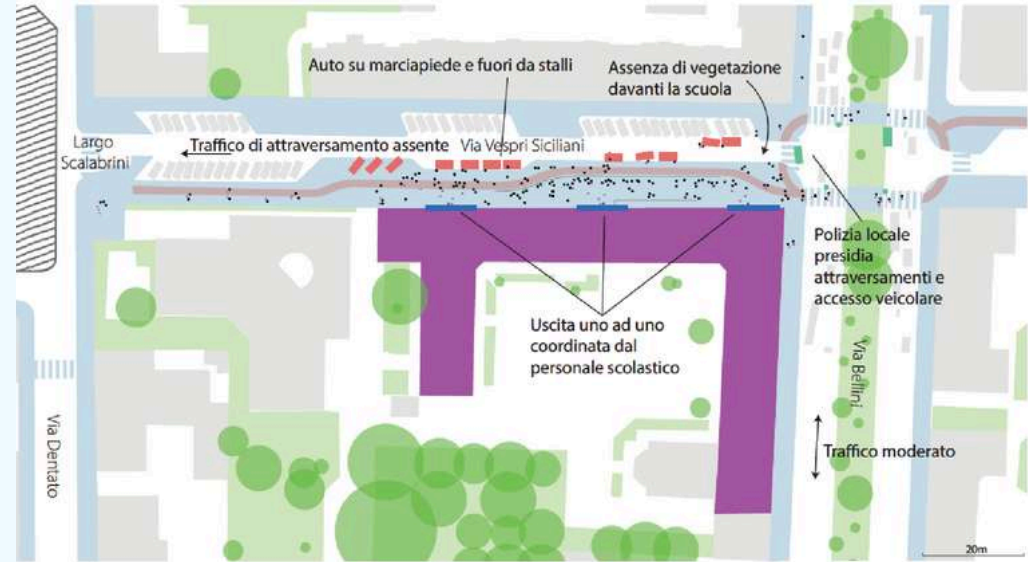
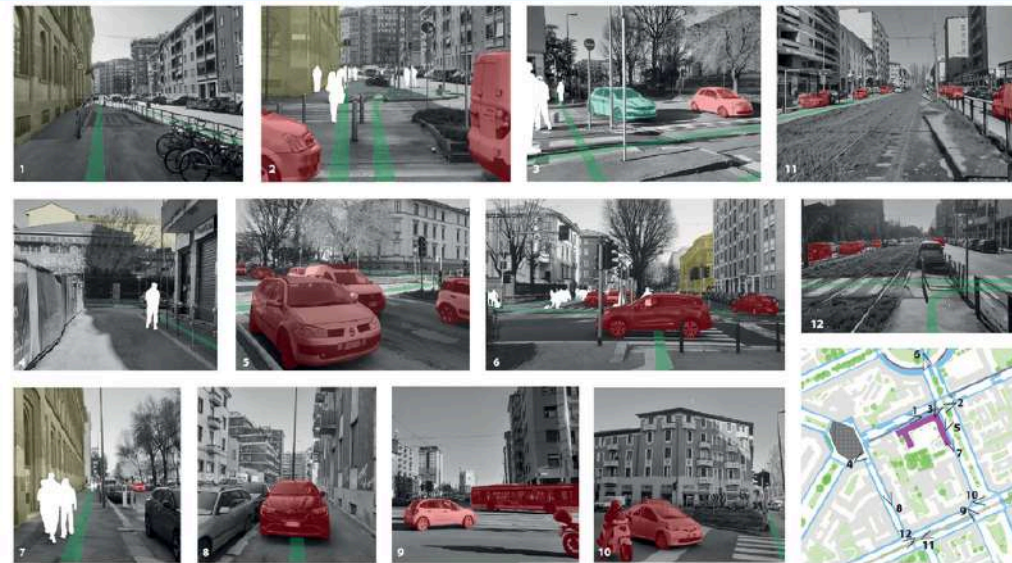
IC Leone Tolstoj - Zuara



GUIDELINES - Monitoring & data People

A place-based inquiry helps reveal how the physical form and everyday use of school surroundings shape children's exposure to air pollution. By combining these observations with high-resolution air quality data and spatial analyses of urban morphology and movement patterns, it becomes possible to identify "areas of concern" around schools and across their wider catchments. These are places where air quality is persistently poor or highly variable, and where vulnerable groups, particularly children, spend significant time. Such areas of concern become priority sites for targeted intervention, focusing on reducing emissions, redirecting pollutant flows, or creating protective spaces that limit exposure.

IC Nazario Sauro



F.AIR FACTS

Images source: PoliMi students' fieldwork
Group Borgolotto M., Guerriero A., Novati A., Ratti M.



F.AIR suggests selecting case-study schools as a small, diverse laboratory of situations rather than a statistically representative sample. The shortlist prioritised primary and preschool facilities in District 6, with a few additional cases in other districts to support specific outreach strategies, combining different Local Climate Zones, contrasting NO₂ exposure levels, proximity to emission sources, active or potential citizen-science sensors, and existing collaboration with school communities.

These case studies were explored through fieldwork by over 80 university students, with up to two or three groups working at the same school to multiply observations and enable a later qualitative selection. 16 schools were retained initially, then grouped into six typical urban situations that support comparison between more and less exposed routes and school micro-environments.

For the full list of schools and clarifications about their selection and involvement throughout F.AIR, see appendix pp. 86–88.

2

Urban form & inequalities in access

Does spatial mapping reveal new patterns of environmental inequality and variations in their distribution across city neighbourhoods and schools' microenvironments?

If so, what are the socio-economic, cultural, urban and environmental factors involved, and the underlying sources at different times of the day and seasons that contribute to such disparities?

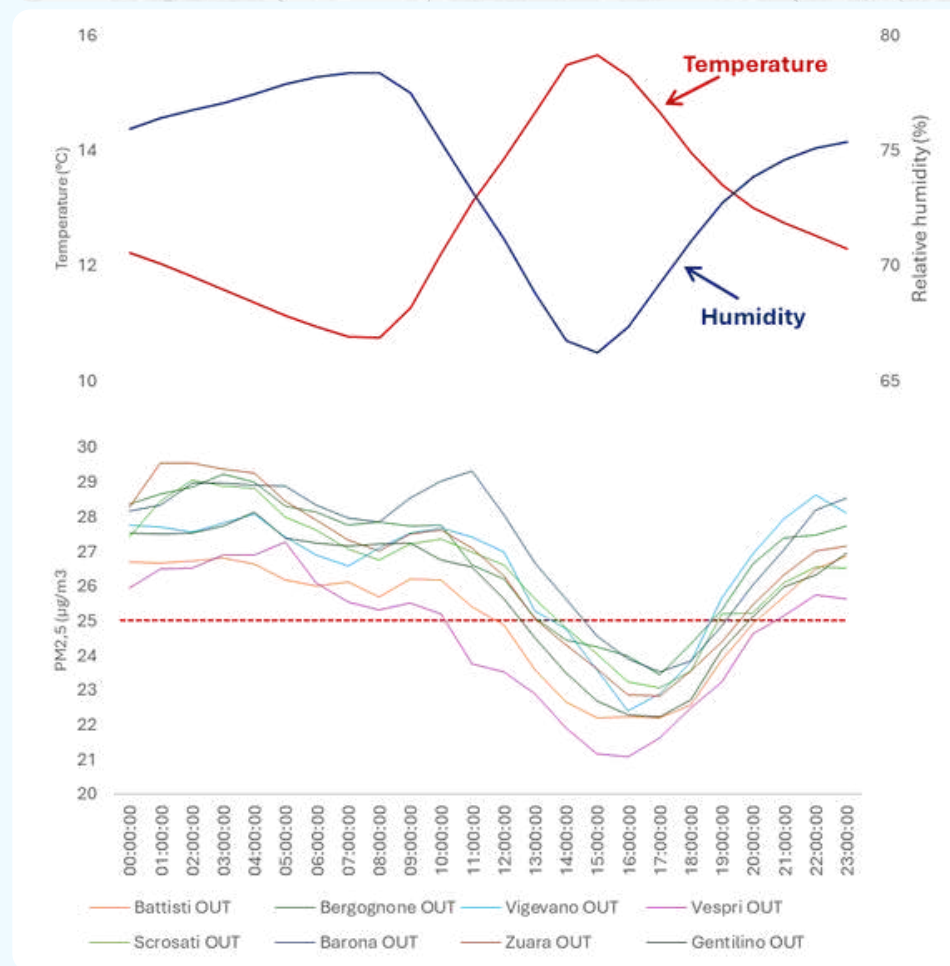
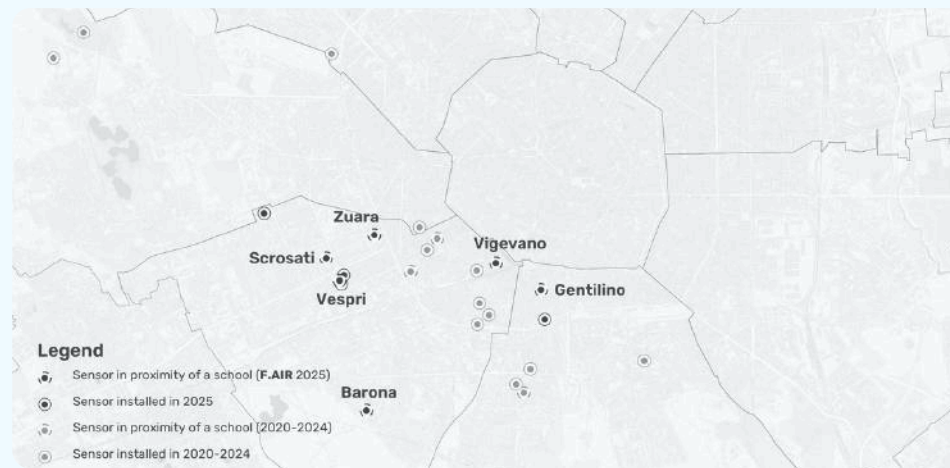
Local variability

Air quality

The strong temporal similarity in PM_{2.5} trends across the F.AIR eight schools*, suggests that concentrations are largely shaped by urban and regional background pollution rather than by individual local sources alone. PM_{2.5} in Milan comes from a mix of sources—especially residential heating (including wood and biomass burning), traffic, and particles that form in the atmosphere from gases released across the wider Lombardy region—and these fine particles can stay in the air for days and travel long distances (INEMAR - ARPA Lombardia, 2025).

This indicates that PM_{2.5} is a city-wide issue, even though local street layouts, traffic, and other emission sources still create differences in levels between schools—especially in Milan's dense urban fabric within the Po Valley, where pollution can easily build up and persist. While schools have limited direct control over regional emissions, they can still reduce children's exposure through targeted interventions around entrances, playgrounds, daily routes, and indoor spaces, bearing in mind that these actions can only influence a fraction of the overall challenge.

Above figure source: Transform Transport; below figure source: DISAT and APS. For full details about MSP sensing units see appendix p. 88.



During the F.AIR project, the Milano Smart Park sensor network for PM_{2.5} and NO₂ was upgraded and extended in both hardware and software, strengthening air quality monitoring around schools. Three existing outdoor units were upgraded, including those shown in the graphs below (Bergognone and Battisti) and six new outdoor units were installed at school sites (as illustrated on the map), alongside eight new indoor units, to improve air-quality monitoring and map critical exposure situations.

The graphs show an example of how meteorological conditions influence the aggregated hourly averages collected by MSP outdoor sensing units in eight schools over three-month period (01/10–31/12/2025) for PM_{2.5}, temperature, and humidity. During the observed period, PM_{2.5} concentrations often exceeds the recommended limit of 25 µg/m³ for many hours each day.

In educational settings, these graphs can support active learning, enabling students to compare conditions between locations and observe how air quality changes in response to traffic patterns, seasonal variations, or new design interventions.

GUIDELINES - Urban form & inequalities in access - *Local variability*

Recognising these limits also helps clarify where schools fit within a broader shared responsibility: regional and city authorities must tackle the main emission sources, while giving special priority to reducing exposure in the places where children spend most of their time, such as schools. Within this shared framework, small differences in air quality may reflect both sensor placement and real local conditions. The sensors can show typical patterns for each school, but not the exact exposure everywhere children move, stay, and play, so more fine-grained monitoring near entrances, waiting areas, and school routes would better capture exposure.

When measurable differences in air quality across locations are observed, to what extent are they shaped by the spatial diversity of school environments?

Do sensor locations, for example, near entrances or in playgrounds, capture different facets of children's exposure, and can mapping these local conditions help identify where and how to act? A closer look at local factors—including street type, entrance position, parking arrangements, vegetation, and proximity to emission sources—can then help explore whether, and how, urban determinants are associated with the observed air-quality differences, without yet assuming a direct correlation.

LCS Vespri
I.C. Nazario Sauro



LCS Gentilino
I.C. Thouar-Gonzaga
Gentilino



LCS Barona
I.C. Sant'Ambrogio,
G. Ferraris



Urban forms and flows

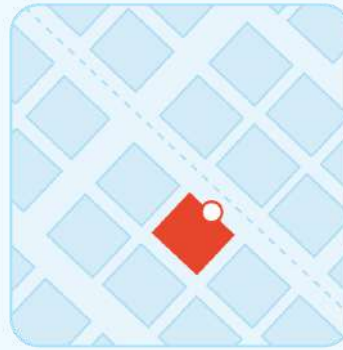
School environments vary in their urban form, surrounding land uses, and everyday mobility patterns. Some are located along dense traffic corridors, others within quieter residential areas, or at the edge of major infrastructures and peri-urban fabric. Exploring this variability helps to understand how each setting shapes exposure to air pollution, the quality of spaces available to children, and the potential for change through design and regulation.

To make these differences visible and comparable, schools can be grouped into a few typical situations based on spatial layout and accessibility. These situations serve as anchors for identifying local hotspots and defining context-specific mitigation measures. Analysing each school's 5–15-minute catchment further links air quality patterns with opportunities for intervention across children's everyday learning geographies and home-school routes.

Source: The six urban situation types were derived from spatial analysis and clustering of fieldwork materials produced across all 16 F.AIR schools (full list p. 87). Each type is represented by one case school (see p. 35) selected for its distinct urban morphology, completeness of fieldwork materials, presence of an MSP outdoor sensor, or proximity to a major traffic axis. These six schools served as the primary sites for the F.AIR co-creation workshops on urban mitigation measures (District 6 focus) and are intended as analytical anchors, not an exhaustive urban classification. Elaborated by Farah Makki, Politecnico di Milano.

COMPACT FABRIC

TYPE 1



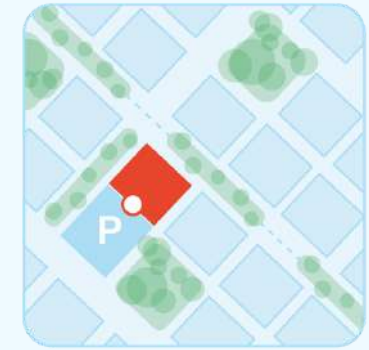
Compact urban fabric close to traffic, street-facing entrance, no parking area

TYPE 2



Compact urban fabric with available parking or waiting area

TYPE 3



Compact urban fabric inserted in a neighborhood equipped with green infrastructures

OPEN URBAN FABRIC

TYPE 4



Close to a major road axis with double entrances

TYPE 5



Sheltered from a major road axis

(PERI) URBAN FABRIC

TYPE 6



On the edge of the peri-urban area with a strong presence of agricultural fields

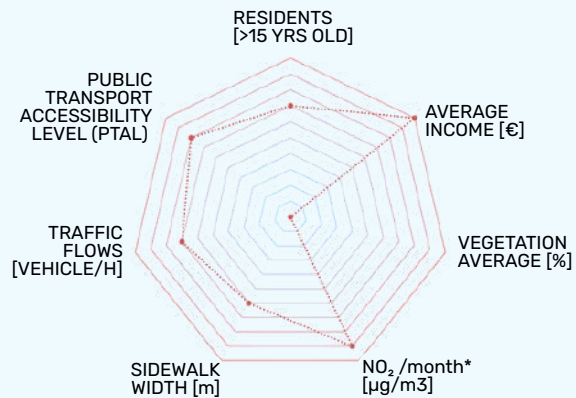
How do F.AIR school environments differ in their urban form, everyday access, air pollution and mobility patterns?



