Removing Pollution from Play

Reimagining Streets, Reducing Air Pollution

Global Designing Cities Initiative

CLEAN AIR FUND

About **Global Designing Cities Initiative (GDCI)**

The Global Designing Cities Initiative (GDCI) works to transform streets into safe, accessible, and vibrant public spaces that prioritize people. By collaborating with city leaders, practitioners, and communities, GDCI provides technical assistance, capacity building, and policy guidance to promote safety, health, sustainability, and equity in urban environments. It has developed key resources like the Global Street Design Guide and Designing Streets for Kids Guide to support human-centered street design. Through programs like Streets for Kids, GDCI helps cities create child-friendly spaces, improving mobility and public access. By fostering innovation and best practices, GDCI empowers cities to reimagine streets as inclusive and dynamic spaces for future generations.

About **Clean Air Fund (CAF)**

Clean Air Fund is a global philanthropic organization dedicated to ensuring everyone breathes clean air by funding and supporting initiatives that tackle air pollution. Working with governments, businesses, funders, and campaigners, they invest in projects that enhance air quality data, build public demand for clean air, and drive policy action. By fostering collaboration and advocating for systemic change, Clean Air Fund influences decision-makers and empowers communities to take meaningful steps toward reducing air pollution. Through strategic partnerships and high-impact initiatives, they work to accelerate progress toward cleaner air and healthier environments worldwide.

Executive Summary

A safe urban environment is essential for young children's healthy early childhood development, as their surroundings shape their physical, cognitive, and emotional well-being. The quality of the spaces where children live, play, and learn influences their growth, impacting everything from their sense of security to their overall health. Among the many environmental factors that affect development, air quality plays a critical role, as exposure to pollution during early years can lead to lasting health complications.

While air pollution is a global crisis, its effects are particularly evident in rapidly urbanizing cities like Accra, Ghana, where **vehicular emissions alone account for 40% of total air pollution**.[1] Combined with open waste burning, these pollutants create hazardous conditions, especially in areas where children live, learn, and play. Many schools and play spaces are situated in high-pollution zones, exposing children to harmful toxins daily. Despite these risks, public awareness remains low, and data on pollution's effects are limited.

The **Removing Pollution from Play** project aims to tackle air pollution in school environments by implementing practical solutions, raising awareness, and empowering communities to advocate for cleaner air. The project began with **training sessions for 43 practitioners** from various districts to highlight the impact of air pollution on children's health. **A workshop with more than 50 students and teachers** followed, further educating them about the risks of air pollution and collecting feedback for the project's design. Through a collaborative process involving multiple stakeholders, the design was developed for **Osu Salem 1 Primary School** to transform a former parking lot into a safe space for play and movement.

The project's completion has catalyzed a range of public health benefits. By reducing vehicle emissions, **it has removed the equivalent of 259 trucks from the street each day** during school hours. In addition to improving air quality, the project has created more space for physical activity, adding **350 m² of new play areas and pedestrianizing 450 m² of street space from 6:30 a.m. to 3:30 p.m. on weekdays**. Shade structures make the space usable throughout the day, **lowering surface temperatures by 10°C and air temperatures under the shade by 2°C**. Noise has also been significantly reduced, with a **60% decrease in sound intensity during school hours**, creating a calmer and less disruptive learning environment. Finally, the project has substantially **improved road safety by eliminating the potential for road crashes** at the site during school hours and adding crosswalks for pedestrians when school is not in session.

This report documents the efforts and summarizes the outcomes of the "Removing Pollution from Play" project, which ran from June 2023 to March 2025. By combining data collection, street-level interventions, and community engagement, the project has successfully created healthier spaces for children and demonstrated scalable solutions for improving urban air quality.

259 trucks

The reduction in emissions is equivalent to removing 259 trucks from passing through the street during school hours each day.

+350 m²

of added play space for <u>150</u> students

+450 m²

of street space pedestrianized during school hours

43

practicioners

50+

teachers & students

engaged in the workshops

-%60

sound intensity reduced during peak traffic hours


OSU SALEM1
KG/PRIMARY SCHOOL

Breathing Danger: The Impact of Air Pollution on Health and Childhood Development

↑ Source: Adapted from *Explaining Road Transport Emissions: A Non-Technical Guide*, European Environment Agency (2016).

Air pollution is the world's leading environmental cause of illness and premature death, impacting not only the lungs but also the heart, brain, and other vital organs. The World Health Organization (WHO) considers it a silent epidemic, comparable to tobacco use in past decades, estimating that it causes approximately 7 million deaths each year while harming billions more. Exposure to polluted air is linked to a wide range of both short- and long-term health issues, including an increased risk of heart attacks, strokes, and diabetes, impaired lung development, and negative effects on brain function throughout life. The widespread nature of air pollution makes it one of the most pressing public health challenges of our time.

Children are particularly vulnerable to air pollution due to their developing bodies and higher breathing rates relative to their size. Exposure during early years can have lasting consequences, increasing the risk of respiratory diseases, cognitive impairments, and other health complications. Airborne pollutants can also reach fetuses through the circulatory system of a pregnant person, leading to negative birth outcomes similar to those associated with maternal tobacco smoking. The long-term impact of early exposure underscores the urgent need for cleaner air, especially in urban environments where children spend much of their time.

The Role of Street Transformations in Enhancing Air Quality

Air pollution not only affects health but also shapes the environments where children grow and develop. The built environment plays a crucial role in their earliest years, influencing cognitive, social, emotional, and physical development. Streets, as primary public spaces, can either contribute to harmful exposure or serve as opportunities to mitigate pollution's effects. Designing streets that prioritize clean air, safety, and accessibility can reduce children's exposure to harmful pollutants while also fostering social interaction, encouraging physical activity, and supporting mental well-being. By addressing air pollution through urban design, cities can create healthier environments where children can thrive, learn, and feel inspired every day. The visual highlights key design strategies to achieving this. These measures collectively contribute to healthier, more sustainable urban environments.

