EVOLVE

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Introduction

As of November 2023, Delhi holds the title of being the most polluted city globally. The escalating count of premature deaths due to air pollution continues to rise, especially impacting the younger population with increased instances of lung ailments like asthma and chronic obstructive pulmonary disease (COPD). The issue is more prominent during winter months with dense smog blanketing the city, prompting governmental closures of schools and recommendations for companies to enable remote work for a few weeks annually during this period. Despite governmental efforts employing short-term solutions such as using anti-smog guns that spray water across the city and implementing curfews to limit vehicular movement, the situation deteriorates each year. Regrettably, there seems to be a lack of long-term strategies to address this escalating crisis.

1. Understanding and Solving the Problem

In order to gain a comprehensive understanding of the challenge, we dissected it into two main categories: water and air pollution. Furthermore, we generated a comprehensive list of primary concerns that could be addressed within each category. Plotting the technology use cases to these specific issues provided us with clearer direction regarding the areas we aimed to explore further.

Topic / Tech	Sniffidrone	VisionAir	Pipe4.0	IALL
Air Pollution				
Industrial	x	x	x	-
Urban	x	-	x	-
Rural	x	-	x	-
Farms	x	-	x	-
Forest	x	-	x	-
Water (over)	x	-	x	-
Diseases	-	x	-	x
Water				
Fishing	-	-	-	-
Aquaculture	x	-	-	-
Acidification	-	-	-	-
Microplastics	x	x	-	x
Antibiotics	-	-	-	-
Reverse Co2	-	-	-	-
Mining	-	-	-	x
Plankton	-	x	x	x
Fresh Water	x	-	x	-

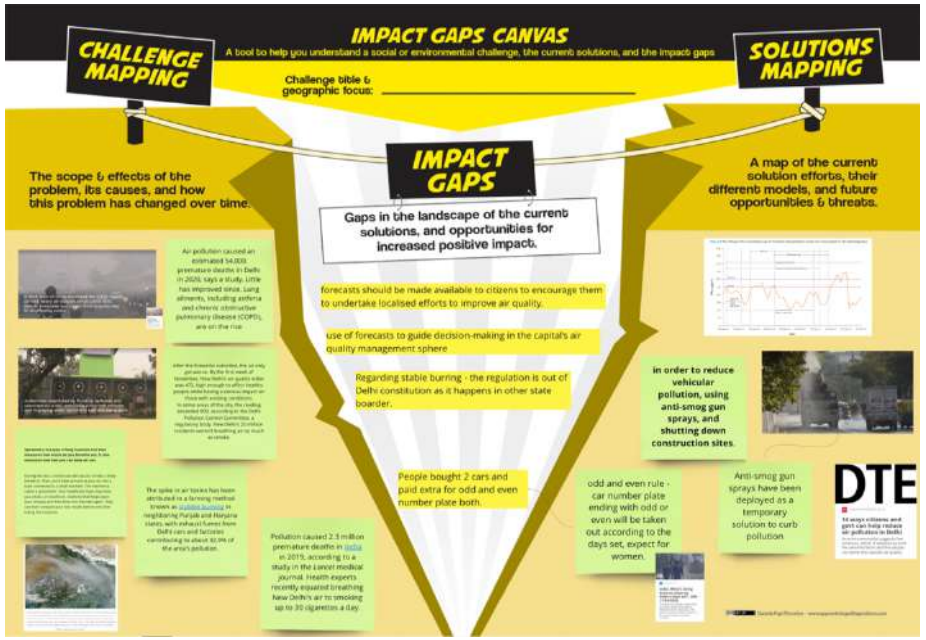
Based on our initial analysis, we decided to address the challenges associated with the #11.6 Sustainable Development Goal (SDG) which aims to reduce adverse environmental impact of cities by paying close attention to air pollution and waste management. Certain members of our team had first-hand experiences living in highly polluted cities, such as New Delhi, which influenced this decision. As we delved deeper into our research, we realised that the issue of air pollution in Delhi surpassed our initial understanding, highlighting an urgent and critical need for a solution.