TYPE 1

COMPACT FABRIC

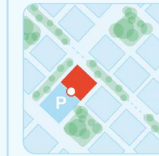
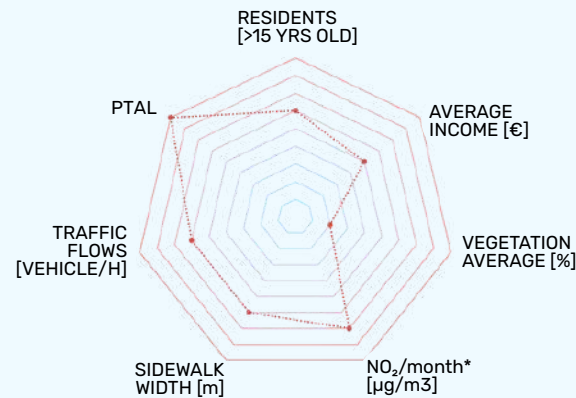
Convitto nazionale Longone
Via Vigevano 19



TYPE 2

COMPACT FABRIC

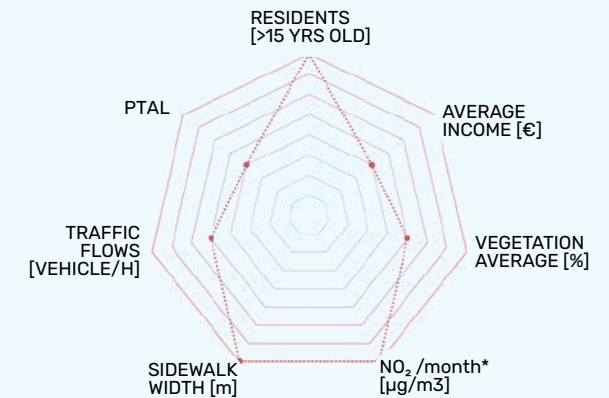
IC G. Capponi
Via G. E. Pestalozzi 13



TYPE 3

COMPACT FABRIC

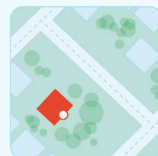
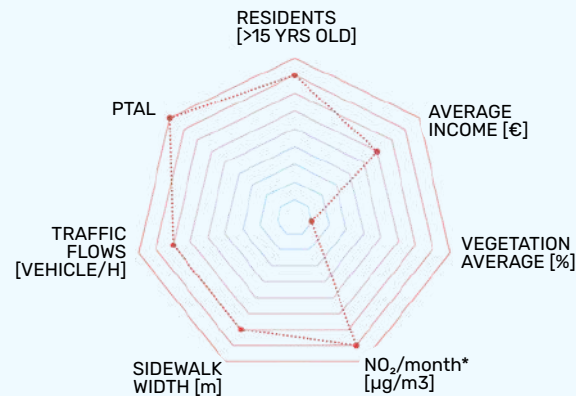
IC Nazario Sauro
Via Vespri Siciliani 75



TYPE 4

OPEN URBAN FABRIC

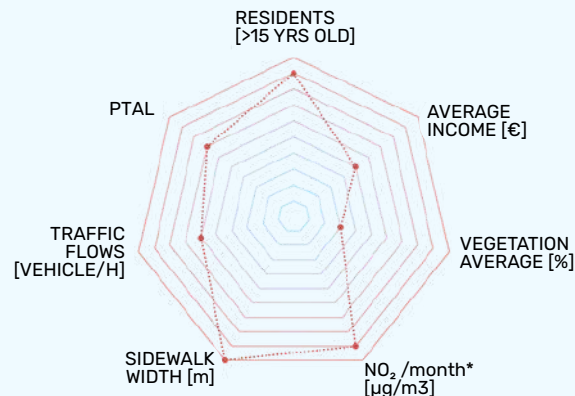
IIC Moisè Loria
Via Foppette



TYPE 5

OPEN URBAN FABRIC

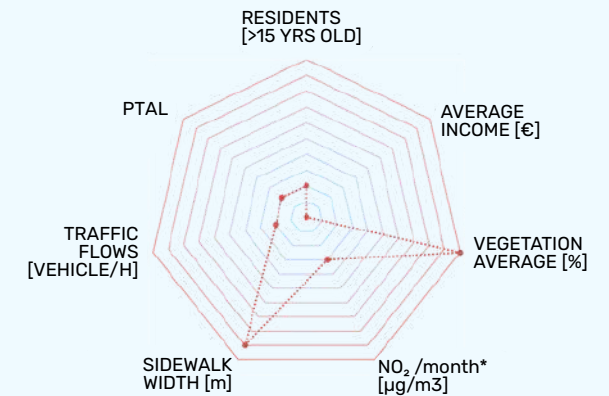
IC Leone Tolstoj - Zuara
Via Zuara 9



TYPE 6

(PERI) URBAN FABRIC

IC Sant'Ambrogio - Sant'Ambrogio
Via E. De Nicola 40



(*) Note on the next page (p.36)

Across the six typical school situations, several patterns emerge that help explain how urban form and everyday use interact to shape exposure. Compact fabrics located near busy traffic corridors tend to show higher NO₂ levels and narrower sidewalks, with schools in dense, street-facing positions or close to major road axes (Types 1, 2, 3) tend to combine higher monthly NO₂, higher traffic flows, and limited pedestrian space. By contrast, greener or more open fabrics do not automatically translate into lower exposure: some schools in ostensibly greener settings (Type 5) still register medium or high NO₂, suggesting that background pollution and nearby main roads can offset the apparent protection offered by vegetation or distance.

Access and parking conditions further modulate these patterns. Where on-street parking and drop-off areas are concentrated close to the main entrance, traffic volumes and potential exposure increase even when the wider building fabric is similar, highlighting the importance of entrance design, parking supply, and circulation schemes. Street type and the precise position of entrances and waiting areas thus emerge as key determinants of exposure. The contrast between compact schools directly on busy streets and those slightly set back (Type 4) or accessed from calmer side streets (Type 5) suggests that even small spatial shifts in where children enter and wait may significantly change exposure—an assumption that new PM2.5 and NO₂ sensors can now test more precisely.

Vegetation also plays an ambivalent role. Radar charts where relatively high vegetation coexists with high NO₂ indicate that “green” elements, if placed without attention to street canyons, airflow, and distance from emission sources, may trap rather than disperse pollutants, reinforcing the need for detailed micro-scale measurements before prescribing specific greening solutions.

Finally, social and mobility profiles can amplify or dampen risk: in situations where NO₂ is moderate but sidewalks are narrow and traffic flows are intense, peak-time crowding around school gates can still create local exposure hotspots (as in Type 1). This underlines the importance of combining static spatial indicators with information on family travel routines, work-related trip-chaining, and mode choice when assessing vulnerability and prioritising interventions.

These patterns should, however, be interpreted with care. The analysis is based on a relatively small set of schools, and the NO₂ values come from a model developed by Cittadini per l’Aria that estimates mean emissions for February 2023, so the correlations observed remain indicative rather than conclusive. More systematic measurements and temporal analyses are needed before drawing strong causal claims, especially for peri-urban schools exposed to both traffic and agricultural sources. Moreover, the NO₂ values shown in the radar charts are not measured at the school gates but derived from coarser, area-based estimates, which means they support relative comparisons between schools rather than precise assessments of local exposure. The new F.AIR PM2.5 and NO₂ sensors installed at schools will provide site-specific data, enabling much more accurate comparisons between entrances, routes, and playgrounds in future analyses.

Meanwhile, these insights point to where and how design can make a difference: at the scale of streets, entrances, waiting areas, and everyday routes, and through measures that both reduce emissions and shield children from the worst exposure. The next pages turn to this design challenge and asks how to develop effective, context-sensitive strategies that not only monitor but also mitigate air pollution around locations where exposure risks are most critical.

(*) Note of p.35

Monitoring data from the citizen science campaign “NO₂ , No Grazie!” (2023) - Source: Boniardi L, Nobile F, Stafoggia M, Michelozzi P, Ancona C. Assessing the impact of traffic restriction interventions on school air quality: a citizen science-based modelling study. Environ Res. 2025 Jul 15;277:121562. doi: 10.1016/j.envres.2025.121562.

3

Design strategies for mitigation

Is it possible to design effective and context sensitive strategies that both monitor and mitigate air pollution around locations, where exposure risks are critical?

How can these actions be implemented effectively and sustained over time, with adequate sources of monitoring by competent institutions and/or citizen groups?

Design thinking to reduce inequalities in access to healthy air around school environments

This section introduces a design-thinking process that can guide practitioners and school communities from problem framing to concrete action. Through six iterative steps, it helps identify sensitive places, choose appropriate intervention scales, activate different areas of response-ability, and select soft and hard measures, while critically reflecting on potential loopholes and unintended consequences.

We invite you to use these steps as a flexible design-thinking framework: start from your own school context, move back and forth between them as new insights emerge, and adapt the sequence to local priorities, capacities, and timelines. Move step by step from mapping inequalities to defining concrete strategies for change. Starting from the wider grid of streets and neighbourhood conditions, you can progressively zoom in on mobility patterns, exposure dynamics, and the school forecourt, identifying where children are most exposed and which levers—design, regulation, and everyday practices—can be combined to make their routes and learning environments healthier.

STEP 1

Sensitive Places

Which sensitive places (hotspots) do you focus on to intervene and reduce the criticality of children's exposure and that of their companions?

STEP 2

Intervention Scale

Which intervention scale do you want to work at (neighbourhood, block, urban canyon, façade)?

STEP 3

Areas of Response-ability

Which area(s) of response do you want to bring in the Air-Chart (mobility, nature-based solutions, other)?

STEP 4

Design strategy

Which design strategy do you adopt (reduce, extend, protect, let the good air flow)?

STEP 5

Mitigation Measures

What type of soft and hard measures can help you address the frictions and hotspots you have identified?

STEP 6

Loopholes

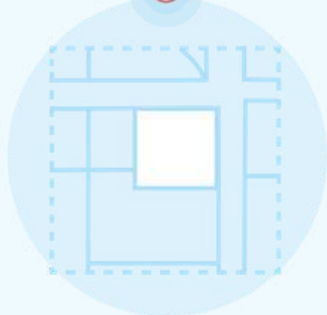
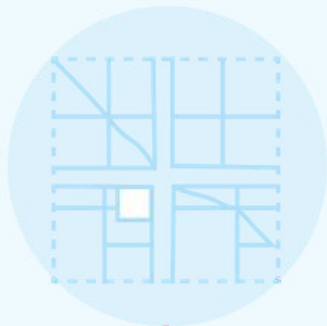
Recognise the loopholes and unexpected consequences of some choices by adopting a place-based perspective

Mapping inequalities in access to healthy children's environments



Strategies for reducing inequalities

GRID OF STREETS AND SCHOOL BLOCK



Locating hotspots along the everyday school route

NEIGHBOURHOOD BUILDINGS AND GREEN INFRASTRUCTURE



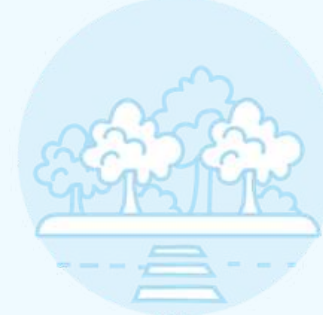
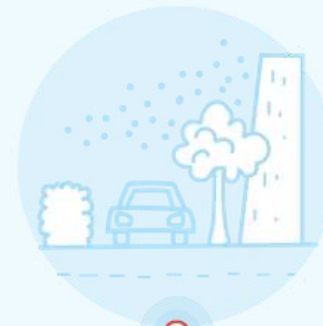
Extending clean and safe school routes

MOBILITY PATTERNS



Intervene at critical junctions where children cross busy roads

EXPOSURE DYNAMICS



Identifying exposure points on trafficked streets with limited green buffers or in pause and play areas

SCHOOL FAÇADE AND FORECOURT



Planning measures for peak-time exposure hotspot

STEP 1 - Sensitive Places invites you to focus first on where exposure and conflicts are most acute. Using the list of “frictions and hotspots” as a guide, you can identify sensitive places along children’s everyday geographies—at macro scale (city and corridors), meso scale (neighbourhood and block), and micro scale (street canyon and façade)—where targeted design and policy interventions are most likely to reduce risks for children and their companions.

STEP 2 - Intervention Scale then helps you decide at which spatial scale your intervention will be most effective and what kind of air-quality process you want to influence. Depending on whether you focus on the neighbourhood, block, urban canyon or façade, you may prioritise measures that reduce emissions at source, enhance dispersion, improve deposition through vegetation, or directly mitigate exposure in places where children spend time. At this stage, you also define your sphere of control—what you and your partners can realistically change—and identify the governance actors who need to be involved at each scale. In the following pages, we zoom in on what this can concretely mean at three key scales—neighbourhood, urban canyon, and façade—illustrating the types of design and policy actions that can be activated at each level.

STEP 3 - Areas of Response-ability invites you to clarify which areas of response you want to activate around the school: for instance, changes in mobility patterns, adjustments to urban form and street design, nature-based solutions, participatory processes, or enhanced monitoring and data use. By consciously selecting and combining these levers, you can align interventions with local priorities and capacities, and ensure that design choices, behavioural shifts, and governance arrangements reinforce rather than contradict one another. Improving air quality around schools is a complex, adaptive challenge that cuts across many domains—from emissions and climate to building form, mobility systems, governance, and everyday habits—so no single intervention is

sufficient; effective action depends on weaving together technical measures, social learning, shared responsibility, and continuous monitoring so that changes in one domain reinforce progress in the others.

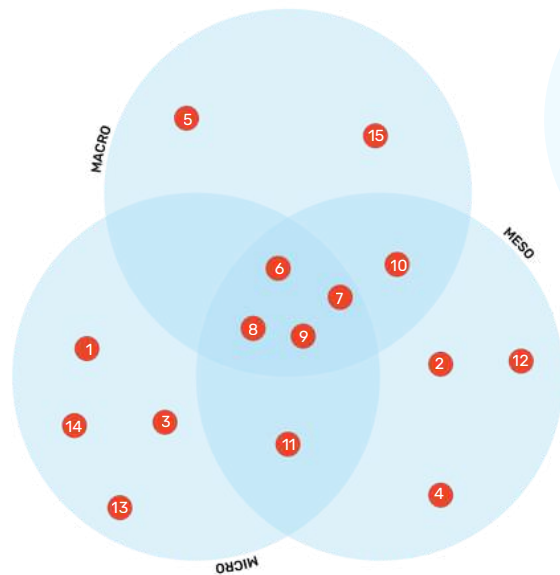
STEP 4 - Design strategy asks you to choose the design strategy—or combination of strategies—that best fits the issues and scales you have identified. Each strategy suggests a different way of acting on emissions, flows, and exposure, and together they can be combined into coherent mitigation and pathways around schools.

STEP 5 - Mitigation Measures turns design strategies into action by proposing concrete soft and hard measures that respond to the frictions and hotspots identified in STEP 1. It invites you to build combinations of interventions—rather than one-off fixes—that reinforce each other over time. Seven clusters of measures were developed through the F.AIR co-creation process, involving more than 45 actors from school communities, civil-society organisations, student inquiries, and policy institutions. They offer a shared repertoire that practitioners can adapt, mix, and sequence to fit their own school environments and governance landscapes.