Project Timeline

June, 2023
Project kick-off

February, 2024
Stakeholder training

April, 2024
Identification of control site for data collection

May, 2024
Deployment of sensors

July, 2024
Student and teacher workshop at Osu Salem 1 Primary School

November, 2024
Community meeting at the church

December, 2024
Start of the construction

March, 2025
Inauguration of the project

↑ Source: Hayrettin Gunc

Air Quality and Street Design Training for Stakeholders

In February, 2024, a practical training session was held for 43 municipality staff, focusing on air quality and urban design. Participants analyzed existing street designs to assess their effectiveness in minimizing air pollution and proposed redesigns for improvement. The training materials were based on international best practices in street design and GDCI's research on the links between street design and reducing air pollution.

Following the training, the GDCI team met with the Chief Executive of the Korle Klottey Municipal Assembly to discuss collaborative efforts in addressing air quality challenges. The team then conducted school site visits in partnership with engineers from the urban road departments. Before the visits, schools were ranked based on their student populations and vulnerability to air pollution.

During these site visits, the team engaged with school headmasters to gather valuable feedback on the current conditions of their schools and to understand their priorities regarding air quality and infrastructure improvements. This interaction was essential for identifying specific challenges faced by the schools and developing targeted solutions to enhance the environment for students and staff.

↑ Source: Capture Ghana

Hands-on Learning: Air Quality Workshop at the School

The workshop, held from July 10–11, 2024, at Osu Salem 1 Primary School in Accra, brought together teachers and students to engage in hands-on learning about air quality and designing streets for kids. Facilitated by the Mmofra Foundation's Ato Annan and Adwoa Amoah, the two-day session aimed to promote air pollution awareness and get feedback for the proposed design of the project.

Day one focused on teacher engagement, presenting project goals, including street closure during school hours and a transformation of the parking space. An interactive "periscope exercise" helped teachers empathize with children's street view, highlighting the need for safer infrastructure for younger students. Teachers raised essential concerns about project logistics, such as maintenance, and contributed design ideas for play elements and educational ground markings. On the second day, students participated in discussions and activities about the project, assessing their awareness of air pollution and gathering their input. They recognized how pollution is defined, identifying key sources such as traffic and refuse burning. Activities included mapping pollution levels around the school using mobile sensors and engaging younger children in creative drawing exercises. Students showed excitement for various games and suggested different play elements, which were subsequently included in the design of the play space markings.

The Mmofra team observed strong school support, with teachers offering to help maintain loose play components and expressing interest in plant care The workshop underscored community enthusiasm, potential maintenance roles for school staff, and the importance of municipality involvement in implementation.

Connecting with the Community: A Meeting at the Church

A community engagement meeting was held at Osu Eben-Ezer Presbyterian Church during a Sunday prayer service, a key venue for reaching the local community. The church plays a central role in the area, serving as a gathering point for residents and a trusted institution for outreach. During the service, municipal assembly members and team members informed the congregation about the project, shared key details, addressed community concerns, and distributed flyers to ensure broader awareness and participation. The church's location and influence made it an ideal setting for fostering community involvement and ensuring diverse participation in the initiative.

↓ Source: Sefakor Fummey

Project Design

↑ Source: Superpool

Transforming the Parking Lot:A Place to Play, Breathe, and Grow

GDCI partnered with Istanbul & Copenhagen based design practice Superpool to develop a design for the space in front of the school. The design aimed to create a play space that offers a balanced environment where children can choose high-energy movement or restful engagement, ensuring fun and enrichment for all personality types and abilities.

The area features a landscape of hills, ideal for running, tumbling, and climbing. These varying elevations create opportunities for active play, where children can test their agility, balance, and coordination. Some hills are gentle slopes, while others have steeper inclines to challenge different skill levels.