We researched on the following topics:

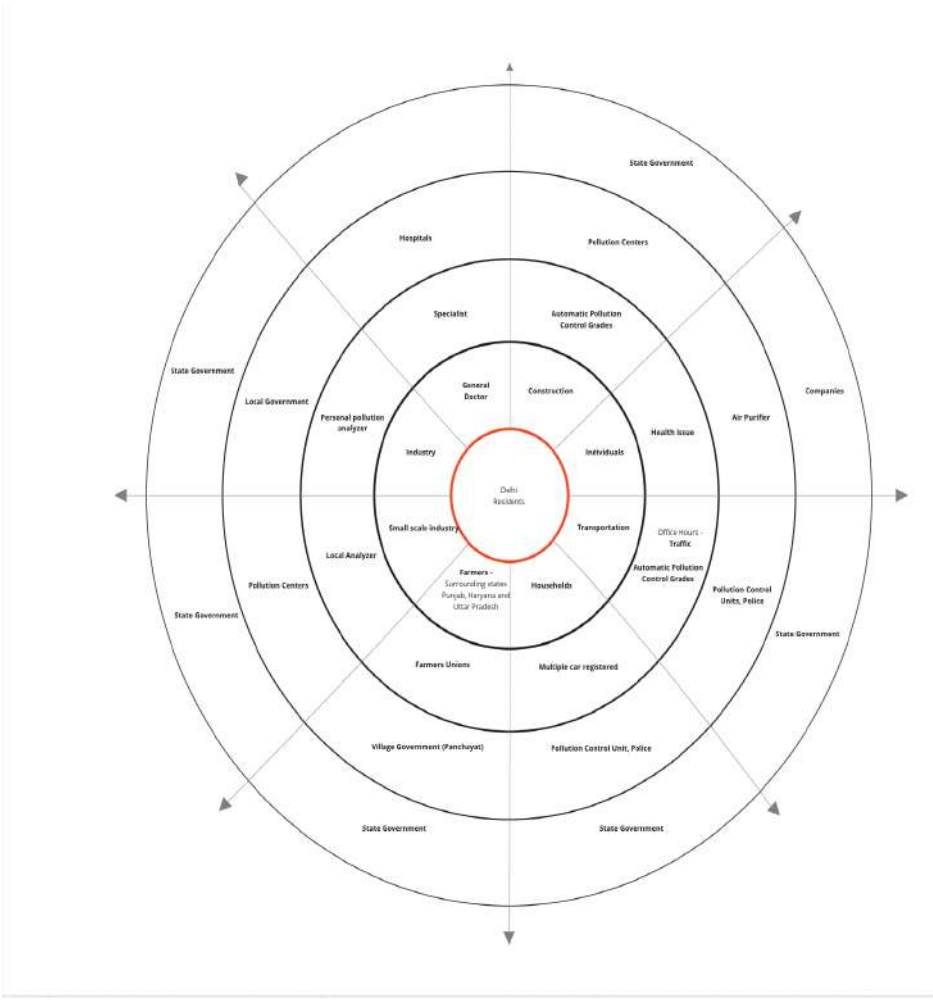
- Which are the most polluted cities in the world?
  - What are the sources of air pollution in New Delhi?
  - What are the most common consequences of air pollution in Delhi?
  - What are the government initiatives to tackle air pollution in Delhi?

To further refine our research and identify what exactly we want to solve for, we used frameworks and canvases which include Impact Gap Canvas and People and Connections Map.

A. Impact Gap Canvas



B. People and Connections Map



C. Desk Research

In our desk research, we aimed to examine the primary sources of pollution in New Delhi, aiming to pinpoint the specific root causes we intended to address. Our discoveries at the source level were as follows:

- **Indoor air quality**

  In a study by the Energy Policy Institute at the University of Chicago (EPIC), researchers uncovered a concerning reality: indoor spaces harbour significantly higher levels of PM2.5 particles—tiny lung-damaging elements—than what outdoor government monitors register. Shockingly, low-income neighbourhoods faced 10% worse indoor pollution. Yet, despite the pressing need for effective indoor air monitoring, existing real-time sensors struggle with stability and reproducibility issues, hampering their widespread use. Hospitals showcased indoor air quality intricately tied to external pollutants, ranging from particulate matter to microbiological contaminants. Interestingly, different hospitals demonstrated varying levels of bacterial and fungal contamination, emphasizing the need for tailored pollution management strategies. Bridging the gap between indoor and outdoor pollutants, a pioneering Indian start-up, backed by Delhi's innovation initiatives, introduced an AC module capable of purifying indoor air by an impressive 80%, offering hope for cleaner, healthier living environments amidst the challenges of modern pollution.