STEP 6 - Loopholes invites a brief but essential moment of reflexive thinking. After selecting strategies and measures, pause to recognise potential loopholes and unintended consequences by looking again at the specific places and communities affected: might a measure shift traffic to another vulnerable street, create new social tensions, or exclude certain groups of children? This final check, grounded in a place-based perspective and open dialogue with local actors, helps refine interventions so they reduce inequalities rather than inadvertently reproducing them.

STEP 1

Which sensitive places (hotspots) do you focus on to reduce children's exposure and that of their companions?



The numbers in the circles correspond to the frictions and hotspots listed on the right. Their position on the diagram indicates the spatial scale at which they primarily occur: macro (city/agglomeration), meso (neighbourhood/block), or micro (urban canyon/façade). A single friction may appear at more than one school and at more than one scale simultaneously.

F.AIR FACTS

Frictions and hotspots

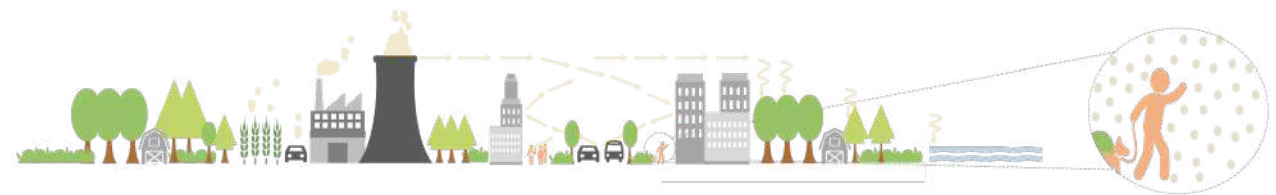
- 1 Children's exposure to vehicle emissions near playgrounds and outdoor learning areas
- 2 Peak-hour traffic, braking, and parking at school times increasing congestion and NO₂/PM exposure for children
- 3 Parents' difficulty in accompanying children safely along busy streets
- 4 Tree canopies that are too dense or poorly placed, trapping pollutants in areas used by children
- 5 Absence of safe, healthy buffer zones around school perimeters
- 6 Lack of green infrastructure shielding children from busy traffic corridors
- 7 Insufficient safe, green, and continuous routes for children walking or cycling to school
- 8 Lack of protected waiting and transit areas near school entrances and stops
- 9 Behavioural dependence on private cars for the school journey
- 10 Air-pollution emissions from nearby urban and peri-urban agricultural areas
- 11 Weak connections between schools, green spaces, and wider ecological networks
- 12 Management, maintenance, and operating-cost challenges for public spaces and services
- 13 Social tensions and conflicts arising from new or existing pedestrian zones
- 14 Fragmented responsibilities, governance difficulties, and limited support for municipalities
- 15 Misalignment between family-school rhythms and available sustainable mobility options

Fifteen recurring friction typologies and spatial hotspots identified across the F.AIR case-study schools.
Source: Frictions and hotspots identified through the clustering of fieldwork data collected by over 80 students across 16 schools, cross-referenced with a targeted literature review on urban morphology, greening and air pollution, and internal review by the research team. Elaborated by Farah Makki, Politecnico di Milano.

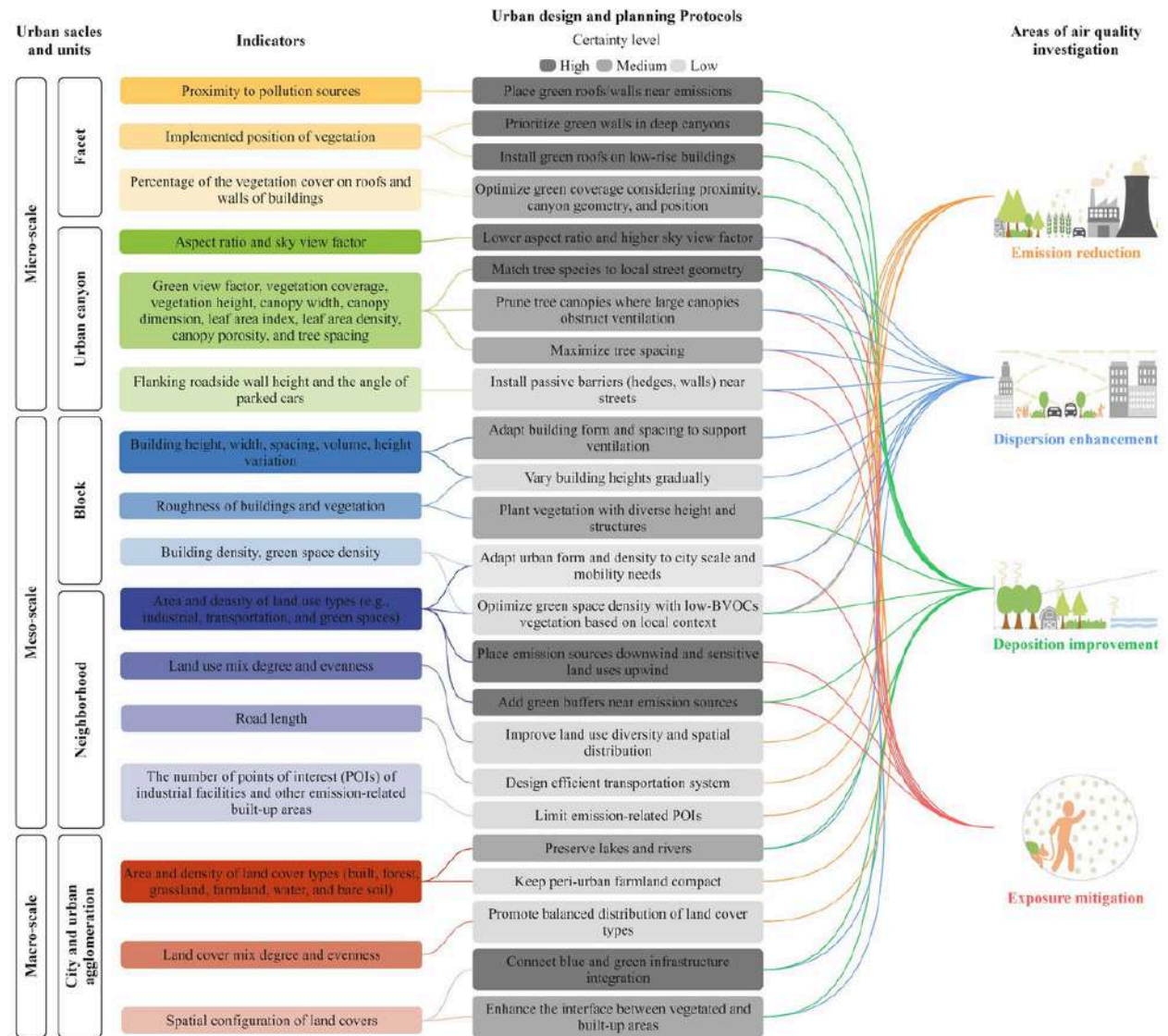
STEP 2

Which intervention scale do you want to work at (neighbourhood, block, urban canyon, façade)? And are you targeting emission reduction, dispersion enhancement, deposition improvement, or exposure mitigation?

Wu C, Makki F, Eldesoky A H, Morello E (2025). "From indicators to actions: design and planning protocols for built-up and green spaces to improve urban air quality." Journal of Physics: Conference Series, 3140, 092020. doi:10.1088/1742-6596/3140/9/092020.



Intervention targets across the four areas of air quality investigation



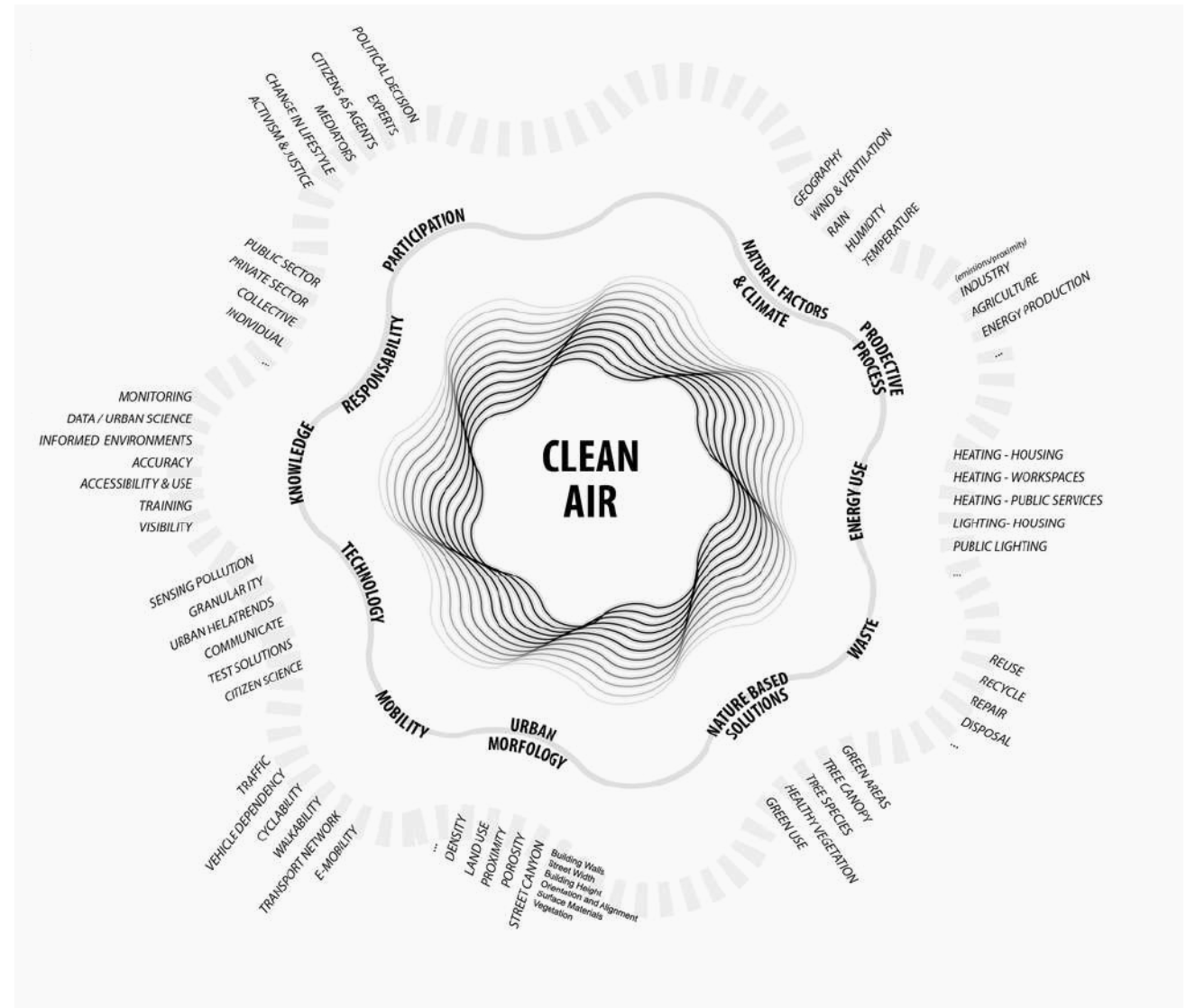
A summary of urban design and planning protocols: linking built-up and green space indicators to areas of air quality investigation.

STEP 3

Which area(s) of response do you want to bring in?

F.AIR FACTS

CLEAN AIR CHART: AREAS OF RESPONSE-ABILITY



Within this wide landscape of responses, F.AIR positions itself at the intersection of mobility, urban morphology, participation, monitoring, and nature-based solutions. The project focuses on how street layouts, traffic patterns and green infrastructures around schools can be redesigned with local communities, supported by new sensor data and citizen-science activities, to make cleaner routes and healthier everyday environments for children.

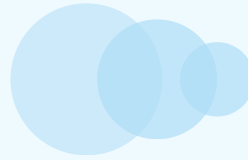
Source: Makki, F., Morello, E., Living labs and urban governance: Addressing complexity for environmental transition - case study of air pollution in Ferrara, Italy, Journal of Urban Management, <https://doi.org/10.1016/j.jum.2025.09.001>

STEP 4

Which design strategy do you adopt (reduce, extend, protect, let the good air flow)?

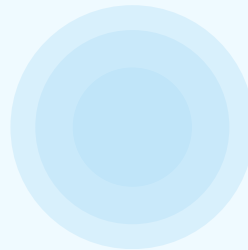
Inspired from source: Ferranti, E, Acton, J, Lindop, A, Wolstoncroft, M, Han, UP, Levine, JG, MacKenzie, R & Grayson, N 2021, Urban design for air quality. WM-Air, University of Birmingham.

MITIGATION & ADAPTATION STRATEGIES



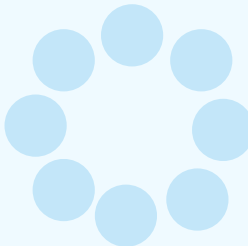
1. REDUCE

Reduce refers to measures that directly decrease emissions, such as traffic calming, low-emission zones near schools.



2. EXTEND

Extend focuses on creating continuous, safe and healthy corridors by improving walking and cycling environments and expanding green infrastructure, increasing the distance between children's routes and emitting sources.

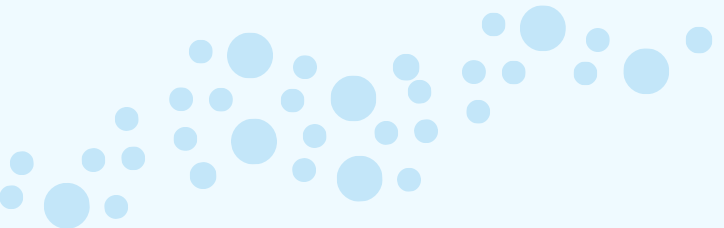


3. PROTECT

Protect highlights the need to create and reinforce protective buffers—such as vegetation barriers, redesigned entrances, or sheltered waiting and play areas—that shield children from the most polluted edges.



4. LET THE GOOD AIR FLOW!



STEP 5

Which specific soft and hard measures can you combine to implement your chosen strategy and address the frictions and hotspots you have identified?

Source: These seven clusters of measures were developed through the F.AIR co-creation process, involving more than 45 actors from school communities, civil society, student inquiries, and policy institutions. data collected and processed by Farah Makki, Politecnico di Milano

7 CATEGORIES OF MEASURES

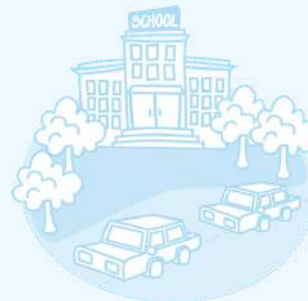
**Education,
engagement,
and co-creation**



**Green and blue
infrastructure
/microclimate**



**Street space
reallocation and
traffic calming**



**Waiting,
gathering, and
social spaces**



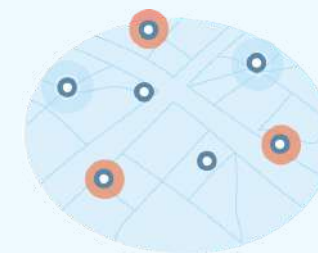
**Sustainable
mobility options
and incentives**



**Food systems
and peri-urban
agriculture**



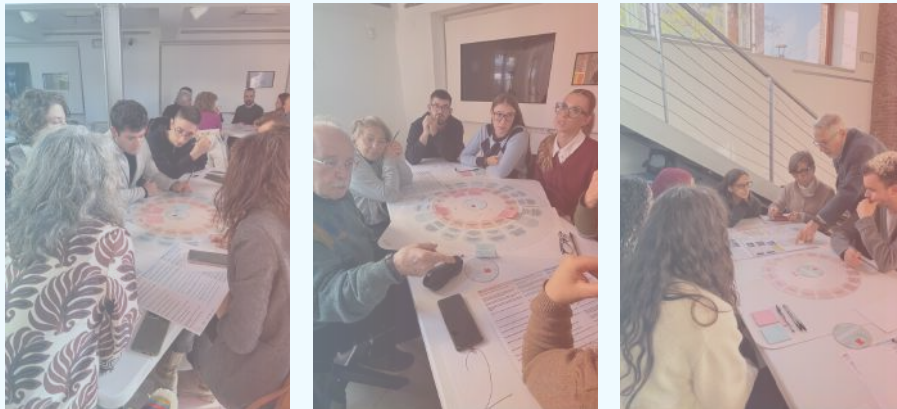
**Air quality
monitoring**





While going through this process, reflect on and co-design measures that are grounded in concrete case studies, actively involving school communities throughout co-creation.