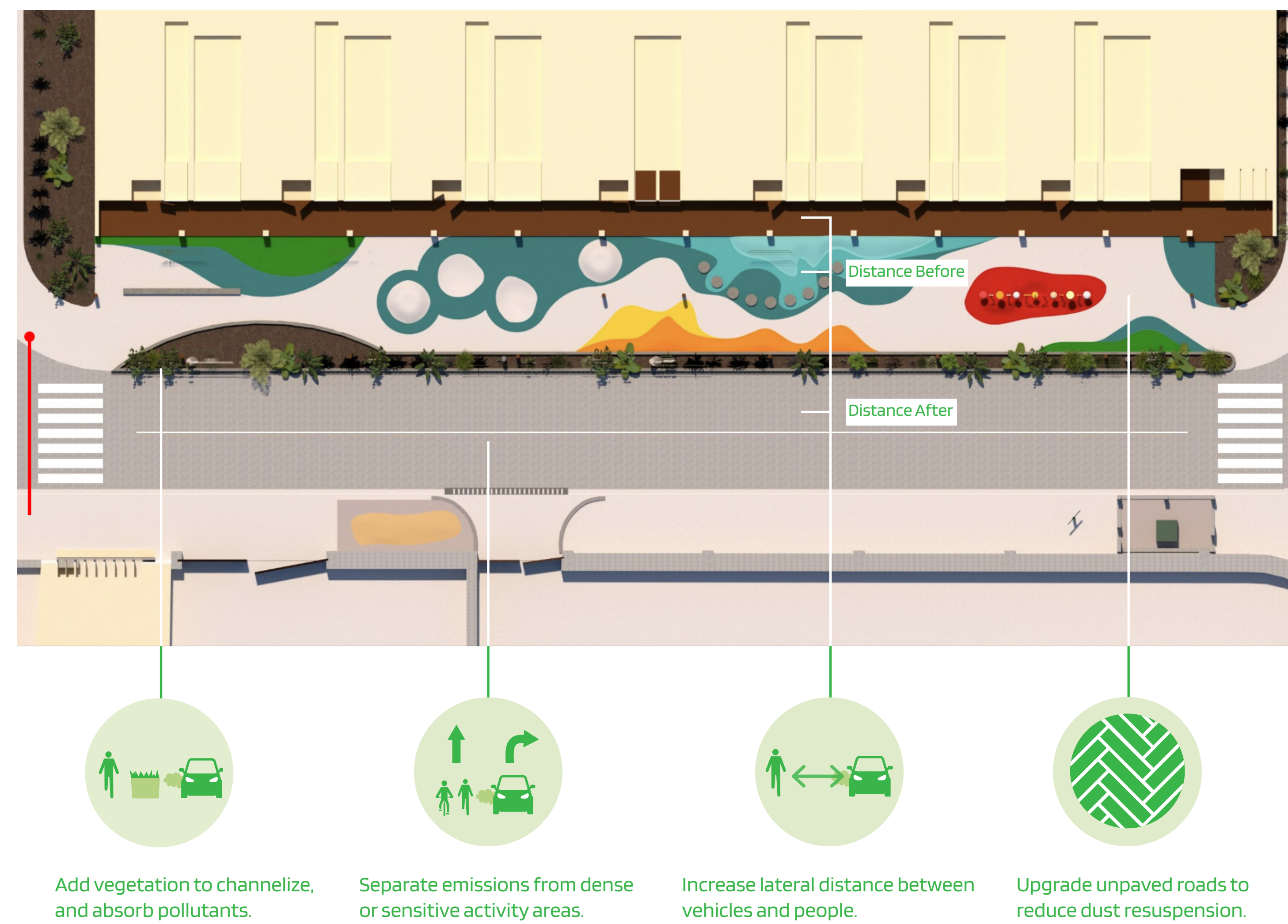
The stepping stones are strategically arranged in a semi-circle, inviting children to hop, balance, and navigate different surfaces. Located right next to a classroom, this outdoor space serves as an extension of the learning environment, encouraging teachers to bring their activities outside.

At one end of the space, a large abstract sculpture serves multiple functions. Its organic shapes invite climbing, sitting, or imaginative storytelling. The inclusion of fishing buoys evokes the idea of a sea creature, adding to its playful, whimsical nature. This sculpture encourages passive play, inspiring quiet observation, social interaction, or creative daydreaming.

Other empty areas provide the perfect setting for games like tag, relay races, or free exploration. These spaces support unstructured active play, where children can create their own games and move freely.

To improve air quality, several strategies were implemented. The most significant impact came from restricting vehicle traffic during school hours. By relocating parked cars away from the school grounds, students were distanced from direct exposure to pollutants. Around the perimeter, the design incorporates planters with medium-height shrubs and bushes, which act as a natural buffer and help filter pollutants from nearby traffic. Additionally, some previously unpaved areas were upgraded to reduce dust resuspension.

Strategies for Improving Air Quality



↑ In the early mornings, pedestrians and cyclists make frequent use of the 'School Street,' taking advantage of the vehicle-free environment. Source: Hayrettin Gunc

Transforming the Street: Reducing Traffic and Enhancing Safety

GDCI explored various design scenarios to reduce vehicle traffic on the segment of Sir Charles Quist Street in front of the school. These included converting the two-way street into a one-way street and adding curb extensions to move pollution sources farther from the school site. Another option considered was implementing a "School Street" by installing barriers at both ends of the street and closing it to vehicular traffic during school hours, from 6:30 AM to 3:30 PM.

The Department of Urban Roads, which oversees the city's street network, supported this approach. Alternative routes were analyzed, and signage and markings were prepared to inform drivers of the changes. Metal barriers were fabricated and installed on both ends of the street to restrict traffic to the street. In addition to these operational adjustments, the design also implemented pedestrian crosswalks to further enhance road safety.

← Informational flyers prepared to inform residents about the changes.

← A banner was installed on the barrier to further inform approaching drivers. Source: Capture Ghana

Defining the evaluation methodology

Physical and operational changes

The intervention transformed a parking space into a play area and limited traffic during school hours.

Changes in use and function

X fewer motor vehicles in the street

↓

Y% decrease in road traffic emissions in the street

Resulting impacts

X% decrease in $PM_{2.5}$ levels

Y% decrease in NO_2 levels

Z% decrease in noise levels

Developing a Methodology

A wide range of air quality metrics is available in the literature, including complex indicators such as daily personal exposure to pollutants, reduced lung capacity, and the prevalence of respiratory illnesses. However, this project focused on a specific set of metrics that were directly related to the street transformation and feasible within the technical, time, and budget constraints.

As a result, long-term health impacts, such as effects on children's lung development, were not included. Measuring these outcomes would require extended observation periods to accurately isolate the effects.

Instead, the impact of the street design on air quality was assessed by examining how it influenced changes in the use and function of the space. These changes, in turn, affected both air quality and noise levels. In this context, the relationship between street design changes and their air quality benefits can be described in the diagram above.

Case Studies

As part of developing our methodology, we examined various programs from different cities.