- **Vehicle emissions**

India, like many Asian nations, faces limitations in leveraging advanced emission control technologies due to inadequate ultra-low sulphur fuels. Proposing gaseous fuel programs with robust fiscal support, infrastructure, and safety regulations, there's a bid to maximize emission reductions. Despite vehicles being the prime polluters, curbing their expanding numbers remains sluggish. Advocates push for advanced remote monitoring for stricter vehicle emissions tests, relating to the current PUC (Pollution Under Control) program which is easy to bypass. Despite a 35% drop in overage vehicles following a ban, the vehicles-per-capita ratio surged from 317 to 655, portraying Delhi's persistent reliance on personal motorized transport. With over 122 lakh registered motorized vehicles, two-wheelers dominate at 67%, totalling over 8.2 million in 2021.

- **Factories & powerplants**

In the fight for cleaner air, Delhi's environment minister has urged the shutdown of 11 coal-fired power plants surrounding the city. However, policy implementation is delayed as these plants have repeatedly missed deadlines for installing emission-reducing technology. Yet, amidst efforts to combat air pollution, gaps persist—inefficient pollution control devices in industries, reliance on multiple energy sources, and unreliable emission data pose ongoing challenges.

- **Stubble burning**

Toxic pollutants released during stubble burning, including carbon monoxide and methane, worsen air quality and pose health risks. The aftermath isn't limited to the air—the soil's fertility diminishes, vital nutrients vanish, and erosion increases, causing a ripple effect on agriculture. Despite Supreme Court orders and efforts from initiatives like Delhi's "Green War Room," the battle against stubble burning requires more than mandates. Ideas range from chemical solutions to decompose crop residue to studying satellite data for culprits.

D. Interviews: Key findings and insights

Conducting interviews with individuals from diverse backgrounds was crucial to obtain a more comprehensive understanding of the on-ground situation in Delhi. Our panel of interviewees ranged a variety of backgrounds, including industry experts, government officials, and residents of Delhi who gave us some very insightful thoughts and questions to think about.

Insight 1: The growth of Delhi and the contribution of urbanization to air pollution

The role of population growth

The air quality issue in Delhi is attributed to the high concentration of population and economic activities in the region. Delhi's population is around 30 million, with significant migration due to employment opportunities and infrastructure in the city. Delhi's urbanization has led to imbalances in development, with planned colonies and informal areas coexisting. The Master Plan for Delhi outlines long-term development over a 20-year period, guiding land use and allocation for various purposes. Challenges in urbanization include the growth of informal settlements, slums, and a rich-poor divide.

Poor waste management practices

The growth of the city has led to poor waste management practices. Ghazipur landfill, described as a "mountain of waste," is an environmentally unfriendly site emitting constant smoke. Efforts are being made to address the waste issue, including waste-to-energy projects, composting, and recycling. However, challenges arise due to the enormous volume of waste. The government has resources and funds, but challenges include the sheer volume of waste and potential governance deficits. The magnitude of the waste challenge and competing priorities may contribute to delays in solving the landfill problem.

Construction activities

The growth of the city has led to the rise of construction activities to provide housing and space for the growing population. These activities produce pollutants like PM2.5 and other that could be harmful to human health.

> "There has been a lot of construction activities happening in the city lot of urban settlements parallelly from late 90s early to 2000s coming in the city so that that boosted up a lot of construction."
> ***Rohit Sharma, PhD - Air Pollution, Climate Change Adaptation, Digital Solutions Expert***

Insight 2: Transportation in Delhi is a big contributor to air pollution

Vehicle emissions and dust

Private vehicles, primarily running on petrol and diesel, constitute a large portion of transportation in Delhi (10-12 million registered motor vehicles). These vehicles are one of the biggest contributors to air pollution in the city. Through harmful emissions and dust. Dust pollution is a significant issue in Delhi, arising from various sources such as vehicle emissions, construction activities, deficiencies in urban planning, and the semi-arid climate.