The F.AIR co-creation process involved more than 45 actors from school communities, civil society, student groups, and policy institutions. A workshop invited them to explore six real cases of primary schools in District 6, reflecting diverse urban conditions, and to address environmental inequalities through five stages of co-design (Cases, Critics, Care, Circle, Communities). The **5C's method** described in the Engagement chapter (see p. 70), enabled the development of proposals for concrete measures and urban policies to transform schools into places where every child can breathe clean air. This pathway revealed key issues and generated over 30 measures to tackle them.



Photos from the F.AIR co-creation Workshop,
November 2025.

Before diving into the measures, we share some of the main issues to take into consideration when implementing and adapting them in other school environments.

Pedibus and volunteering

The Pedibus emerges as a promising yet structurally fragile initiative, relying largely on the goodwill of a small group of volunteers. Experience shows that, even when many families are interested, the service may never start if too few people are available to cover daily shifts—especially when everything depends on a single volunteer. This shifts the focus away from supposedly “unwilling parents” towards the limits of the support ecosystem: without broader volunteer networks, effective coordination, and clear institutional recognition, the Pedibus tends to remain sporadic and struggles to scale.

Flow conflict

The conflict between school traffic (children and parents walking or cycling during peak hours) and logistical or commercial traffic (vans, loading and unloading, through traffic) has become increasingly evident. Many streets simultaneously serve as corridors for urban logistics and as primary access routes to schools, creating hazardous intersections precisely when children are most present. This is experienced less as a technical problem and more as a governance challenge: although rules on restrictions and time windows often exist, weak enforcement and the lack of clear prioritisation between school safety and deliveries mean that these traffic flows remain incompatible at school entrances.

Mobility data and governance

Another prevalent theme is the recognition of frequently operating in a data vacuum: we lack precise knowledge regarding the origins of parents, children, and workers, as well as the necessity of parking in relation to the potential for sustainable mobility. This underscores the concept of conducting periodic mobility surveys as a foundation for assessing trade-offs (e.g., lane reductions, traffic closures, parking reorganisation).

Design for slowness and quality of urban environments

Slowness is not simply a matter of speed bumps or restrictions; it concerns the overall quality of spaces, including wider sidewalks, green barriers, shade, seating, and continuous pathways that make safe walking or pausing feel natural. The idea of “design for slowness” integrates green infrastructure, permeable pavements, and comfortable parking areas to transform school streets into vibrant and appealing environments, while also reducing car use and their role as fast-moving logistics corridors. This approach weaves together micro-design elements (trees, pergolas, rain gardens) with psychological perceptions (feelings of safety and comfort) as catalysts for behavioural change.

Green infrastructure maintenance

Managing green infrastructure is understood as a long-term challenge: while installing pergolas, planting trees, or laying new pavements is relatively straightforward, their upkeep requires financial resources, technical know-how, and clear agreements among schools, associations, and institutions—especially during periods of school closure.

Communication, accountability, and education

There is a growing recognition that no physical measure is effective without accompanying communication and educational initiatives that highlight the links between everyday choices and the quality of air and environments. Pollution is seen as a shared responsibility: agricultural practices (such as pesticide use), urban logistics, parental travel patterns, and the use of public spaces all shape the air that children and staff breathe in educational settings. Awareness campaigns, simple slogans (such as “Let’s water the plants”), and gradual experiments (for instance, trial weeks rather than abrupt bans) are viewed as tools for nurturing, over time, a community that consciously cares for mobility, greenery, and health as parts of a single, interconnected system.

Taken together, these issues suggest that many levers for cleaner air around schools are already within reach of local actors and municipalities, yet more systemic and collective efforts are still needed to sustain healthier educational environments over time.

In the next pages, we present a matrix of around 30 measures, conceived as a place-based menu of options that practitioners and municipalities can combine and adapt to their own school contexts. These measures are clustered and further detailed in seven thematic sheets, each illustrated with case studies.

Measures for healthier air zones around schools

a place-based perspective

TYPE 1



TYPE 2



TYPE 3



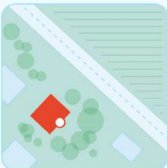
TYPE 4



TYPE 5



TYPE 6



Measure type



Disclaimer: this matrix reflects priorities from the specific F.AIR co-creation case studies and may differ in other contexts.

It offers a grounded starting point for co-design and shared decisions on which actions to invest in.

Author: Farah Makki, Politecnico di Milano

	Urban type						Measure
	1	2	3	4	5	6	
Education, engagement, and co-creation							Run awareness initiatives for parents & school communities on mobility and air quality.
							Deliver educational activities on environment, air quality, and urban health.
							Test new measures (e.g. mobility, heating) before implementing structural changes.
							Co-design more air-friendly school courtyards and spaces.
Green and blue infrastructure / microclimate							Partner with local design districts to promote and brand Clean Air Zones.
							Build neighbourhood partnerships (schools, trade, associations, parishes) for green and public space stewardship: e.g. the "Let's water the plants" initiative.
							Plant pollutant-absorbing, drought-resistant trees near to schools.
							Install protective green infrastructure aligned with local air-pollution dispersion and deposition dynamics (e.g., tree, hedge and green strip buffers along carriageways).
Street space reallocation and traffic calming							Provide pergolas and green structures for shade and comfort.
							Implement permeable and draining pavements to reduce heat and absorb water.
							Create rain gardens for stormwater management and climate education.
							Activate underused urban spaces as clean air and green friendly school zones.
Waiting, gathering, and social spaces							Monitor and enforce against illegal parking near school entrances.
							Deconflict school, parent and logistics traffic at drop-off and pick-up times by coordinating delivery schedules, access routes and children's waiting zones.
							Widen sidewalks and reduce vehicle lanes near school entrances and routes.
							Close streets in front of schools tactically or permanently.
Sustainable mobility options and incentives							Create pedestrian-priority buffer zones within a 5-minute walk of schools.
							Relocate parking away from school gates for safer, healthier access.
							Implement safety and traffic calming measures at main crossings: "playful" speed bumps, clear signage, and wide pedestrian-friendly junctions.
							Design slow streetscapes (reduced speeds, narrowed lanes, green buffers) to ensure safe, pleasant walking routes between schools and neighbourhood facilities.
Food systems and peri-urban agriculture							Provide low-exposure "healthy oasis" waiting areas at bus and tram stops.
							Install appealing indoor and outdoor seating for accompanying adults to wait up to 15 minutes at pick-up time, marked as clean-air waiting zones.
							Conduct periodic surveys on school travel patterns, parking needs, and alternatives.
							Ensure long-term support and coordination for the Pedibus scheme and strengthen the visibility and organisation of its volunteering networks.
Air quality monitoring							Offer incentives for cycling and public-transport use.
							Provide protected bicycle lanes and parking areas away from main traffic flows.
							Link school kitchens to low-emission local food chains.
							Support low-emission farming around schools with incentives, campaigns, and technical assistance.



Urban type						Measure
1	2	3	4	5	6	
						Run awareness initiatives for parents and school communities on mobility and air quality.
						Deliver educational activities on environment, air quality, and urban health.
						Test new measures (e.g. mobility, heating) before implementing structural changes.
						Co-design more air-friendly school courtyards and spaces.
						Partner with local design districts to promote and brand Clean Air Zones.

Measure type



Education, engagement, and co-creation

Improving air quality around schools is not only a technical challenge; it is a cultural and social learning process that invites children, families, educators, citizens, and policymakers to rethink how they move, learn, and care for the city together. Through educational-playful formats, creative campaigns, and co-design processes, school communities and the wider city can experiment with new practices, test concrete measures, and turn everyday routes into spaces of awareness and collective action.

Children can become “guardians of the air,” using games, stories, and missions to explore how pollution is produced and how it can be reduced in their daily lives. This kind of role-play builds confidence, curiosity, and a shared language about environmental health, so that engagement does not end with a single workshop but becomes part of classroom life and family conversations. Student-led urban innovation and design projects can extend this energy across the urban fabric through living laboratories. University students can map spaces, materials, and social life, then translate these insights into prototypes for healthier learning environments. Collaborations with creative communities can brand “Clean Air Zones,” making them visible, desirable places that affirm children’s right to breathe well.

Festivals and public events can amplify these efforts by opening them to the whole city. A multi-day “Air Festival” can bring together workshops, walks, and performances on air, health, and climate, turning squares and schools into open laboratories for citizen engagement and urban imagination. By inviting parents, teachers, residents, urban policymakers, and local practitioners into co-design processes, these events weave new alliances, keep air quality on the public agenda throughout the year, and help shape pilot interventions in real settings before structural changes are made.

Co-monitoring campaigns further ground this narrative in data that communities generate and understand. When residents use simple tools to measure pollutants along their daily routes, and when these measurements are collaboratively validated and visualised, invisible risks become tangible and discussable. Shared evidence of pollution hotspots can then support advocacy for better regulations and mitigation measures, ensuring that the voices and experiences of those most exposed help shape the city’s transition path toward cleaner air.

Education, engagement, and co-creation

FESTA DELL'ARIA



The "**Festa dell'Aria**" in Ferrara is a three-day festival of events, workshops, creative contests, social drinks events and guided tours dedicated to air quality, health, environment, and climate, conceived as an open urban laboratory for citizen engagement and innovation.

AIR RANGER



Image source: APS

In the F.AIR context, the **AIR Ranger** approach is a mixed educational-playful format where children take on the role of "Air Rangers" who protect and care for the air, using games and missions about air quality. It is designed to be highly rewarding for children and to build a sense of belonging and identity, so that their engagement with air-quality issues continues over time rather than ending with a single activity.

F.AIR STUDENT PROPOSAL



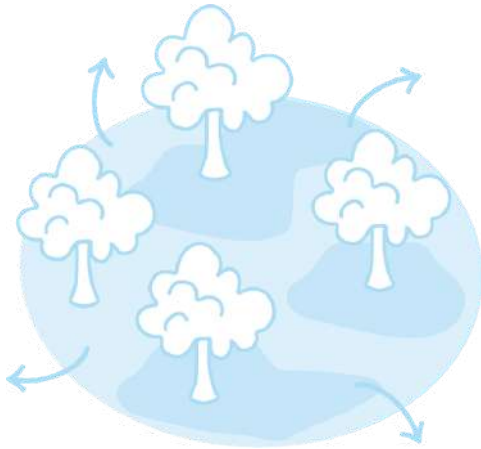
Image source: PoliMi students' fieldwork - Group Kantsybko V., Pelligra G., Raschetti P.

This F.AIR student proposal imagines using the Tortona Design District as a live catalog of potential allies for transforming school spaces. Students would use Tortona Design Week as a "lab" to spot brands and studios working on air-friendly open spaces, materials, urban furniture, and visual identities for healthy school environments, then feed these contacts and ideas into co-design.

SALVIAMO L'ARIA



"NO₂ , NO GRAZIE" is a participatory monitoring campaign led by Cittadini per l'Aria, where citizens themselves measure nitrogen dioxide in their neighborhoods using simple samplers. The collaboratively collected and scientifically processed and validated data is then used to reveal traffic pollution hotspots and push for cleaner mobility and stronger air-quality policies.



Urban type						Measure
1	2	3	4	5	6	
						Build neighbourhood partnerships (schools, trade, associations, parishes) for green and public space stewardship: e.g. the "Let's water the plants" initiative.
						Plant pollutant-absorbing, drought-resistant trees near to schools.
						Install protective green infrastructure aligned with local air-pollution dispersion and deposition dynamics (e.g., tree, hedge and planting-strip buffers along carriageways).
						Provide pergolas and green structures for shade and comfort.
						Implement permeable and draining pavements to reduce heat and absorb water.
						Create rain gardens for stormwater management and climate education.
						Activate underused urban spaces as clean air and green friendly school zones.

Green and blue infrastructure/ microclimate

Green and blue infrastructure can transform home-school routes and school surroundings into cooler, cleaner, more welcoming everyday landscapes. By working with trees, soil, water, and shade, these interventions moderate microclimates, filter pollutants, and offer children spaces for play, rest, and care. Neighbourhood partnerships between schools, local businesses, associations, and parishes can take shared stewardship of streets, courtyards, and small urban voids, turning them into visible "clean air" landmarks. Community initiatives such as "Let's water the plants" help maintain vegetation, strengthen local ties, and make climate a collective, hands-on practice rather than a purely technical task.

Strategic planting of pollutant-absorbing, drought-resistant trees and hedges near schools and along busy corridors can intercept emissions, provide shade, and visually mark safer, quieter routes. When aligned with local dispersion and deposition dynamics, these vegetated buffers—trees, hedges, and planting strips—create protective edges between traffic and the spaces children use every day. It also can create green corridors at district scale. Nature-based solutions on and around school grounds can also address heat, flooding, and comfort. Pergolas and green structures offer shade in waiting and gathering areas, while permeable and draining pavements reduce surface temperatures and allow water to infiltrate. Rain gardens capture stormwater, slow runoff, and double as outdoor classrooms where students can observe seasonal change, water cycles, and urban biodiversity.

Finally, underused corners of the city can be reimagined as green, child-friendly school zones that test new typologies of public space. Modular green walls and pocket parks along school routes can bring colour and biodiversity to hard spaces, while also buffering noise, trapping particulates, and inviting residents to linger. In this way, each intervention contributes to a network of green and blue spaces that cool the city, support health, and make environmental quality tangible in everyday urban life.

Green and blue infrastructure/ microclimate

ORBITAL PARK BETWEEN THE NAVIGLI



Image source: Milano 2030 PGT

Project map of the "Orbital Park between the Navigli" in District 6 of Milan, part of the Milano 2030 PGT (Territorial governance plan) flagship projects, illustrating a continuous green loop along the outer ring road that connects Porta Genova, the San Cristoforo rail yards, and the Famagosta junction, linking parks and nearby regeneration projects.

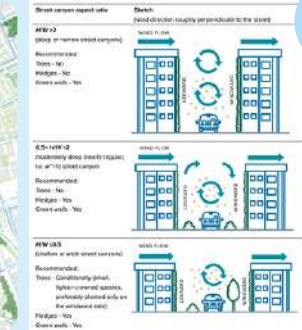
F.AIR STUDENT PROPOSAL



Image source: PoliMi students' fieldwork - Group Borgolotto M., Guerriero A., Novati A., Ratti M.

Extend green infrastructure along home-school routes, creating continuous green corridors that connect parks and use air-pollutant-absorbing plants. Planting along street sections can follow healthier strategies aligned with local air-pollution dispersion and deposition dynamics, for example using tree, hedge and planting-strip buffers along carriageways.

Source:
<https://doi.org/10.6084/m9.figshare.8198261.v4>



F.AIR STUDENT PROPOSAL

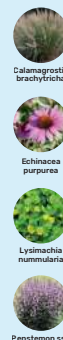


Image source: PoliMi students' fieldwork - Group Kantsybo V., Pelligra G., Raschetti P.