Sant Antoni Superblock

Barcelona, 2018

The first phase of the superblocks program in the Sant Antoni neighborhood was completed in May 2018. This phase included installing a modal filter at the intersection of Av. Comte Borrell and Tamarit, near the Sant Antoni Market, and enhancing the streets in the surrounding blocks. At this intersection, the assessment indicates a decrease of 25% in NO_2 (14.6µg/m^3) and 17% for PM_{10} (4.1 µg/m^3 ambient concentration.[1]

↑ Source: Use this link to access the report
→ Photograph by Del Río Bani

School Streets in London

London, 2021

School Streets restrict vehicle access on roads adjacent to schools during specific hours, particularly during drop-off and pick-up times. This creates a safer and cleaner environment for walking and cycling to school In some implementations, such as those in Hackney, London, no major street redesigns were made. Instead, time-restricted traffic signs were installed to enforce the changes. An evaluation by Transport for London of 18 School Street schemes found that children were exposed to 23% less nitrogen dioxide (NO_2) during arrival and departure times.[2]

↑ Source: Use this link to access the report
→ Photograph by City of London

Measuring Traffic Related Pollution

To effectively assess the impact of our interventions on air quality, this project focuses on two key pollutants: Particulate Matter and Nitrogen Dioxide.

The air quality metrics evaluate the impacts of the project on these pollutants both on the changes in emissions and the changes in their ambient concentration.

Changes in traffic emissions in the area

Changes in fine Particulate Matter levels

Changes in Nitrogen Dioxide (NO_2) levels

Particulate Matter (PM) is a critical pollutant emitted by vehicles, consisting of fine particles like soot that can penetrate deep into the lungs and impair respiratory function. Long-term exposure is linked to reduced lung capacity and increased risks of respiratory diseases such as asthma and bronchitis. PM is also categorized by particle size, being $PM_{2.5}$ (particles smaller than 2.5μm) and PM_{10} (particles smaller than 10μm) the most commonly analyzed.

Nitrogen Dioxide (NO_2) is another major traffic-related pollutant, contributing to both short- and long-term health issues. High levels of NO_2 are associated with respiratory conditions, impaired lung development in children, and increased hospital admissions due to respiratory distress. Monitoring NO_2 provides valuable insights into the direct effects of vehicular pollution on air quality. They can also be measured as general Nitrogen Oxides (NO_x), especially when estimating emissions.

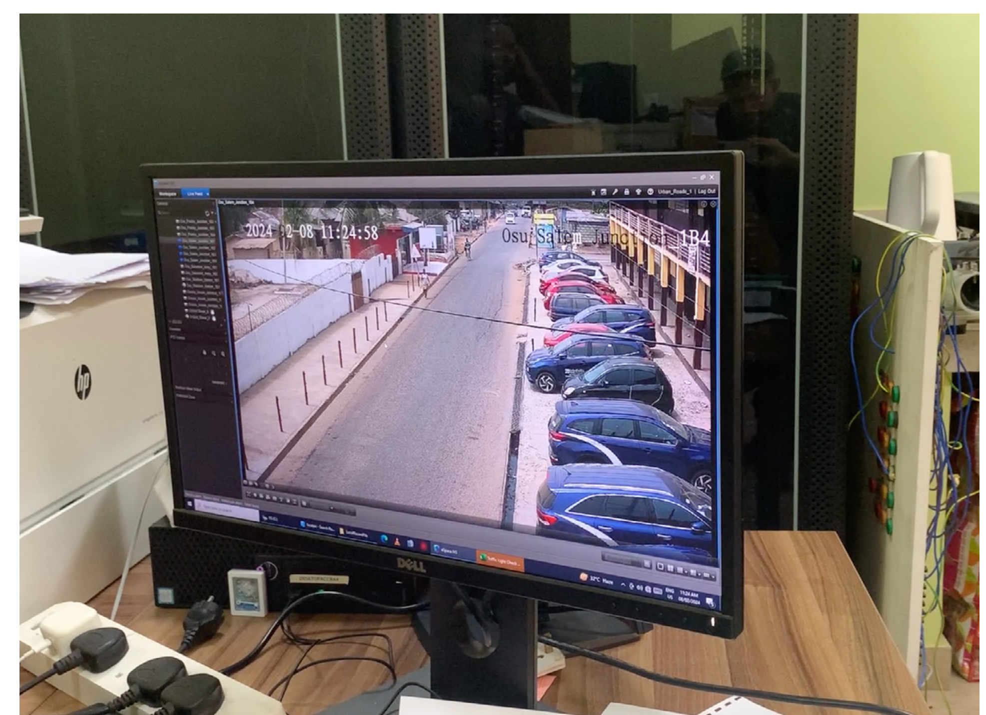
Measuring Changes in Traffic Emissions

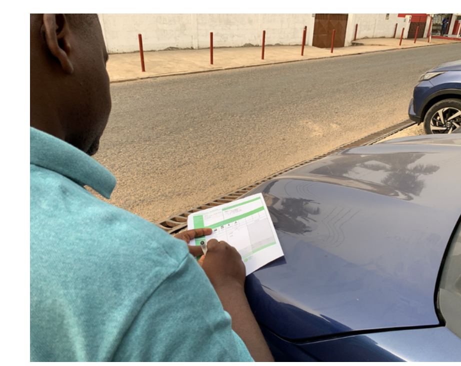
This metric focuses on how the intervention affects the polluting activity of interest, in this case traffic, and helps isolate it from other sources of pollution. This is desirable because while ambient concentration metrics are more robust, they might not capture the impact of changes in traffic if other sources (such as waste burning or transported pollution from other areas) are dominant.

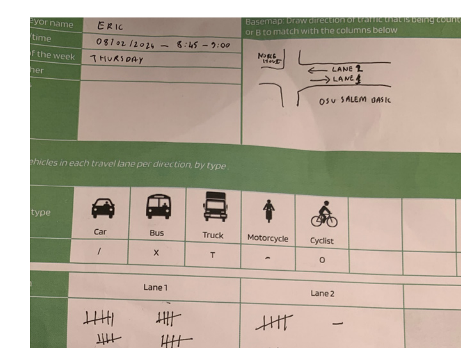
Changes in traffic emissions are estimated using the combination of changes in traffic volumes and distances traveled, multiplied by emission factors – parameters that represent the average amount of pollution produced per kilometer by each vehicle category.