> "The distances are long, and one has to travel. These are not walkable, or one cannot travel in cycles and other non-motorized forms of transport because the distances are long for which motor vehicles are required."
> ***Rumi Aijaz - Senior Fellow at ORF (Observer Research Foundation)***

> "Dust is a complex problem with multiple sources, not limited to vehicle emissions. Construction, vacant spaces, and loose sand contribute to the dust problem in the city. Dust pollution is a challenge that requires comprehensive solutions. "
> ***Rumi Aijaz - Senior Fellow at ORF (Observer Research Foundation)***

> "Whenever we reduce the number of vehicles on the road, there was a dip in pollution levels and during pandemic, a lot of papers came up with the comparison of the non-pandemic and pandemic when there were a few cars on the road."
> ***Rohit Sharma, PhD - Air Pollution, Climate Change Adaptation, Digital Solutions Expert***

The public transport system shifts to environmentally friendly alternatives

Public transport includes the metro rail, city buses, three-wheeler auto-rickshaws, and app-based taxi services (Uber, Ola). Public transport

vehicles have shifted to more environmentally friendly fuels like compressed natural gas (CNG) and, more recently, electric vehicles. The Delhi Metro started operations in the early 1990s to address traffic congestion, and it has undergone various phases and expansions. The growth of the metro system has significantly contributed to addressing transportation needs in the city.

"You cannot run public transport without a CNG system installed in your vehicle. This significantly reduced pollution. More recently, there has been a shift to electric vehicles, although this has its challenges."
Rumi Aijaz - Senior Fellow at ORF (Observer Research Foundation)

Insight 3: The role of the government

Government Projects and Initiatives

The Delhi government runs various programs with their aim to combat air pollution. Some of them include; The Smart Cities Mission is a global concept adopted by India to respond to urbanization challenges. Infrastructure projects under the Smart Cities Mission aim to address urban challenges and improve living conditions. Initiatives by both government and non-government organizations, such as the Centre for Science and Environment (CSE) and app-based taxi services (Uber, Ola), contribute to improving air quality. Efforts include addressing transportation issues, controlling air pollution, and engaging various stakeholders in planning

"There are few interventions started by government to closely monitor pollution. Whatever areas were highly polluted, there were strict regulations done like, for instance, the hospital areas, the school areas and the garden areas were termed as low pollution zones where primary pollutants being Particulate matter 2.5, Ozone and others are kept below permissible limit. "
Rohit Sharma, PhD - Air Pollution, Climate Change Adaptation, Digital Solutions Expert

The collaboration between government and citizens

The future outlook for Delhi in terms of transportation and urbanization depends on the concerted effort of the government and citizens. Transformation requires time and genuine efforts, and the next 50 years may witness mixed results based on the approach taken by authorities.

"The government is increasingly involving non-governmental stakeholders in planning, which is a positive development. The Centre for Science and Environment (CSE), a non-government organization based in Delhi, plays a crucial role in developing plans to control air pollution in the city. "
Rumi Aijaz - Senior Fellow at ORF (Observer Research Foundation)

Insight 4: Residents of Delhi neglect precautions against air pollution

The role of socioeconomic landscape

In Delhi, although some of the wealthiest individuals reside, the majority of the population comprises low and middle-income groups who migrate from nearby cities in search of employment opportunities. While affluent

households prioritize their well-being by employing air purifiers and adopting precautionary measures like wearing masks outdoors, the same level of concern and action is notably lacking among the lower and middle-income groups. The issue here isn't solely related to awareness; it also pertains to the affordability of available solutions.

> "The air is much cleaner in the village I come from but there aren't any opportunities there. We know there is air pollution and heavy smog, especially in winter months every year but what are we supposed to do about it? This is something which is not under our control."
> ***Sulekha - Housemaid***

2. Conceptual Development: Finding a Solution

A. Problem Reiteration

Following interviews with multiple stakeholders and thorough research, we aimed to delve deeper into the issue of vehicular emissions. It's evident that there's insufficient action to reduce the pollution stemming from vehicles on Delhi's streets, and a significant portion of the population remains unaware of the substantial contribution vehicles make to air degradation. The current tools available to monitor vehicle emissions are inadequate, primarily focusing solely on four-wheeled vehicles. There's a notable absence of a solution to effectively track emissions from two-wheelers thus far.

B. Ideation Process

We went ahead and utilized the Impact Gap Canvas to identify the disparities between the challenges we were facing in Delhi and the solutions that were already in place. This canvas helped us pinpoint the areas where the existing solutions were falling short in addressing the specific issues in Delhi.