Spot environmentally vulnerable spaces at the school entrance that can be redesigned to integrate mitigation and adaptation measures. By adding rain gardens, climate-regulating planting, permeable surfaces, shade and other nature-based solutions, this weak point can become a protective green buffer that cools, absorbs water, and makes daily access more comfortable and climate-resilient.

F.AIR STUDENT PROPOSAL



Image source: Parkly

Transform urban spaces along home-school routes into green, vibrant places that test new solutions for environmental quality. Vertical greenery integrated with seating can bring coolness, biodiversity and calm to transit spaces. These modular green walls, if carefully located and composed of well-chosen species, can also help protect children from noise and air pollution.



Urban type	Measure					
1 2 3 4 5 6						
						Monitor and enforce against illegal parking near school entrances.
						Deconflict school, parent and logistics traffic at drop-off and pick-up times by coordinating delivery schedules, access routes and children's waiting zones.
						Widen sidewalks and reduce vehicle lanes near school entrances and routes.
						Close streets in front of schools tactically or permanently.
						Create pedestrian-priority buffer zones within a 5-minute walk of schools.
						Relocate parking away from school gates for safer, healthier access.
						Implement safety and traffic calming measures at main crossings: "playful" speed bumps, clear signage, and wide pedestrian-friendly junctions.
						Design slow streetscapes (reduced speeds, narrowed lanes, green buffers) to ensure safe, pleasant walking routes between schools and neighbourhood facilities.

Street space reallocation and traffic calming

Re-designing street space around schools can be an effective way to protect children from traffic, noise, and air pollution while making daily journeys calmer and more sociable. By redefining how cars, bikes, and pedestrians share the road, school surroundings can shift from hectic drop-off zones to safer neighbourhood spaces that invite walking, cycling, and lingering.

The process often starts with observing peak periods: when traffic queues form, where families cross, and where children wait or play before and after school. These insights guide tactical measures such as monitoring and enforcing against illegal parking at gates, coordinating delivery schedules with drop-off times, and separating logistics flows from family routes and waiting areas. Small changes in timing and layout can already reduce conflicts and stress at the busiest moments of the day.

Physical reallocation of space then makes these behavioural shifts visible and lasting. Widening sidewalks, narrowing vehicle lanes, and relocating parking away from school entrances open up room for wider forecourts, meeting spots, and safer crossings. Streets in front of schools can be closed tactically during school hours or transformed more permanently into pedestrian-priority areas within a short walking radius, so that children encounter a buffer of calm streets as they arrive and leave.

Traffic calming elements complete this transformation by slowing vehicles and clarifying that people come first. Playful speed bumps, raised or colour-marked crossings, clear signage, and pedestrian-friendly junctions signal drivers to reduce speed and pay attention to those on foot and on bikes. Combined with green buffers and street furniture, these "slow streetscapes" make routes between schools, homes, and neighbourhood facilities more pleasant.

Street space reallocation and traffic calming

F.AIR STUDENT PROPOSAL



Images source: PoliMi students' fieldwork - Group Kantsybo V., Pelligra G., Raschetti P.

The F.AIR scenario for the school on via Foppette (Milan District 6) proposes closing the street in front of the school entrance, either tactically or permanently, to remove traffic from the secondary low-flow road and create a healthier buffer and more comfortable pedestrian route.

F.AIR STUDENT PROPOSAL



PRE

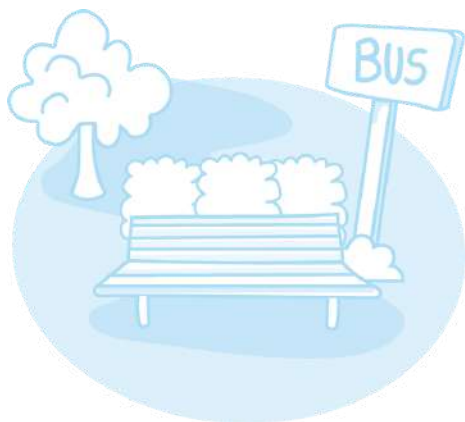


POST



Images source: PoliMi students' fieldwork - Group Li Gotti A., Ruseva A., Paredes K., Podestà C.

The F.AIR scenario at IC Nazario Sauro uses the hectic drop-off and pick-up period to test safer, calmer and less exposed streets. It starts from on-site observations - when congestion peaks, which routes families use, and where parents and children wait - and then redesigns the street section with permeable paving to create a wider pedestrian forecourt. By narrowing vehicle lanes and moving parking away from the entrance, the school frontage becomes a clear, welcoming space that prioritises people over cars.



Urban type						Measure
1	2	3	4	5	6	
						Provide low-exposure "healthy oasis" waiting areas at bus and tram stops.
						Install appealing indoor and outdoor seating for accompanying adults to wait up to 15 minutes at pick-up time, marked as clean-air waiting zones.

Waiting, gathering, and social spaces

Designing healthier school environments also means rethinking where children, caregivers, and teachers spend time waiting and meeting before and after class. Rather than standing at the edge of traffic, these everyday pauses can take place in welcoming, low-exposure spaces that extend the school's social life into the surrounding neighbourhood.

Around school entrances, simple spatial changes can make waiting more comfortable, playful, and clearly oriented towards people rather than cars. Green zones, rain gardens, and small seating areas can be combined with safer routes to and from school, so that the approach to the gate already feels like part of a protected learning environment. With careful paving, planting, and micro-furnishings, these areas become recognisable child-friendly places instead of leftover roadside strips.

On a wider scale, small interventions such as pocket parks or parklets can convert parts of streets or parking bays into intimate public spaces with benches, planters, and sometimes cycle parking. Positioned between the roadway and the school entrance, they act as buffers from traffic and offer parents and children a place to rest, talk, and play while still fitting within tight street sections.

Transit stops and busy junctions can similarly evolve into healthy, breathable zones where people wait a few metres away from traffic, under shade and in cleaner air. Providing appealing indoor or outdoor seating for accompanying adults who often wait up to 15 minutes at pick-up time, and marking these as clean-air waiting zones, acknowledges this daily routine as a legitimate use of public space.

Tactical programmes that reclaim intersections as temporary or permanent public squares reinforce this shift, turning car-dominated spaces into social stages where school communities and neighbours can reclaim space and make everyday urban life healthier and more convivial.

Waiting, gathering, and social spaces

F.AIR STUDENT PROPOSAL



Images source: PoliMi students' fieldwork - Group Kantsybo V., Pelligra G., Raschetti P.

The F.AIR students' proposal for via Foppette reimagines the areas around the school as more comfortable and child-friendly waiting spaces, closely linked to safer routes to and from school. It provides welcoming green zones, encourages slower, largely car-free access, and introduces a rain garden, adds shade and clearly marks the school as a pedestrian-oriented place. The design uses playful paving and micro-furnishings in line with the Tortona design district's experimental character, making the surroundings feel like an extension of children's daily learning and social life rather than a traffic edge.

POCKET PARKS



"Pocket parks" (or parklets) are very small public spaces created by converting parts of streets or parking bays into green, welcoming areas with seating, planting and sometimes cycle parking, usually through light, modular structures. In dense urban fabric, schools can reclaim these spaces as platforms or decks with benches and planters, creating a buffered waiting zone between the road and the school entrance while still fitting within tight street cross-sections.

THRIVE ZONES

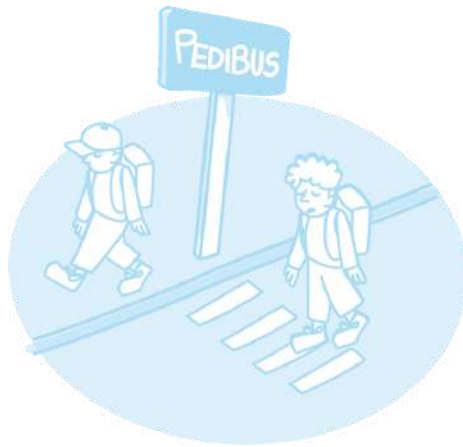


Jan Gehl's Thrive Zones proposal is about redesigning everyday places like bus stops so people, especially children and caregivers, can wait in cleaner air a few metres away from traffic rather than right next to it.

PIAZZE APERTE



"**Piazze Aperte**" is a tactical urbanism programme in Milan that turns car-dominated streets and intersections into pedestrian-priority public squares, with a dedicated phase focused on the spaces in front of schools.



Urban type						Measure
1	2	3	4	5	6	
						Conduct periodic surveys on school travel patterns, parking needs, and alternatives.
						Ensure long-term support and coordination for the Pedibus scheme and strengthen the visibility and organisation of its volunteering networks.
						Offer incentives for cycling and public-transport use.
						Provide protected bicycle lanes and parking areas away from main traffic flows.

Sustainable mobility options and incentives

Shifting school travel towards healthier, low-carbon modes requires both physical changes and supportive programmes that make active trips easy, safe, and attractive. Sustainable mobility options around schools can help families replace routine car journeys with walking, cycling, and public transport, reducing pollution exposure while fostering children's independence.

School mobility plans offer a shared framework for understanding how students currently travel and how they would like to move. Regular surveys on routes, parking needs, and alternatives reveal latent demand for active travel, highlight barriers, and guide targeted interventions. When schools, municipalities, and parent groups co-design these plans, they can coordinate measures across neighbourhoods rather than treating each school in isolation.

Soft initiatives then translate these insights into everyday practice. Walking-bus schemes such as Pedibus allow groups of children to walk along fixed routes with trained volunteers, combining safety, social interaction, and road-safety education. Pilot projects that gradually increase pupils' autonomy on the home-school route help families build confidence step by step, smoothing the transition from escorted trips to independent travel.

At the same time, infrastructure and incentives are needed to sustain these behavioural changes over time. Protected cycle lanes, secure bike parking, and traffic-calmed crossings make cycling a realistic option for more families, while positioning parking areas away from school gates discourages short car trips. Financial or symbolic rewards for cycling and public-transport use, coupled with visible campaigns, signal that choosing sustainable mobility is both valued and supported by the wider community.

Sustainable mobility options and incentives

SCHOOL MOBILITY PLAN



Periodic surveys on school travel patterns can help design fairer, healthier access scenarios. In District 6 in Milan, a 2022–2023 survey carried out with Genitori AntiSmog as part of the School Mobility Plan showed that a very high share of students would like to travel actively, on foot or by bike (86% in primary schools and 80% in lower secondary schools). Yet, although 75% of primary pupils live less than a 15-minute walk from school, only 1% make the journey without an adult, highlighting very low autonomy in home-school travel. In response, a pilot project with Capponi primary school “Siamo nati per camminare” (We were born to walk) is supporting fifth-grade students and their families in gradually gaining more independence on the route to school. The aim is to smooth the transition between primary and lower secondary school mobility habits and reduce safety risks linked to a sudden increase in unaccompanied trips.

PEDIBUS



Pedibus is a home-to-school “walking bus” in Milan, where groups of children walk along fixed routes with adult volunteers instead of travelling by car, promoting active mobility, road-safety education. F.AIR school communities expressed the need to consolidate this scheme over time, ensuring stable support while strengthening the organisation of its volunteering networks.

CAMMINO DEI PARCHI



“Cammino dei Parchi” (The Parks Walkways) is a proposal from citizen initiative “Alberi e Ambiente” in Milan’s District 5 aimed at improving pedestrian connections between existing local parks and transforming them into safe, pleasant routes that enable children to travel independently between home and school.



Urban type						Measure
1	2	3	4	5	6	
						Link school kitchens to low-emission local food chains.
						Support low-emission farming around schools with incentives, campaigns, and technical assistance.

Food systems and peri-urban agriculture

Healthier school environments also depend on what is served in canteens and how nearby agricultural lands are managed. Linking school kitchens to sustainable, low-emission food systems reduces climate impacts while shaping children's everyday eating habits and food culture, and it also calls attention to emissions from urban and peri-urban farmlands located close to schools.

Urban food policies encourage short supply chains, seasonal menus, and fair access to good food. Public catering services can develop school menus that prioritise vegetables, legumes, and locally sourced ingredients, while working with producers to adopt low-emission farming practices—such as reduced synthetic inputs, careful soil management, and efficient logistics—in the fields surrounding the city.

Campaigns and thematic weeks make these shifts visible and engaging. Special low-emission menus, paired with educational materials and simple environmental indicators, show how more plant-based dishes, fewer ultra-processed foods, shorter supply chains, and climate-aware farming methods can cut emissions while still being tasty and appealing.

Peri-urban agriculture and farmers' alliances can put this transformation into practice on the ground around the city. By encouraging low-emission farming in fields close to schools and linking these producers to school kitchens, cities can cut emissions from food production and transport while improving local soil and air quality. Incentives, purchasing commitments, and technical assistance create stable demand for seasonal produce and support air and climate-aware farming, while farm visits and co-designed canteen projects bring fresh food and sustainable practices directly into children's and parents' daily experience.

Food systems and peri-urban agriculture

MILAN URBAN FOOD POLICY PACT



The Milan Urban Food Policy Pact is an international agreement that guides cities in building sustainable, inclusive food systems. It calls on cities to promote sustainable urban and peri-urban food production and to support short food chains that link producers and consumers. These initiatives, which help reduce emissions, can also inspire low-impact sourcing models for school canteens.

MILANO RISTORAZIONE



Milano Ristorazione works within the framework of the Milan Food Policy, adopted in 2015, which sets five priorities for creating a healthier and more sustainable city food system. In collaboration with the Municipality of Milan, it develops educational projects and school menus that prioritise vegetables, legumes and locally sourced ingredients, helping children, teachers, educators and families adopt healthier, lower-emission eating habits at school and at home.

GREEN FOOD WEEK 2025



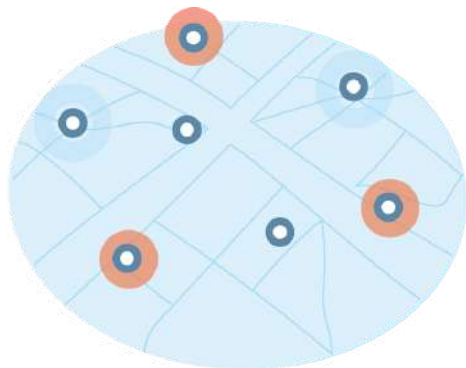
GREEN FOOD WEEK 2025 is an initiative of the Municipality of Milan's Food Policy unit and Milano Ristorazione to promote healthier and more sustainable food in school canteens. During the week, schools serve special low-impact menus richer in vegetables and legumes, together with educational materials for teachers and staff, showing how school kitchens can reduce emissions by choosing more plant-based dishes and ingredients from local, short supply chains.

FARMERS' ALLIANCES

NO al junk food Sì al cibo a km zero: il Manifesto per l'educazione alimentare nelle scuole di Coldiretti



Farmers' alliances can help co-design low-emission school food systems by adopting sustainable farming practices and bringing zero-kilometre, seasonal food and practical nutrition education into schools, replacing ultra-processed snacks with fresh, local products and building long-term healthy habits among students.



Urban type

1	2	3	4	5	6

Measure

Deploy a diffused air-pollution monitoring network in and around school environments.

Develop educational air-quality monitoring through place-based labs.

Establish regular forums for knowledge co-production actors (health, air quality, urban data) to better understand and address environmental injustices.

Air quality monitoring

Strengthening air-quality monitoring in and around schools is essential to make invisible risks visible and to guide fairer, more effective actions. Dense networks of sensors can reveal how pollution varies between playgrounds, streets, and classrooms, helping communities focus efforts where children are most exposed.