While these parameters are derived from previous studies (see Appendix X for more information), traffic volumes and distances traveled were collected using a combination of CCTV cameras and in-situ counts, providing both automated and observational data to assess variations in vehicle activity.

↓ Source: Hayrettin Gunc







Measuring Changes in Ambient Concentration

The amount of pollution suspended in the air in a given period, or its ambient concentration, helps represent the level of pollution people are exposed to in a given environment and period. It is influenced by the combination of all sources of pollution in an area and the factors affecting their dispersion (wind patterns, topography, buildings, etc.).

Measuring ambient concentration also requires a more complex approach, with pollutant-specific devices and deployment protocols. For Particulate Matter, microsensors are often used for accurate measurements as long as they are calibrated to the local context. For Nitrogen Dioxide, however, similar devices are less recommended and passive samplers are more commonly used as lower cost alternatives.

For this project, PurpleAir PA-II and Ogawa passive samplers were used to measure PM (PM2.5 and PM10) and NO2 levels, respectively. PM2.5 readings were calibrated following previous studies, however they were not available for PM10, see Appendix Y.

In order to isolate the intervention's effect, we must determine a "business as usual" or "trend" scenario[3]. This is done by establishing a comparison site, a location that shares characteristics with the main analysis site, but is not affected by the intervention, as illustrated below.

↓ **Before** the Intervention

↓ Comparison Site

↓ **After** the Intervention

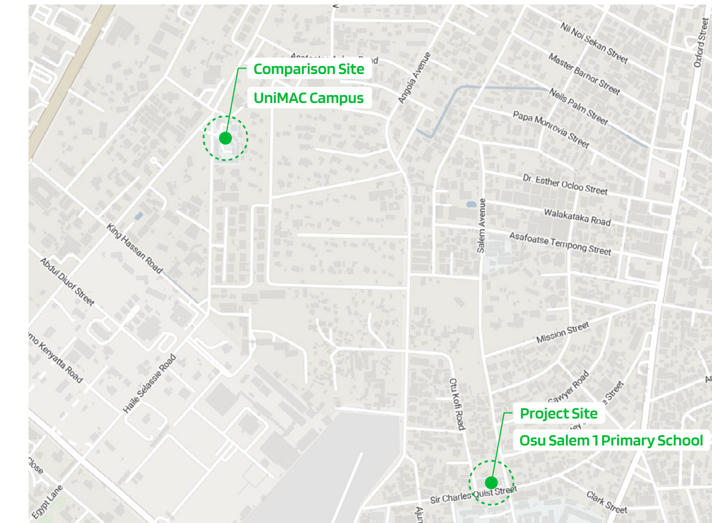
↓ Comparison Site, **unchanged**

Choosing the Comparison Site

The comparison site was chosen in order to mirror some of those key characteristics of the project site, being also close enough to capture regional factors, but without being subject to the intervention's effect – in this case, mainly diverted traffic.

Thus, the UniMAC campus was chosen as a comparison site, situated along Haile Selassie Street near the British High Commission and northwest of the intervention site.

Both PurpleAir sensors and Ogawa samplers were deployed at the same location on the sites, on building facades facing the street and at a height that would prevent interferences, while still capturing street level pollution, as illustrated in the photos below.



→ Passive samplers deployed at the intervention site (top) and at the comparison site (bottom).
→ Source: Raphael Arku

Measuring Changes in Noise Levels

The WHO strongly recommends reducing traffic-related noise levels to under 53 decibels (dB)[4] , as long-term exposure to higher levels is associated with critical health outcomes including cardiovascular disease, annoyance, and cognitive impairments. For children and young people, which are more susceptible to noise pollution than adults, exposure to noise pollution at school can lead to decreased concentration, increased stress levels, and reduced cognitive function.[5]
Because vehicular traffic is a major source of noise pollution, it can be reduced near schools and improve the health of children and adults by redesigning streets near schools and lowering traffic speeds and volumes. Evidence indicates that restricting vehicles on the street in Gurgaon, India, for carfree Raahgiri Day decreased noise levels on the street by 16 decibels.[6]

For this metric, we used a simple before and after comparison of noise levels during school hours (06:30 AM to 03:30 PM). A comparison site was not used as we considered regional factors were not relevant in the case of noise for that context.

A sound level meter was deployed at the school facade from July 5 to July 24, 2024 and then again after the implementation from March 24 to April 5, 2025.

↑ Source: Raphael Arku

Assessing Thermal Comfort Improvements

Due to their ongoing development, children have lower capacity to regulate their temperature and are more vulnerable to urban heat. However, streets are often large areas of asphalt and other impervious surfaces in urban areas that contribute to higher temperatures in an increasingly warmer world. Exposure to heat was also a concern often indicated by members of the school community during the conception phase.

Thus, shading and better surface materials were a fundamental factor in designing the play area.

In order to better analyze the intervention's benefits towards exposure to heat, we measured the surface temperature of the shaded playing area and air temperature, comparing it to the asphalt, non-shaded area for reference. To measure the surface temperatures and air temperature, we used a FLIR C3-X thermal imaging camera and a Protmex HT607 ambient thermometer.

It is important to disclose that this was not a structure evaluation effort, but rather an exploratory effort during the post-intervention stage.

↑ Protmex HT607 Source: Hayrettin Gunc

Public Health Impacts

↑ Source: Hayrettin Gunc

Changes in traffic volumes and emissions

Considering a typical weekday, the traffic counts indicated considerable vehicle volumes during the 06:30AM to 03:30PM period, as illustrated in the table below.