Gap between current transport pollution and their solution to get some opportunity areas

Existing solutions	Current gaps
Pollution under control (PUC) centres to test vehicle emission	Ineffective monitoring of vehicles at Pollution under control (PUC) centres due to static testing
Community solutions where people can report to police if they see an old vehicle and location for the govt to take it away	Locating de-registered and old vehicles
Water sprinkling to reduce air pollution and dust in pollution hotspots. Distance covered is 150- 170km/day	Accurately locating pollution hotspots caused by dust and vehicles for water sprinkling
Realtime stations to test the air quality with different information about different pollutants	No testing of PM2.5, PM10 and other pollutants from vehicles harmful to human health
Tax reduction and subsidises to move to electric vehicles under the Graded response action plan (G.R.A.P) policy	Monitoring of implementation of the G.R.A.P

To come up with ideas, we employed a two-pronged approach. First, we engaged in brainstorming sessions where we threw around a bunch of creative ideas. This allowed us to tap into the collective imagination of the team and generate a diverse range of concepts. Following that, we delved into an analysis of potential future scenarios. By envisioning how our ideas might play out in different situations, we gained insights into their feasibility and impact. This combination of brainstorming and future scenario analysis proved to be a robust ideation process for us.

After reviewing the analysis, we managed to connect the pieces. The collected data highlighted a crucial point: 2-wheeled vehicles, such as motorbikes, were the primary source of vehicular emissions, accounting for 67% of all vehicles on the road, predominantly owned by low and middle-income communities. Interviews had previously revealed a significant awareness gap within these communities, leading us to conclude that addressing emissions from 2-wheeled vehicles was crucial for air pollution reduction in the city.

Idea 1: Filter for motorbikes

- The device will filter out main toxic gases which contain CO2, NO from the air coming out of the tailpipe of 2-wheelers
- The device will monitor the number of toxic gases coming out of the tailpipe of the vehicle and this data will be shared with authorities to indicate the effectiveness of the filter

Idea 2: Filter for motor bikers.

This solution revolves around three primary objectives:

1. **Acquire City-wide Pollution Data**

Our first goal is to gather extensive data on pollution throughout the city. This data will provide us with a holistic understanding of air quality patterns, enabling us to make informed decisions and implement targeted interventions.

2. **Engage and Build Awareness**

We recognize the importance of public awareness in addressing air pollution. Our second objective is to engage with the community and raise awareness about the severity of air pollution. Through educational initiatives, we aim to enlighten the public about the detrimental effects of pollution and the advantages of transitioning to electric bikes.

3. **Facilitate Transition to Electric Motorbikes**

To promote sustainability, we're committed to establishing partnerships with electric bike providers. This involves creating pathways for affordable access to electric bikes, incentivizing the transition, and ensuring the necessary infrastructure is in place to support the adoption of electric vehicles.

By focusing on these three pillars, our solution aspires to create a positive impact on both the environment and the communities, fostering a greener and healthier future for all.

c. Prototyping

The first idea was to analyse and filter out the emissions by two wheelers which are the maximum emissions contributors. However, we soon realized that creating a prototype for this concept posed challenges in terms of considering the chemical processes involved and the complications that would arise from adding an external device to the motorcycle. Furthermore, we discovered that this idea had already been implemented previously.

Hence, we shifted our focus and concentrated on transition of the two wheeled vehicles to electric vehicles and reduce the emissions but to enable that people to need to be aware about the air quality they are breathing which led us to explore the option of incorporating filters into the drivers' helmets. Initially, we considered using two separate filters: one for air filtration and another for collecting samples. However, to optimize the design, we decided to integrate both functionalities into a single filter when we found a suitable model that could fulfil both purposes. The filter design is tailored for full-face helmets, with the device placed at the front and featuring an opening for easy insertion and removal of the filter while ensuring unobstructed breathing. The chosen filter will be for single-use

purposes only and will have to replaced once it reaches its filtering capacity. The shape of the filter is designed to be aerodynamic and lightweight.
Looking ahead, we are considering modifying the design to accommodate half-face helmets, allowing for broader compatibility and adoption of the filter system.