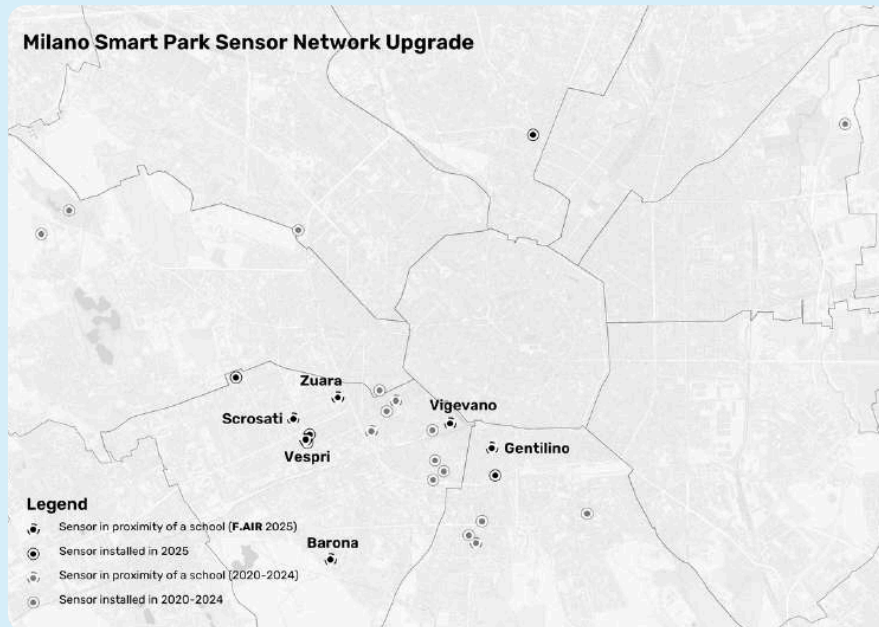
Upgrading and expanding local monitoring networks, both in hardware and software, allows cities to track key pollutants with greater spatial and temporal detail. When sensors are installed near schools and along pupils' daily routes, they capture critical exposure situations—such as drop-off peaks or polluted corridors—that might be missed by distant reference stations. Making these measurements openly available supports transparency, reuse, and joint analysis by institutions, researchers, and residents.

Educational labs turn monitoring into a learning process rather than a purely technical exercise. Through hands-on workshops, students, teachers, and families use low-cost sensors, mapping, and storytelling to understand air quality around their schools and neighbourhoods, and to connect data with questions of health, justice, and everyday urban life. Involving school communities in data collection and interpretation builds shared ownership and makes it easier to discuss trade-offs and priorities for change.

Regular forums for knowledge co-production can bring together health professionals, environmental agencies, municipalities, urban planners, and citizen science groups to interpret findings, fill data gaps, and better understand the determinants of environmental injustices. By aligning local sensor, urban, and human data with city-wide climate and air-quality plans, these sense-making spaces help ensure that insights from school environments inform broader research, policies, and investments, closing the loop between measurement, learning, and action for healthier access to air-friendly school microenvironments.

Air quality monitoring

F.AIR MONITORING NETWORK



Map source: Transform Transport

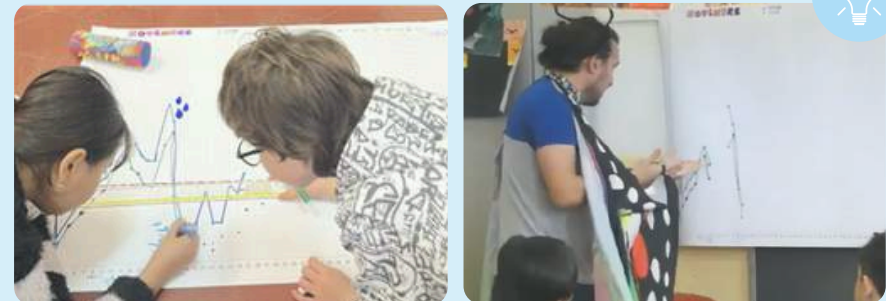
During the F.AIR project, the Milano Smart Park sensor network for PM_{2.5} and NO₂ was upgraded in both hardware and software, strengthening monitoring in the area. Six new outdoor and eight indoor units were installed in and around schools to improve air-quality monitoring and map critical exposure situations. All school measurements are collected and shared as open data to support transparency, reuse and collective learning.

ALLIANCE FOR AIR AND CLIMATE - MILANO CAMBIA ARIA



In 2021 the city of Milan approved the Air and Climate Plan, an operational tool to tackle climate change and improve air quality with targets for 2030 and 2050. Within this framework, Milan created the Alliance for Air and Climate, where businesses commit to voluntary actions that cut emissions, improve air quality and support the city's climate-neutral transition, though further work is needed on integrated data.

EDUCATIONAL LABS



Images source: APS

Milano Smart Park (MSP) educational labs are hands-on workshops where school communities learn to monitor and understand air quality around their schools and streets. In F.AIR, they involved 186 children and 20 teachers from 8 primary schools, using low-cost sensors, mapping, and playful storytelling to understand data on pollution and link it to environmental justice and healthier school environments. Further details are provided in the engagement section below.

4

Engagement & co- creation pathways

How should active participation be structured to co-produce knowledge, and encourage informed mitigation actions?

How can these processes support evidence-based policies to reduce exposure and promote clean air zones, especially around schools and other identified sensitive areas?

The F.AIR geography of response-ability

The concept of response-ability refers to the capacity to respond effectively to air quality challenges by acknowledging and acting within diverse domains of influence, rather than placing responsibility on any single actor or sector. It calls for the co-production of knowledge and action for air-friendly school environments through participatory journeys where diverse groups learn and act together (Makki & Morello, 2025, 2026). Engagement journeys may include environmental co-monitoring, tailored educational activities in classrooms, co-design events, and policy-level dialogues that bring the air-pollution challenge closer to children, future urban professionals, school communities, policymakers, and citizens. They help each group recognise its role, share situated knowledge, and contribute to tangible improvements in and around schools.

Engagement formats

F.AIR's engagement experiences produced a small repertoire of adaptable templates and formats that can be applied in other contexts. They address participation at different levels to foster transformative urban capacity (Wolfram, 2016)- understood as the ability of diverse actors to mobilise their distinct resources toward a common purpose. Building on the three spheres of sustainability in environmental transition processes (O'Brien et al., 2013), we understand transformative capacity as spanning three interlinked spheres of change.

March-December 2025 Citizen science monitoring network upgrade and extension

Upgrade of existing units and new sensing units installed in eight schools in Districts 5 and 6.

June-November 2025 Public outreach (Citizens)

5 public events and participation in Thematic conferences
survey >1,190

29 November 2025 Co-creation workshop

Co-creation workshop with stakeholders and District 6 schools to co-construct guidelines > 45 pers. involved

**Guidelines and
public sharing**

March-June 2025 Participatory action research on schools environments

> 80 university students involved in the inquiry of 16 schools in Districts 5 and 6.

**7 October -
13 November 2025**

Children educational Labs on air quality

in 8 schools of Districts 5 and 6 (10 classrooms, >180 children and 20 teachers involved)

3 February 2026 Policy dialogue

Presentation of results with the City of Milan, the districts and civil society networks

 **F.AIR journey**

GUIDELINES - Engagement & co-creation pathways

The practical sphere concerns concrete mitigation actions, everyday routines and technical solutions—such as how people travel to school, and engage with air-quality monitoring tools. The structural sphere refers to the institutions, rules, funding arrangements, planning frameworks and professional capacities that shape what is possible in the long term, including municipal regulations, school policies, and citywide mobility or air-quality plans. The cultural sphere encompasses the meanings, values, narratives and shared imaginaries that influence how communities perceive air pollution, children's rights, and their own role in driving change.

Engagement journeys that deliberately connect these three spheres—by shifting practices, adjusting structures, and nurturing new cultural understandings—are more likely to generate lasting transformations in how environmental responsibilities are distributed and enacted.

In the following pages, we encourage practitioners to explore, reuse and remix these templates as starting points, tailoring them to local priorities, timeframes, and capacities, while keeping the core principle of shared response-ability at the centre.



School Communities (parents, teachers, civil society, neighborhood)

Engagement format:

- F.AIR Co-creation Workshop: Schools as 'Islands of Fresh Air'



Policy actors

Engagement format:

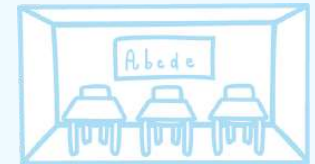
- Policy dialogues



Citizens (incl. civil society businesses, parish centers)

Engagement formats:

- Public meeting for community engagement
- Citizen science monitoring campaign
- Environmental festival & pop-up events
- Public survey



The children in their classrooms

Engagement format:

- Primary school citizen science toolbox



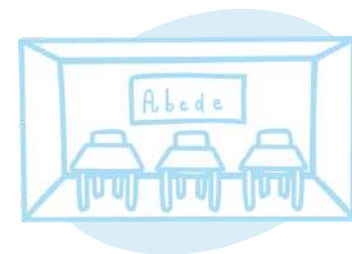
Future urban professionals and university students

Engagement format:

- "F.AIR Schools" Urban Design Studio

The children and their classrooms

Primary school citizen science toolbox



Type of event

AIR QUALITY EDUCATIONAL LAB



Objective

Raise awareness of air–health links and introduce scientific method through local air quality co-monitoring.



Difficulty / criteria



Medium: strong educational impact but needs teacher buy-in, clear didactic framing, and basic data-handling capacity.



Description

Children receive two air quality sensors—one indoor unit and one outdoor unit—and take on the mission of monitoring the air around their school. By exploring and discussing the data, they share their feelings and imagine solutions for cleaner routes and healthier play spaces.



Time

4 lessons of 90 min each



Invitees

One or more classes, including eco or science club.



Resources and materials

Low-cost sensors
MSP Educational package
“Air Ranger” playful animation materials.



Number of participants

15–40 per class

Actors/collaborators

Citizen science group
School leadership
Municipal environment office
Research partners providing toolbox design.

Preliminary preparation needed

Adapt toolbox to local curriculum
Pre-test sensing units
Secure consent
Agree data-sharing and school timetable.



Location

Classroom with projector or interactive whiteboard, wall space for large maps, floor space for circle seating, and access to an outdoor area (or large corridor).

Facilitators

Teachers
Education-focused researchers
Creative facilitator used to working with 10–12 year olds.

Primary school citizen science toolbox

F.AIR's citizen science laboratories are hands-on workshops where school communities learn to monitor and interpret air quality around their schools and nearby streets. The mixed educational-and-playful approach proved highly rewarding for the children, fostering curiosity, collaboration, and a sense of belonging within the group of young "AIR Rangers," thus ensuring continuity and shared ownership of the project's results.

Air quality co-monitoring in schools

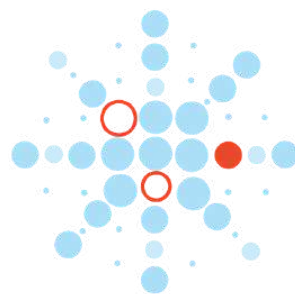
What if we became "Air Rangers"?

Equip

The F.AIR process starts with a presentation of a replicable educational package to teachers. Two air-pollution sensing units are adopted by the school. These belong to the Milano Smart Park citizen science network for outdoor and indoor monitoring. Through the MSP educational package children learn about air quality, health effects and sustainable behaviour

Sense

To guide comprehension, data collection and analysis, including PM2.5 monitoring and the influence of meteorological conditions (temperature, humidity, rain, wind), four 90-minute sessions were sufficient to engage each participating classroom. The Milano Smart Park (MSP) educational package is available to support replication in other contexts.



Access here
[MSP educational package](#)

Make sense

Throughout the process, F.AIR proposes a mixed educational-playful approach, created by two facilitators, "Bro & Fiu". Through storytelling, games, and experiments, children learn air-monitoring and data analysis motivated by emotional involvement. This fosters a sense of belonging to the AIR Ranger community, to support sustained engagement over time. Furthermore, to extend local involvement low cost sensors are deployed in school surroundings to engage the enlarged community and understand mobility patterns.

F.AIR FACTS



Images of the F.AIR educational activities in schools. Source: APS

Red and blue tones are aesthetic photo filters and carry no analytical meaning.

Future urban professionals & university students

“F.AIR Schools” Urban Design Studio



Type of event

FIELD-BASED UNIVERSITY COURSE



Objective

Bring university students closer to air quality challenge. Map inequalities in access to healthy air in children environments and co-develop design strategies with schools and policy actors.



Difficulty / criteria



High: multi-actor, multi-phase process; strong learning and impact potential but requires robust coordination with several schools and municipal partners.

Description



Select a number of schools to inquire (e.g. 10–20) during a university course, while considering spatial variability within a specific district, student teams work in 2–3 person groups per case study, collect and analyse air data and everyday exposure hotspots along the routes and access to schools, identify areas of response-ability, and propose (re)design strategies that feed into a public co-creation with school communities and policy actors.



Time

8–10 weeks studio with milestones, including co-creation moments with school communities.



Invitees

Urban planning, design, environmental engineering, public health actors who can provide feedbacks during reviews.



Resources and materials

Local air data and sensors, base maps of school surroundings, WebGis data on urbanscape and flows, Air-Chart, F.AIR guidelines including the templates for critical mapping, urban types and design thinking steps and tools.



Number of participants

Up to 80

Actors/collaborators

University, municipal environment and mobility offices, civil-society organisations, participating schools.

Preliminary preparation needed

Jointly select schools with partners; secure access and data-sharing; schedule field visits and interim presentations (critical mapping, response-ability, design scenarios, and co-creation events).



Location

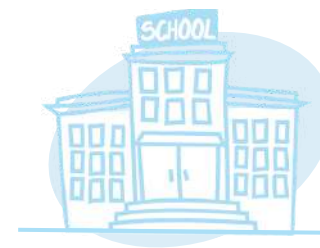
University studio space, multiple school field sites with data access and meeting facilities.

Facilitators

Studio professor (urban planning & ecology), air-quality, data and sustainable mobility, researchers, co-creation facilitator, civil-society partner.

School Communities

F.AIR Co-creation Workshop: Schools as 'Islands of Fresh Air'



Type of event
CO-CREATION WORKSHOP



Objective
Engage school communities and policy actors in co-designing measures and policies that turn schools into 'Islands of Fresh Air', reducing inequalities in children's exposure.



Difficulty / criteria ● ● ●
High: intensive format that builds vision over concrete measures; requires careful facilitation, good representativeness, and follow-up with schools and policy actors.



Description

A 5C's method guides participants from understanding to action. In Cases, they explore selected school case studies and exposure maps; in Critics, mixed groups analyse frictions and existing proposals. In Care, they use the F.AIR Compass to draft design and policy scenarios; in Circle, they present and debate these in a Sharing Circle. Finally, in Communities, they identify who can act, what support and commitment are needed.



Time
4 hours



Invitees
Parents committees, teachers, students' representatives, nearby residents, local shopkeepers and everyday users of the school area.



Resources and materials
5 Cs prompts, case-study sheets, and design scenarios, exposure/air quality data visuals and maps, F.AIR Compass board with typical frictions and measures, post-its and markers, documentation tools.



Number of participants
Up to 50

Actors/collaborators
School leadership, parents' committee, neighbourhood associations, municipal departments, local NGOs or health agencies.

Preliminary preparation needed
Select and prepare school case studies with students' inputs; compile local air data and maps; brief municipal actors; invite and confirm diverse school-community participants; agree on how workshop outputs feed into school and city decisions.



Location
Open and bright space that accommodates up to 8 working groups, with digital connection and screen.

Facilitators
Co-creation facilitators, school staff, municipal officers (mobility, environment), civil-society partners.

F.AIR Co-creation workshop: Schools as 'Islands of Fresh Air'

The air around Milan's schools presents critical issues that threaten children's health, but together we can change things. This co-creation workshop invites us to address environmental inequalities through five stages of co-design (Cases, Critics, Care, Circle, Communities) to develop concrete measures and urban policies that transform schools into spaces where every child can breathe clean air and grow up healthy.