Vehicle type	Traffic Volumes **(Before)** (06:30AM to 03:30PM)	Traffic Volumes **(After)** (06:30AM to 03:30PM)
Motorcycles	472	0
Cars	1987	0
Trotros (Shared taxi or minibus)	45	0
Light Commercial Vehicles	72	0
Total	**2576**	**0**

→ See **Appendix** for more detail about this analysis

Traffic emissions were calculated using emission factors (represented in the table below) and typical traffic volumes, multiplied by the distance traveled by vehicles before the project.

Vehicle Category	Recommended Emission factor	References
Cars	Euro II	
Buses	Euro II	George Faah (2008).
Trucks	Euro I	
Motorcycles	Euro II	Extrapolated from other modes.

The emission estimates were calculated using a spreadsheet model, which compiles traffic volumes and travel distances to estimate Vehicle-Kilometers Traveled (VKT) for each transport mode during the analysis period. These VKTs were then multiplied by mode-specific emission factors to quantify pollutant output.

A comparison site was not designated for this metric, as the post-intervention scenario occurred shortly after the pre-intervention data collection. Therefore, traffic patterns—particularly vehicle volumes and fleet composition—were assumed to remain consistent with those observed in February 2024.

By eliminating vehicular traffic in front of the school from 6:30 AM to 3:30 PM, it is estimated that approximately 2.5 kg of particulate matter (PM) and 31.4 kg of nitrogen oxides (NO_2) emissions were avoided near children during school hours over the course of one year.

This reduction is equivalent to preventing 259 trucks from passing along the street during school hours.

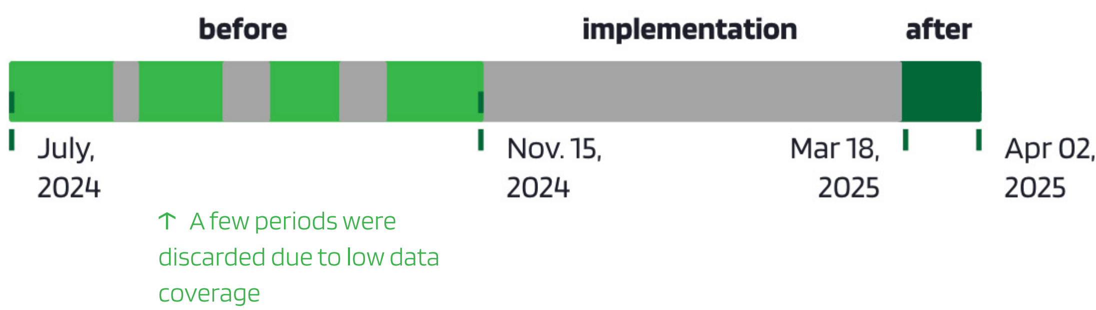
Changes in PM Ambient Concentration

Changes in ambient PM concentrations were analyzed based on daily averages of $PM_{2.5}$ and PM_{10} levels during school hours, defined as 6:30 AM to 3:30 PM.

Data from the PurpleAir sensors were filtered to exclude days when data coverage was insufficient, typically due to human interference or temporary power outages. Specifically, any day in which the sensor recorded less than 85% of the school-hour period was excluded from the analysis.

Additionally, the implementation phase was excluded from the dataset. This period, spanning from November 15, 2024, to March 18, 2025, coincided with the construction of the play area, which involved pavement removal and other activities that temporarily altered normal conditions. This timeframe also overlapped with intense Harmattan activity, further justifying its exclusion from the analysis.

→ See **Appendix** for more detail about this analysis



As previously noted, the evaluation applied a Differences-in-Differences (DiD) approach, operationalized through a linear regression model. The analysis indicated a reduction in $PM_{2.5}$ and PM_{10} concentrations—estimated at 0.68 μg/m^3 and 0.95 μg/m^3, respectively—during the observed period following the intervention. However, these results were not statistically significant.

This outcome is not unexpected, given the relatively short duration of the analysis period compared to what is typically recommended in the literature.[1] It may also suggest that background pollution levels, influenced by broader urban and regional sources, exert a stronger influence than local traffic-related emissions.

Pollutant	Reduction (μg/m3)	p-value	
$PM_{2.5}$	1.06	0.29	Not statistically significant
PM_{10} **(not-calibrated)**	1.56	0.37	Not statistically significant

Changes in NO_2 Ambient Concentration

A similar methodology was applied to assess the intervention's impact on ambient NO_2 concentration levels, utilizing a Differences-in-Differences (DiD) approach to isolate the effects of the street redesign from broader regional trends and baseline conditions.