The filter analyses the driver's personal intake of pollution as well as the pollution that is on the route taken to later analyse the quality of air in different parts of Delhi that can be accumulated in one data ultimately. The goal of this project is to help people convert into electric vehicles and reduce the current vehicular emissions being produced.

3. Final Idea

3.1 Project Insights

A. Description

EVOLVE

EVOLVE is a universal solution with a vision to foster a seamless transition from combustion two-wheeled vehicles to electric bikes for people in low to middle income communities.

This solution has three main objectives

1. Acquire City-wide Pollution Data: This is to gain comprehensive insights into air quality patterns in the city.
2. Engage and Build Awareness: To educate the public on air pollution severity and the benefits of switching to electric bikes.
3. Facilitate Transition to Electric Motorbikes: To promote sustainability through partnerships with electric bike providers.

With this objective EV*OLVE *has set a goal to transition 1 million motorbike riders from combustion motorbikes to electric bikes by 2030.

B. FUNCTIONALITY AND TECH

To achieve the objectives and goal of the project the riders of **EV**OLVE will use two main technologies that will be in the hands of the riders. This includes the **EV**OLVE filter and **EV**OLVE mobile App.

EVOLVE **Filter**

The **EV**OLVE filter is a tool that attaches to the motorbike rider's helmet. This filter captures pollutants in the air and is meant to protect riders from the harmful elements in the air and capture air samples. The filter is to be deposited by the riders after 2 days to be analysed to detect the pollutant the rider has been exposed to when wearing the helmet and acquire data on pollutants in the city. The detection is possible through the PiPe 4.0 technology, the in-depth working of the same is mentioned in the report in Section 3.2.c.

EVOLVE **Mobile App**

This user-friendly mobile app will be used by motorbike riders who are part of the **EV**OLVE community. It brings value to the users through engaging and building awareness to educate the users of the personal impact has on them and promote support the riders transition to motor bikes through partnerships with electric bike providers and special incentives for users. Below are key motives of the mobile app as well as its features:

1. **Awareness among users**

By providing riders with air quality data at the city level and the individual level showing them their exposure to air pollution and the possible health effects.

- *City pollution map*

This allows users to save favourite places that they frequent allowing them to view air quality data in their frequented location.

- *Individualised pollution data*

From the samples deposited by the riders they will receive a report about the samples that they deposit from their helmet. This will show them how much pollution that they have been exposed to how much pollution the filter has protected them from as they ride their bikes.

2. **Free filter replacement**

Riders using the **EV**OLVE filter will drop them off at designated points around the city. This drop off should be done within two days. The drivers can replace the old filter with a new one for free at the drop off points.

- *Notification reminders*

Notifications to remind the riders when to drop of their filters.

- *Drop off points map*

A map showing the users and directing them where they can drop off their filters.

3. Community engagement

The community is meant to create a place for riders who have a shared goal to transition to an electric bike. The users will be able to share their progress on the transition to electric motorbike to motivate other riders, they could also share tips they learnt from their personal experience. A key part of this is to collaborate with local celebrities and influencers to engage the community.

- *Photo sharing*

Users can share photos with each other sharing progress and insights into their electric motorbike transition.

- *Air quality data sharing*

Users will be able to share the data of the pollution filtered and avoided by them through the filter with other app users.

4. Motorbike marketplace

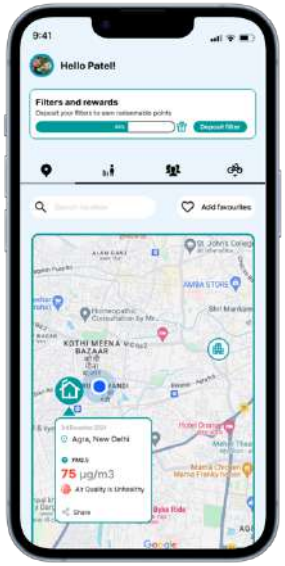
The riders will have access to a marketplace where they will be able to rent or buy new electric bikes at a reduced price. The aim of this is to make electric bikes more affordable to people from all communities. The discounts will be achieved through cooperation with electric motorbike manufacturers.