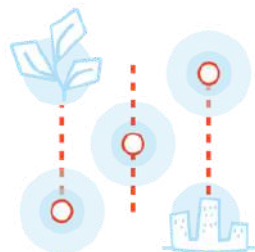
Co-creating with the 5 "C"s of F.AIR

What if schools could become "Islands of Fresh Air"?



Cases

We start from immersion in real case studies to explore the typical situations of exposure to pollution in Milan's schools, with a specific focus on District 6.



Critics

Case studies critiques - sessions where groups analyse case studies, preliminary data, and mitigation proposals, offering constructive feedback on the most relevant measures and identifying critical issues that remain to be addressed.



Care

F.AIR Design Care - creative phase dedicated to the development of concrete scenarios for "islands of fresh air", integrating urban measures and policies that take into account the different users and multiple scales of intervention



Circle

F.AIR Sharing Circle - a moment where participants present, discuss and mutually validate the developed scenarios, building a shared vision for the future.

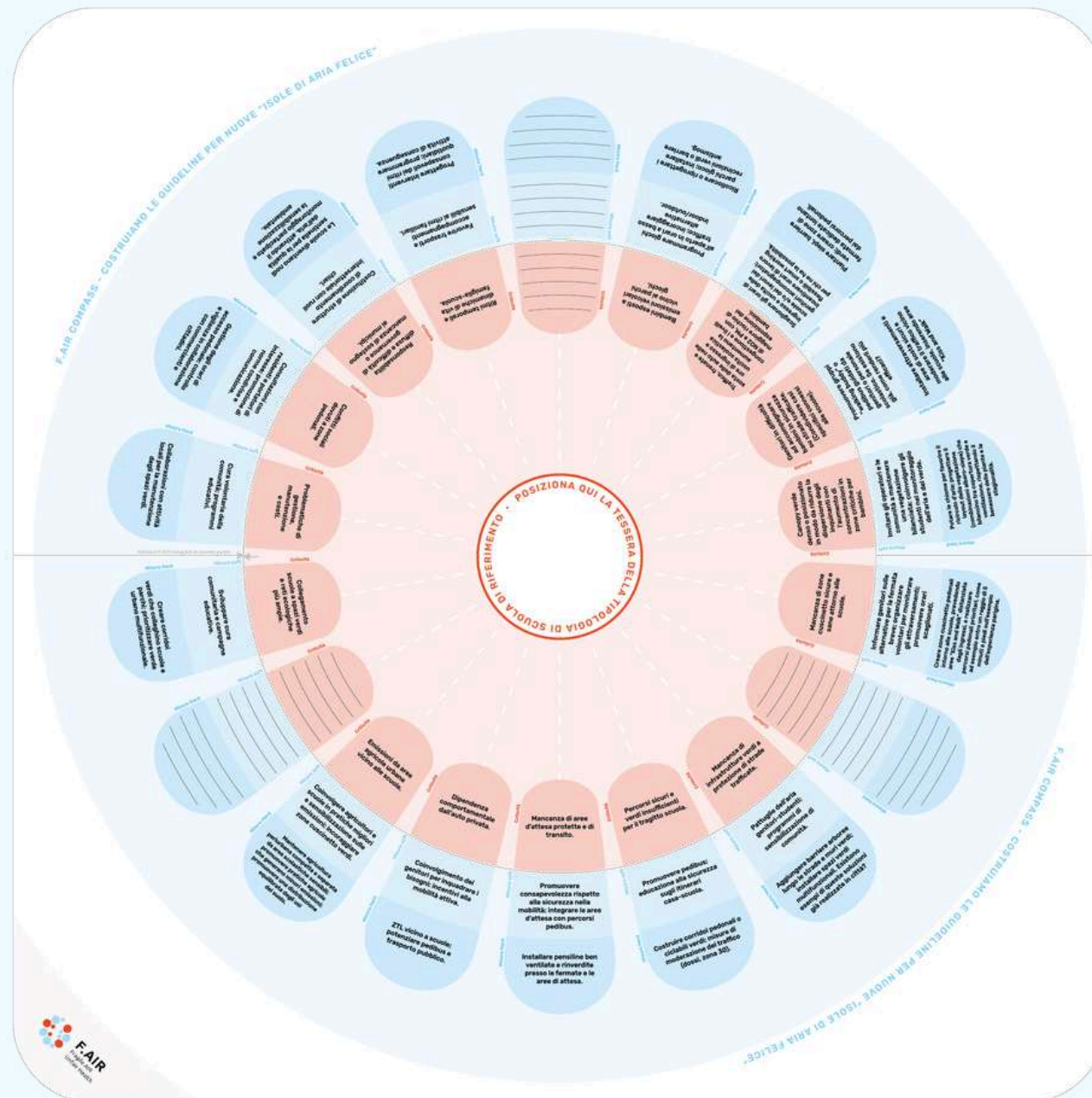


Communities

Community of Action - concludes by mapping who can lead the actions and what support is needed, defining the geography of shared responsibilities to implement the proposed scenarios.



Throughout this journey, the F.AIR COMPASS focuses reflection on three fundamental questions:
 What are the five main frictions and fragilities we observe and consider priority areas for intervention?
 What types of soft and hard measures can address them, and how can these be adapted to the specific context?
 Who can support putting these measures into practice?



F.AIR COMPASS:
 concept and content by Farah Makki, Politecnico di
 Milano (DASTU) with the support of Plam Studio
 (graphic design and production)

Citizens

Public meetings for community engagement



Type of event
PUBLIC MEETING



Objective
Bring citizens closer to air-quality challenges, deepen understanding of local conditions, and lay the groundwork for their involvement in future research activities.



Difficulty / criteria ● ● ●
Medium: good legitimacy and visibility; depends on trust-building and clarity on how results influence policy.



Description
Preliminary brainstorming with citizens, stakeholders, institutions and community representatives regarding air quality mitigation actions and environmental injustice.



Time
4 hours



Invitees
Residents of targeted neighbourhoods, including public and private parties.



Resources and materials
Simple explanatory visuals.



Number of participants
60-120

Actors/collaborators
Public institutions, universities, environmental agencies, community organisations, schools, citizens.

Preliminary preparation needed
Recruitment through local networks.



Location
Community centre, town hall venues, library, or school hall with room for presentations.

Facilitators
Scientific moderator

Citizens

Citizen science Monitoring campaign with low cost sensors (LCS)



Type of event
MONITORING CAMPAIGN



Objective
Empower citizens to collect and interpret local air quality data and co-design individual and collective actions.



Difficulty / criteria ● ● ●
Medium: identify a reliable LCS, maintenance, community engagement.



Description

Deployment of low-cost sensors or diffusion tubes, followed by a meeting to visualise and interpret the results, and to mobilise key actors to make concrete commitments and formulate specific advocacy asks.



Time
Monitoring over time;
one 2-hour meeting



Invitees
Residents of targeted neighbourhoods,
local public and private institutions.



Resources and materials
LCS and simple explanatory
visuals.



Number of participants
30–60

Actors/collaborators
Public institutions, universities,
environmental agencies, community
organisations, schools, citizens.

Preliminary preparation needed
Recruitment through local
networks.



Location
Community centre, town hall venues,
library, or school hall with room for
presentations, gallery walk, and small-
group discussions.

Facilitators
Community engagement specialist

Citizens

Environmental festival & pop-up events



Type of event
PUBLIC INFORMATION



Objective
Make air pollution tangible and relatable through arts, playful labs, and informal dialogue spaces in public events.



Difficulty / criteria ● ● ●
Medium: excellent reach and symbolic value; resource-intensive and best when tied to longer-term programmes.



Description

Plan informational stands during environmental festivals and/or combine live performances, creative labs for kids, micro-workshops and short talks, all linked to local air quality themes and ongoing initiatives.



Time
1 day or series of short events



Invitees
Broad public, including families, youth groups, and passers-by.



Resources and materials
Stage or public space, informational stands, sound equipment, booths, creative materials, portable exhibits or sensors.



Number of participants
100–300+

Actors/collaborators
Municipal culture/environment departments, local arts groups, civil society networks.

Preliminary preparation needed
Secure venue and permits, curate programme with local partners, communication campaign.



Location
Public outdoor space (piazza, park, street) or community hall with multiple station areas; weather contingency.

Facilitators
Event organiser, artists, NGOs, science communicators.

Citizens

Public surveys



Type of event
PUBLIC SURVEY



Objective
Capture perceptions, habits, priorities and contradictions on air quality and school environments from a broad population, to complement sensor data and inform future actions.



Difficulty / criteria ● ○ ○
Low-medium: easy to deploy at scale; quality depends on clear questions, accessibility, and good communication to avoid bias and survey fatigue.



Description

Short online and/or paper questionnaires distributed through schools, community hubs, and local channels, asking residents, parents, students, and workers about their experiences of air pollution, mobility routines, and views on possible measures; results are summarised and fed back.



Time
Preparation 2–3 weeks;
survey open 2–6 weeks



Invitees
Parents and caregivers, students (age-appropriate versions), school staff, local workers, and residents in the school catchment areas.



Resources and materials
Survey platform or printed forms, consent and privacy information, communication materials, simple result-visualisation templates, feedback venues.



Number of participants
100–500+

Actors/collaborators
Schools, municipalities, universities or research centres, parent associations, local NGOs.

Preliminary preparation needed
Design and test the questionnaire, obtain ethical/administrative approvals, set up distribution and collection channels, plan data-management and analysis.



Location
Hybrid: online, plus paper surveys via schools, community centres, libraries, public events.

Facilitators
Survey designer, data analyst, community outreach staff.

Environmental festival / pop-up events & public survey

Within F.AIR, several initiatives were carried out, between September and December 2025, in the city of Milan to inform and engage citizens in a collective reflection on air pollution. The objective was twofold: to understand residents' existing level of knowledge about air quality and to explore their willingness to adopt more air-friendly practices.

Awareness raising channels

How to bring air quality closer to citizens?

DATA & INFORMATION

To achieve this, a mixed set of communication and engagement tools was used. Ten informational posters distributed across different city locations during public events offered accessible insights about air pollution and its local relevance.

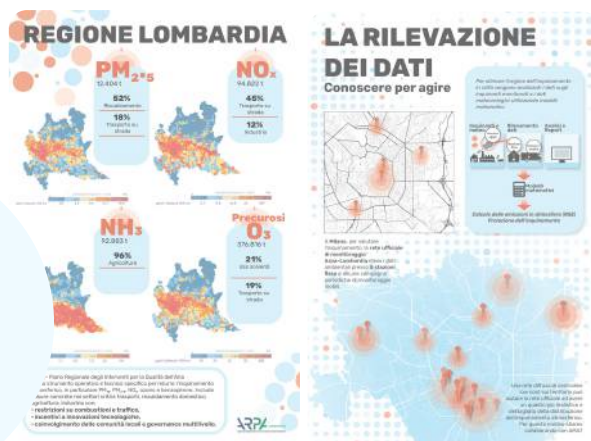
OUTREACH EVENTS

Plug-ins in existing environmental events (e.g. Green Week) connected the F.AIR initiative to broader discussions on environmental health and sustainability. An interactive "fortune teller" tool invited curiosity and participation, turning technical information into a playful inquiry experience.

PUBLIC SURVEY

A questionnaire composed of 22 questions gathered individual perspectives and daily practices. Over the three-month period, a total of 1,194 valid questionnaires were collected. It provided a nuanced understanding of how Milan's citizens perceive air quality and how ready they are to change practices.

F.AIR FACTS



Images of the F.AIR materials used in public promotional stands.
Source: APS

Policy actors

F.AIR policy dialogue



Type of event
PUBLIC DIALOGUE



Objective
Convene policy actors and researchers and civil society to align regulatory, health, and urban design responses to local air challenges and identify action pathways.



Difficulty / criteria ● ○ ○
High: politically sensitive but strategic; needs clear follow-up mechanism and transparent documentation.



Description

Short evidence inputs are followed by mixed breakout groups (health, transport, education, environment) that co-create priority measures and timelines, often framed as a 'clean air pact' or roadmap.



Time
Half day to full day



Invitees
Policymakers at local, regional, national level; key implementers and regulators.



Resources and materials
Briefing pack with local air data, legal framework, case studies, templates for roadmaps.



Number of participants
Up to 15–50

Actors/collaborators
Environment agencies, city departments, public health agencies, research institutions, civil society.

Preliminary preparation needed
Political sponsorship, mandate clarity, synthesis of existing policies and gaps, identification of realistic levers.



Location
Open, bright and easy to access space, flexible enough to accommodate 3–4 thematic groups, with a digital connection, microphones and a screen.

Facilitators
Neutral convenor, senior policy facilitator, technical experts.

Pockets for the future

From fragile air to fairer environments

Building on the F.AIR experience, the approach shows how combining granular air data, spatial analysis, place-based fieldwork and citizen-science activities can move the focus from abstract “air quality” to the concrete inequalities present in children’s daily environments.

By identifying areas of concern and turning them into clear priorities for action, this approach helps cities and school systems move from fragile air and unfair health risks towards more equal access to healthy environments for all children, and it offers a framework that other territories can adapt.

In its final phase, the F.AIR policy dialogue showed how the project is helping to build alliances, tools and practices that connect schools, neighbourhoods and urban policies around the linked issues of air quality and health. The following recommendations are intended to guide the next steps of this pathway and to share lessons that can support similar initiatives in other contexts, bringing together the different perspectives that emerged.

Data, information and access

A first line of work concerns how public data are used and turned into information that can genuinely support decisions and concrete change. It is important to distinguish clearly between data and information, and to specify who they are for and with which aims: shared diagnoses, setting priorities for intervention, or communicating with citizens.

It is therefore recommended to build stable alliances among health agencies, research institutions and other competent bodies, in order to ensure access to health and environmental data through clear and replicable procedures. At the same time, quantitative data (monitoring, health impact estimates, maps) should be systematically combined with place-based contextual information, citizen-science contributions and the situated knowledge of those who live and work in each neighbourhood.

Citizen-generated data can play a key role in making air quality tangible and in bringing communities closer to the challenge in their everyday lives. At the same time, it raises sensitive questions about robustness, comparability and expectations that need to be handled with care.

Recognising these limits openly, while also valuing the ability of such data to spark interest, responsibility and local insight, is an important part of building a transparent data culture. Adopting the principle that “those who are missing from the dataset are missing from care” means constantly asking who is left out of statistics – the most exposed children, marginalised communities, and those who struggle to make their voices heard – and adjusting data collection, vulnerability analysis and priority-setting accordingly.

In this way, future processes can support more inclusive data practices and a more nuanced understanding of environmental and health inequalities, offering approaches that can be taken up and adapted by other cities and school systems.

Participation, alliances and governance

Participation here is understood not as simple consultation, but as co-production of data, narratives and solutions. Schools, associations, parent groups, active citizens and community networks bring experiences that both enrich and challenge any project’s technical framework. It is recommended to keep investing in dedicated spaces and time for collaborative work between different levels of administration, schools, civil society organisations and community groups, so as to build shared diagnoses and recognise that responses or “treatments” may differ from one context to another.

Particular attention should be paid to those who seem indifferent, working with bridging figures – such as school mobility managers, health professionals, teachers and community educators – who can translate air quality issues into everyday concerns.

The political role of local and city administrations is crucial: they need to collect citizens’ demands, raise the level of ambition, and at the same time manage the frustration created by regulatory constraints and limited resources.

The F.AIR guidelines can be understood as a tool that helps decision-makers orient choices, build consensus and connect initiatives that would otherwise remain fragmented, offering governance arrangements and relational infrastructures that can also inspire similar processes in other contexts.

Schools as drivers of transformation

A strong message here is the role of schools as drivers of urban transformation. The route to changing the city “passes through the school”: school buildings, school squares, urban furniture, and safe, green and breathable home-to-school routes become the core of an urban policy that brings together air quality, health, mobility and public space.