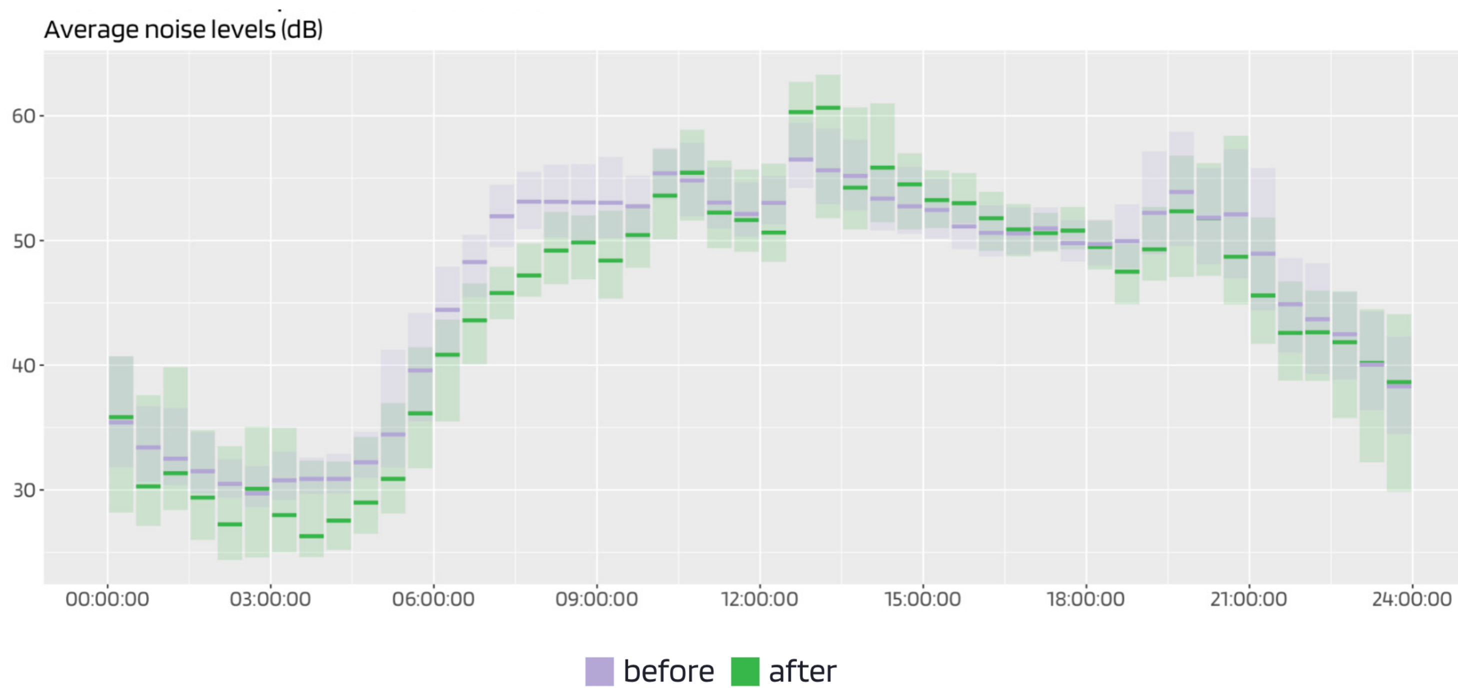
For this analysis, passive samplers were used to measure NO_2 concentrations. These devices provide weekly average values based on continuous 24-hour sampling, which contrasts with the PM analysis that focused specifically on school hours. As a result, it is not possible to filter NO_2 data to isolate the school-time window.

At the time this interim report was completed, the Ogawa passive samplers had not yet been transported from Ghana to the United States for laboratory analysis. Therefore, this version of the report does not yet include results from the NO_2 evaluation.

Changes in Noise Levels

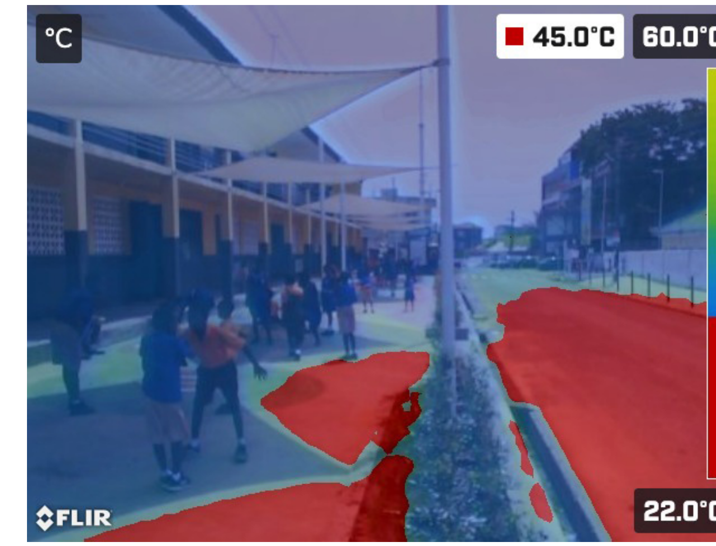
Noise data was collected from July 5 to July 24, 2024, and again from March 24 to April 5, 2025, with measurements averaged at one-minute intervals. The dataset was filtered to include only weekdays, excluding Saturdays, Sundays, and selected public holidays, such as Eid.

The analysis revealed a statistically significant average reduction of 1.1 dB across the full school-day period (6:30 AM to 3:30 PM). When focusing specifically on the morning hours (6:30 AM to 12:00 PM), which encompass the majority of classroom instruction time, the average reduction increased to 2.7 dB.



Compared to the morning traffic peak hour, from 6 to 10 AM, the intervention reduced noise levels at the school by 4.0 dB. **As noise is measured through a logarithmic scale, this means sound intensity reduced by nearly 60% of its previous intensity during peak traffic hours.**[2] This reduction contributes to a quieter and less disruptive classroom environment, benefiting students and their learning.

A noticeable increase in noise levels was observed between 12:00 PM and 3:30 PM, which is likely attributable to elevated activity from children during recess and post-class periods.



Change in Thermal Comfort

Thermal imagery captured using the FLIR C3-X camera indicates that surface temperatures in the shaded play area **averaged approximately 37 °C**. In contrast, unshaded sections of the street, particularly the asphalt roadway, **reached temperatures as high as 50 °C.** Areas highlighted in red on the thermal images correspond to surfaces exceeding 45 °C, a threshold commonly recognized as critical for maintaining thermal comfort and safety for children. In regards to the air temperature, the play space was 1.7°C lower than the unshaded space, which is more comfortable and ensures the play space is usable throughout the day to allow for active play.[3]

→ Air temperature measurements on the street (left) compared to those under the canopy in the play space (right).