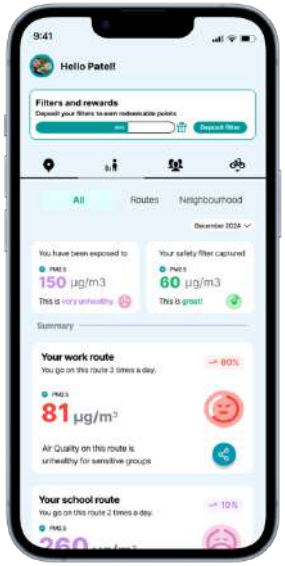
- *Reward points and discounts*

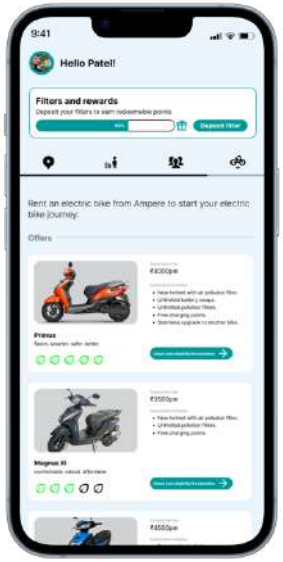
The riders will be able to gain points from the filters that they deposit from their helmet. These points can be redeemed to get discounts on new electric bikes.

- *Check for government subsidy eligibility*

The riders will also be able to check to see if they qualify for government subsidises to get a bike at a reduced price.







c. Problem-solving Aspect

Incentives making electric bikes accessible to people from all communities

Through incentives like the redeemable points from the filter deposits as well as discounts and deals offered through the app. The solution allows individuals from low to middle income communities to access electric bikes and make an easier transition. These discounts and access to subsidies reduces one of the biggest challenges which is the lack of funds to transition to the electric bikes.

Awareness educating riders about severity of air pollution and benefits of transitioning to an electric bike

The solution provides the users with personalised air pollution data from the samples they deposited from their helmets. This shows users the severity of the air pollution in the city and how they are personally affected by this. This will promote awareness and provide them with a way that they can contribute to reduction of air pollution. The transition to an electric vehicle is a small way they can contribute to the reduction of the pollution and be part of the **EV**OLVE goal to reach 1 million new electric bikes by 2030.

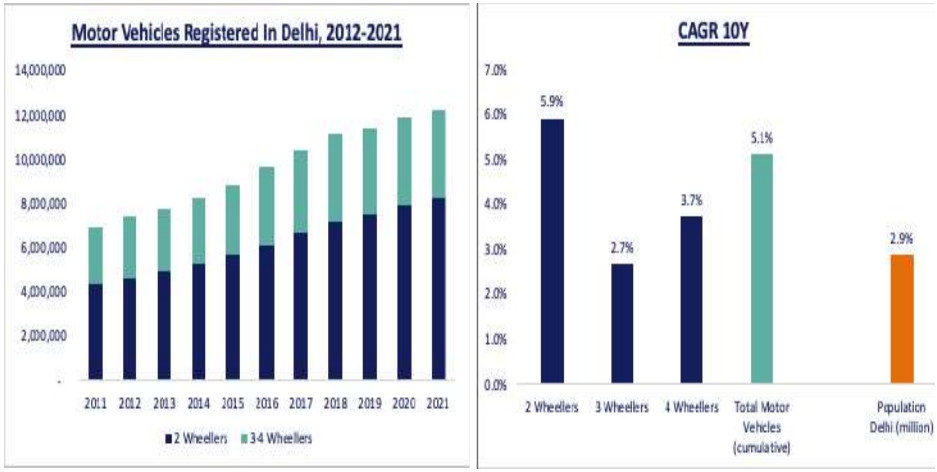
City wide pollution mapping promoting action on areas of concern

EVOLVE will analyse the filters deposited by the riders using the PIPE4.0 technology. With the riders GPS and the samples, they will be able to map

the pollution at the neighbourhood level which could help pinpoint areas of concern in neighbourhoods.

D. Expected Impact

Delhi, a metropolis with a population of 31 million, houses a vehicle fleet of around 13 million vehicles, not accounting for the significant expansion of the road network, which has doubled since 1981, expanding from 15,000 km to 33,000 km. Over the past decade, this fleet has seen an annual growth of 5%, surpassing the modest 3% population increase. Of the total vehicles, 67% comprise two-wheeled models, showing an annual growth rate of 6%. The accompanying charts illustrate the trends observed in the city over the last 10 years.