It is recommended to strengthen and expand the network of schools involved in co-monitoring and educational activities, developing tools such as games, workshops, events and performances that enable children to become agents of change also within their families. Every school should be able to count on a space in front of the entrance where it is possible to breathe cleaner air, as well as on safer, more legible and more welcoming routes between home and school.

From a One Health perspective, actions around schools should bring together air quality, road safety, climate and green infrastructure, using collected data to guide interventions on traffic, paving, shading, parking and the care of public spaces. In this way, the F.AIR journey can become a device that links educational, health and urban policies around shared objectives, while offering transferable models for school-centred transformation in other urban settings.

Public space, tactics and experimentation

The process also highlighted the value of tactical urbanism: open squares, depaving, murals and other devices that make the link between public space and air quality tangible. Such interventions make it possible to test solutions, try out different uses of streets, and open public discussions on traffic, parking, greenery and safety.



It is recommended to treat project actions as platforms for tactical experimentation, in which trees, furniture, monitoring devices and new uses of space are introduced in a reversible way, while clearly communicating both limits and potential.

The experimental dimension – for example, the difference between trees in pots and permanently planted trees – should be openly discussed with residents and schools, in order to activate shared care, responsibility and reflection on the feasibility of more radical interventions for more pleasant living environments and routes.

At the same time, it is important to connect existing pilot cases – open squares, school streets, invisible urban green spaces, cycling routes for children, and networks of parks potentially equipped with sensors – and turn them into opportunities for collective learning, explicitly including what has not worked.

Making space to talk about failures becomes a way to improve tools, processes and goals, and to generate knowledge that is clear, shareable and usable for other municipalities experimenting with similar tactics.

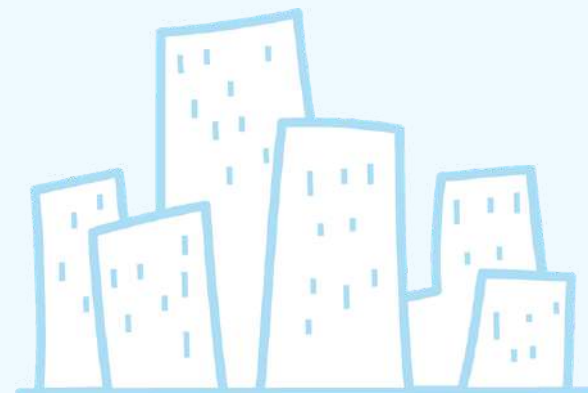
Communication, narratives and justice

Finally, there is a clear need to build shared narratives around air, health and inequality.

This is not only about disseminating data, but about turning them into stories, images and devices that help people recognise themselves in both the problems and the solutions.

It is recommended to organise public feedback events in local areas, involving young people as mediators of change within families and communities.

Events, performances, cultural initiatives and creative communication formats can make complex issues such as air pollution, road safety and climate change more accessible, and can be adapted by other territories that want to engage residents on air and health.



To “make the invisible visible”, it is useful to employ physical markers in public space – signage, street furniture, trees and devices that change over time – that signal emerging improvements or critical issues, turning technical information into everyday experience.

In parallel, attention to gratitude and mutual recognition among researchers, administrators, activists and schools can strengthen the cohesion of the process and keep alliances alive beyond the formal duration of the project, while also modelling a culture of collaboration that other urban initiatives can draw on.

These are some of the stones and seeds that help lay the ground for future F.AIR pathways, supporting a transition from fragile air to fairer school environments.

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Appendix

Acronyms & Abbreviations

APS – Associazione Parco Segantini

DASU – Department of Architecture and Urban Studies
(Politecnico di Milano)

DISAT – Department of Environmental and Earth Sciences (Univ.
Milano-Bicocca)

EEA – European Environment Agency

GIS – Geographic Information System

LCS – Low-Cost Sensor

MSP – Milano Smart Park

NO₂ – Nitrogen Dioxide

PM_{2.5} – Particulate Matter ≤ 2.5 μm diameter

PoliMi – Politecnico di Milano

PTAL – Public Transport Accessibility Level

TT – Fondazione Transform Transport ETS

WHO – World Health Organisation

Glossary

Calibration: Comparison and, where necessary, adjustment of raw sensor readings against reference-grade measurements to correct for sources of error such as humidity interference, temperature variation, and sensor drift, thereby improving the accuracy and reliability of the collected data.

Citizen sensing: Practice of involving non-specialist citizens in collecting environmental data, typically using low-cost portable or fixed sensors, to supplement official monitoring networks.

Co-monitoring: Collaborative monitoring process in which researchers, institutions, and community members jointly collect, share, and interpret environmental data.

Granular sensing: Environmental measurement at fine spatial scales, capturing local variations that remain invisible to sparse official monitoring networks.

Isochrone: Line on a map connecting points reachable in the same travel time from a given origin; used here to define 15-minute walking catchments around schools.

Local Climate Zone (LCZ): Classification system for urban and rural landscapes at the local scale, based on physical and thermal properties of surface cover, structure, materials, and human activity, used to assess and understand spatial variations in local climate.

Low-cost sensor (LCS): Environmental monitoring device that is substantially more affordable and easier to deploy than reference-grade instruments, but typically exhibits higher measurement uncertainty and potential bias, and therefore requires appropriate calibration, validation, and maintenance.

NO₂ (Nitrogen Dioxide): Gaseous pollutant mainly produced by combustion processes, especially vehicle traffic and other fossil-fuel sources; widely used as a key indicator of traffic-related air pollution.

PM_{2.5} (Particulate Matter $\leq 2.5 \mu\text{m}$): Fine inhalable particles with aerodynamic diameter less than or equal to 2.5 micrometres, suspended in air and capable of penetrating deep into the lungs; a major indicator of air quality and population health risk.

Response-ability: Concept describing the distributed capacity and shared responsibility of different actors, including individuals, communities, municipalities, and regional authorities, to notice, interpret, and respond to environmental challenges.

Urban determinants: Spatial, infrastructural, and social features of the built environment, such as street width, green cover, traffic density, and building typology, that shape health and well-being outcomes.

WebGIS: Web-based Geographic Information System that uses internet technologies to store, visualise, query, and analyse spatial data online, allowing multiple users to interact with maps and geodata without specialised desktop GIS software.

$\mu\text{g}/\text{m}^3$ (micrograms per cubic metre): Unit expressing pollutant mass per unit volume of air, commonly used to report airborne pollutant and particulate matter concentrations.

Clarifications

The F.AIR research engaged schools across Districts 5 and 6 of Milan through three interconnected levels of involvement: fieldwork and urban analysis, air quality monitoring, engagement and co-creation.

Selection of the 16 fieldwork schools

16 schools* in Districts 5 and 6 were the subject of fieldwork by Politecnico di Milano students, who conducted urban morphology analyses and social interaction observations to map vulnerability hotspots in schools' microenvironment.

Of these 16 schools, 6 urban situation types were defined (see pp. 34–35)— each representing a distinct combination of urban morphology, traffic exposure, and spatial configuration. One school was selected as the case study for each cluster, primarily for co-creation workshops on urban mitigation measures. Selection criteria included: representativeness of a specific urban morphology; completeness of the fieldwork materials collected by students; presence of an MSP outdoor air quality sensor; or proximity to a major traffic axis. Co-creation workshops were conducted mainly with schools located in District 6.

From the same set of 16, 8 schools received both new indoor and new outdoor Milano Smart Park (MSP) low-cost sensors. The F.AIR analysis focuses exclusively on outdoor air quality monitoring.

(*) A set of 16 primary and early childhood schools was selected for fieldwork based on the following criteria: school type, with primary and early childhood schools prioritised; location, with District 6 as the primary focus and two District 5 schools included for their active parent committee; availability of an existing MSP air quality sensor, or potential for sensor installation during the project; level of existing contact with schools, representation of distinct Local Climate Zones; proximity to traffic-related pollution sources; varying levels of NO₂ exposure based on citizen-collected monitoring data; and participation in the "Open Schools as Post-Lesson Civic Centre" programme.

Air quality monitoring: two sensor networks

The F.AIR research draws on two distinct but related sensing infrastructures: The first is the pre-existing Milano Smart Park (MSP) outdoor PM2.5 monitoring network, consisting of 16 sensing units distributed across Districts 5 and 6 and active between 2020 and 2024. The MSP citizen science network, managed by APS, provided baseline air quality data for the broader area. Of these 16 sensors, two are located at F.AIR school sites: sensor 9 (Bergognone), at G. Oberdan C.A. Porzi, and sensor 13 (Savona), at Foppette.

The second is the set of MSP sensing units installed or upgraded directly at F.AIR school sites during the project. Eight of the 16 fieldwork schools received both new indoor and outdoor MSP units, strengthening the local monitoring network: 3 schools upgraded a pre-existing unit (G. Oberdan C.A. Porzi and Foppette, corresponding to sensors 9, 13 and 14 in p.22), and 6 schools received newly installed units in 2025. The F.AIR analysis focuses exclusively on outdoor air quality data.

The full list of schools, their district, sensor status, and involvement in fieldwork and co-creation as well as the full list of MSP sensing units are provided in the table shared in the following pages.

Schools involved in the F.AIR research

School	District	Name	Complex	MSP outdoor air quality units	MSP outdoor sensing unit status	Proximity to traffic-related pollution source (Ministry of Education)	Students' fieldwork	Case study for the F.AIR co-creation workshop	Type of urban situation
Primary	6	IC Moisè Loria	G.Oberdan C.A.Porzi	Bergognone	<i>upgraded</i>	—	X		
Primary	6	IC Moisè Loria	Foppette	Foppette	<i>upgraded</i>	—	X	X	Type 4: Open urban fabric, close to a major road axis with double entrances
Primary	6	IC G. Capponi	G. Capponi	No unit			X	X	Type 2: Compact urban fabric, available parking area
Primary	6	Convitto nazionale Longone	Convitto nazionale Longone	Vigevano	<i>added in 2025</i>	—	X	X	Type 1: Compact urban fabric, close to traffic, street-facing entrance, no parking area
Primary	6	IC Leone Tolstoj	Zuara	Zuara	<i>added in 2025</i>		X	X	Type 5: Open urban fabric, sheltered from a major road axis
Primary	6	IC Nazario Sauro	Nazario Sauro	Vespri	<i>added in 2025</i>		X	X	Type 3: Compact urban fabric, inserted in a neighborhood equipped with green infrastructures
Preschool	6	IC Nazario Sauro	Soderini	No unit			X		
Primary	6	IC Cardarelli-Massaua	Scrosati	Scrosati	<i>added in 2025</i>		X		
Primary	6	IC Ilaria Alpi	G. Casati	No unit		—	X		
Primary	6	IC Ilaria Alpi	Tre Castelli	No unit			X		
Primary	6	IC Sant'Ambrogio	De Nicola	No unit		—	X	X	Type 6: (Peri) urban fabric, on the edge of the peri-urban area with a strong presence of agricultural fields
Preschool	6	IC Sant'Ambrogio	De Pretis	No unit			X		
Primary	6	IC Sant'Ambrogio	G. Ferraris	Barona	<i>added in 2025</i>		X		
Preschool	5	IC Jacopo Barozzi	Giambologna	No unit		—	X		
Primary	5	Thouar-Gonzaga	Gentilino	Gentilino	<i>added in 2025</i>		X		
Primary	6	IC Ilaria Alpi	Sandro Pertini	No unit			X		
Primary	5	IC Palmieri	Battisti	Battisti	<i>upgraded</i>		<i>added to the research after fieldwork began</i>		

List of Milano Smart Park outdoor sensing units

MSP sensing unit		Located in a School site	School name	School complex	Installation date	Upgraded or added during F.AIR	Phase of involvement in F.AIR			
1	Bosco				2020-2024		Monitoring & data			
2	Cascina Biblioteca				2020-2024		Monitoring & data			
3	WAU				2020-2024		Monitoring & data			
4	Segantini2				2020-2024		Monitoring & data			
5	Segantini1				2020-2024		Monitoring & data			
6	Valenza				2020-2024		Monitoring & data			
7	Montegani				2020-2024		Monitoring & data			
8	Solari40				2020-2024		Monitoring & data			
9	Bergognone	yes	IC Moisè Loria	G.Oberdan C.A.Porzi	2020-2024	upgraded in 2025	Monitoring & data	Urban form & inequalities in access		Engagement & co-creation pathways
10	Cermenate				2020-2024		Monitoring & data			
11	FCUB				2020-2024		Monitoring & data			
12	Moisè Loria				2020-2024		Monitoring & data			
13	Savona	yes	IC Moisè Loria	Foppette	2020-2024	upgraded in 2025	Monitoring & data	Urban form & inequalities in access	Design strategies for mitigation	Engagement & co-creation pathways
14	Battisti	yes	IC Palmieri	Battisti	2020-2024	upgraded in 2025	Monitoring & data	Urban form & inequalities in access		Engagement & co-creation pathways
15	I.T. Giorgi				2020-2024		Monitoring & data			
16	Frutta in Campo				2020-2024		Monitoring & data			
17	Marche				2025		Monitoring & data			
18	M5 Tibaldi				2025		Monitoring & data			
19	Bellini 1				2025		Monitoring & data			
20	M6 Legione Romane				2025		Monitoring & data			
21	Vigevano	yes	Convitto nazionale Longone	Convitto nazionale Longone	2025	added in 2025	Monitoring & data	Urban form & inequalities in access	Design strategies for mitigation	Engagement & co-creation pathways
22	Vespri	yes	IC Nazario Sauro	Nazario Sauro	2025	added in 2025	Monitoring & data	Urban form & inequalities in access	Design strategies for mitigation	Engagement & co-creation pathways
23	Scrosati	yes	IC Cardarelli-Massaua	Scrosati	2025	added in 2025	Monitoring & data	Urban form & inequalities in access		Engagement & co-creation pathways
24	Barona	yes	IC Sant'Ambrogio	G. Ferraris	2025	added in 2025	Monitoring & data	Urban form & inequalities in access		Engagement & co-creation pathways
25	Zuara	yes	IC Leone Tolstoj	Zuara	2025	added in 2025	Monitoring & data	Urban form & inequalities in access	Design strategies for mitigation	Engagement & co-creation pathways
26	Gentilini	yes	Thouar-Gonzaga	Gentilino	2025	added in 2025	Monitoring & data	Urban form & inequalities in access		Engagement & co-creation pathways

Data sources

Map	Parameter	Unit	Source	Year
Residents under 15	Total population under 15 years per H10 cell, redistributed from ISTAT census units	No. of individuals	ISTAT	2021
Average income	Mean annual income per H10 hexagonal cell, distributed proportionally from postal areas (CAP)	Euro	Ministry of Economy and Finance	2023
PTAL	Public transport accessibility level, based on pedestrian access time to stops and average waiting times; classified in 6 levels (1a–6b)	Classification (1a–6b)	AMAT	2025
Vegetation	% urban vegetation per hexagonal cell (NDVI > 0.25, normalised 0–1)	Normalised index (0–1)	Sentinel-2	2024
Sidewalk width	Average sidewalk width per hexagonal cell, calculated as length-weighted mean across all street segments	Metres	Transform Transport	2020
Traffic flows	Total vehicles per road segment during morning peak hour, aggregated per hexagonal cell	Vehicles/hour	Systematica	2019
NO₂	Monthly NO ₂ levels (February 2023), transferred from a 5×5 m regular grid to H10 hexagonal grid via proportional redistribution	µg/m ³	Cittadini per l'Aria*	2023

Data sources of illustrated maps on pages 26–28, elaborated by Transform Transform

*Monitoring data from the citizen science campaign "NO₂, No Grazie!" (2023) – Source: Boniardi L, Nobile F, Stafoggia M, Michelozzi P, Ancona C. Assessing the impact of traffic restriction interventions on school air quality: a citizen science-based modelling study. Environ Res. 2025 Jul 15;277:121562.



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