Before and After

Before and After

Before

After

Before

After

Before and After


Before


After


Before


After

Before and After

Before

After

Before

After

Before and After

Before

After

Before

After

Appendix

Choice of Emmision Factors

The traffic counts for motorized vehicles were divided into 4 categories:

- Cars, including convertible, SUVs, minivan, hatchback, and sports cars. Most cars in Ghana run on gasoline with a few running on diesel (some SUVs and minivans) and gas (some taxis);
- Motorcycles, also including tricycles (locally called "Aboboyaa" and "Pragea"). They commonly use gasoline as fuel, with rare exceptions being electric.
- Buses, including Mercedes Benz (Sprinter, 208 and 207), Urvans, Caravans, Marcopolo Bus and coaches. The commercial buses for transporting people within short distances are called "trotro" which literally means "small small". Buses in Ghana mostly run on diesel with some operating on petrol.
- Trucks, including tipper trucks, mini trucks (called "Abosokai Macho"), bongo trucks, etc. The majority of trucks use diesel as fuel.

Unfortunately, Ghana lacks a country-specific EFs, as indicated in the Ghana's Fifth National GHG Inventory Report 2021 (NIR5) by the Environmental Protection Agency (EPA). Consequently, in the absence of such a specific factor, reliance is placed on the IPCC EFDB for further analysis.

The EPA recommended the use of 2006 IPCC EFs, guided by assumptions about their appropriateness for the specific application to the Ghanaian conditions which has also been employed by Volta River Authority (VRA) in the corporate greenhouse gas inventory report 2023 (Source).

However, some studies have also recommended the emission factors to be applied to specific vehicle categories even though Ayetor et al (2021) ranked Ghana among African countries with Euro II vehicle emission standards (Source).

Finally, George Faah's doctoral thesis "Road Transportation Impact on Ghana's Future Energy and Environment" (Source) guided the choice for emission factors, with the only exception of motorcycles, which was defined as Euro II for gasoline fuel. The chosen values came from the European Environmental Agency's Air Pollutant Emission Inventory Guidebook 2023 (Source), and included non-exhaust emissions for PM.

Vehicle Category	Recommended Emission factor	References
Cars	Euro II	George Faah (2008).
Buses	Euro II	
Trucks	Euro I	
Motorcycles	Euro II	Extrapolated from other modes.

Sheets for calculations

The calculation sheet can be accessed here, and is divided into four tabs:

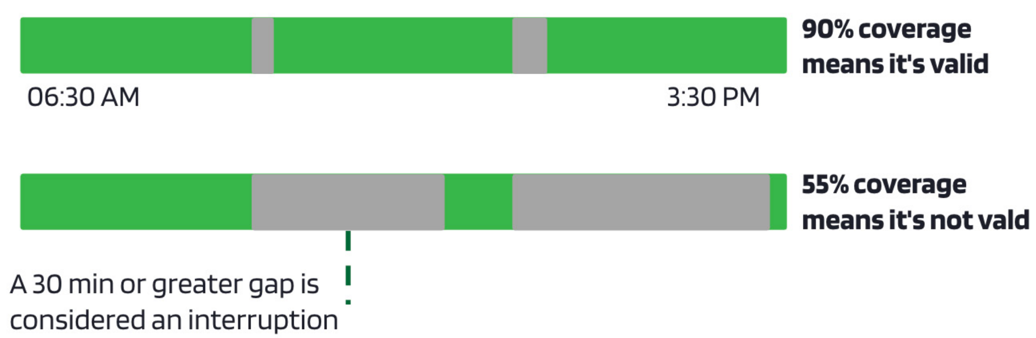
- An Area Map, illustrating the location and extent of the intervention,
- Traffic Counts, which contains the volumes assumed typical for a weekday during school hours,
- The calculation tab, combining the typical volumes, distances traveled, and emission factors.
- A Parameters tab, containing emission factors extracted from EEA's Air Pollutant Emission Inventory Guidebook 2023 (Source).

Appendix

Assessing Data Quality and Calibration

To filter out days with low data coverage, both PM sensors were analyzed for continuity of measurements. This means the intervals between consecutive readings were investigated in order to find potential interruptions.

In case the interval between readings was equal or higher than 30 minutes, it would be considered an interruption. In case the interruptions were equal or greater than 15% of the 06:30 AM to 3:30 PM interval (that is, with the data coverage 85% or lower), that date would be considered invalid for use, as illustrated in the figure below.



PurpleAir's PM2.5 readings were calibrated using a previous study based in Accra (Source), illustrated by the equation below, where T represents temperature and RH is relative humidity. Unfortunately, a similar study covering PM10 was not found.

$$PM2.5_{calibrated} = -47.33 + 0.54 \times PM2.5_{raw} + 1.56 \times T(°C) + 0.12 \times RH\ (\%)$$

Differences-in-Differences Evaluation

As previously mentioned, the impact evaluation on PM ambient concentration follows the Differences-in-Differences rationale, illustrated by the equation below. The routines for reading, treating, and applying that methodology to data can be found here.

$$PM = \alpha + \beta_{site} + \beta_{week} + intervention + \varepsilon$$

Where:
α is the equation's intercept, representing the urban background level,
β_{site} is the site-specific constant, factoring in locational differences between the intervention and comparison site,
β_{week} is the time-specific constant, factoring temporal variations and differences between the sampling weeks,
$intervention$ represents the coefficient attributed to the presence of the intervention, which is 1 at the intervention site after the implementation and 0 otherwise. It estimates the impact of the intervention, isolating it from locational and temporal factors.

Notes

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Ing. Eric Nyame-Baafi | 1986-2024

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Though he is no longer with us, his impact remains, and we are forever grateful for the time we had to collaborate with him. This report stands as a testament to his hard work and dedication. May his legacy continue to inspire us all.

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