In general terms, vehicles contribute to 40% of Delhi's air pollution, responsible for emitting 75 PM2.5 (µg/m3) out of a city-wide total of 187 in 2022. Two-wheeled vehicles, constituting 67% of the vehicle population, account for 45 PM2.5 (µg/m3) of the air breathed by Delhi's inhabitants in 2022. This data strongly emphasizes the pressing need to promote more sustainable mobility in the region. **EV**OLVE aims to lead this shift by facilitating the adoption of eco-friendly solutions, especially among users of two-wheeled vehicles, transitioning from Internal Combustion Engine (ICE) vehicles to electric vehicle (EV)-based alternatives.

To begin, let's consider the 2022 and 2023 estimates of Delhi's vehicle fleet. Additionally, a vital piece of information for the project is that transitioning from an ICE two-wheeled vehicle to an EV represents a reduction of 0.00001 PM2.5 (µg/m3). Using these initial figures, we can calculate the impact per user making the transition from ICE to EV and the resulting pollution reduction within the vehicle universe we are assisting in transitioning.

Data		2022	2023
PM2.5 (µg/m3)	Delhi (Total)	187	200
	No Vehicles	112	120
	%	60%	60%
	Vehicles	75	80
	%	40%	40%
# Vehicles in Delhi	Total Vehicles (Milions)	12.6	12.9
	2w (Millions)	8.8	9.0
	EV 2w (#)	1.2	1.8
	Var. # EV	-	0.6
	% total Vehicle	10%	14%
	No EV 2w (#)	7.6	7.2
	% total Vehicle	60%	56%
PM2.5 No EV 2w		45	45

Expected Impact

# Users		PM2.5	%
PM2.5 (µg/m3) per 2w out	1	6E-06	-
	100,000	1	1%
	150,000	1	2%
	250,000	2	3%
	500,000	3	7%
	1,000,000	6	14%
	5,000,000	31	69%
	7,000,000	44	97%
TOTAL PM2.5 No EV 2w		45	100%

Thus, **EV**OLVE endeavours to facilitate the transition of 1 million users over the next decade, aiming to contribute significantly—15%—towards alleviating pollution from two-wheelers, resulting in an average annual reduction of 6 PM2.5 (µg/m3). This initiative stands as a crucial step towards a cleaner, more sustainable future for Delhi citizens. The projections and impacts for the next 20 years can be found in the appendix titled 'Expected Impact (20 years).' This section provides a comprehensive outlook on the anticipated outcomes and implications for the coming two decades.

Finally, is important to follow the next metrics to secure the success of **EV**OLVE:

- **User acquisition:** Track the number of new users joining the **EV**OLVE community and their engagement levels within the app.
- **Filter deposits and analysis:** Monitor the frequency of filter deposits and the accuracy/efficiency of pollution data analysis.
- **Electric solutions adoption:** Measure the number of electric solutions rented/sold through the app and the impact on pollution reduction.

3.2 Detailed Analysis

A. Design Elements

Engagement and Incentives

To actively engage the individual's part of this program, the incentives play a big role. The incentives make the transition cheaper and more accessible to people from all communities which aims to solve the problem of low adoption of electric bike because of high electric bike prices. With these incentives the riders will be able to contribute to the reduction of air pollution with their transition to electric bikes.

Community

The purpose of the community in this solution is to bring people together who have a shared goal. In this case the goal is to transition to electric bikes. With the community the riders will be able to see and quantify the small part they are playing to combat air pollution. Through their community they will also see the impact that their collective efforts have made to reduce air pollution in the city and the electric bike transition.

Partnerships

To make the motorbikes more affordable their needs to be collaboration with electric manufactures in Delhi who share the enthusiasm for sustainability and the reduction of air pollution in the city. These partners will be part of the program to provide discounts to buy or rent new electric bikes. This will also help their bottom-line.

User - friendly technology and processes

The filter and mobile app used in the solution are designed for individuals to use easily in their everyday lives. The process of depositing the filter is easy and deposit spots are placed in convenient places like office buildings, parking spots and among other to allow for easy access. The mobile app is also easy to understand using visual language and maps to communicate air quality data in a way that everyone can understand

B. Business/Organizational Considerations

Our solution's main emphasis lies in two key aspects: collecting extensive city-wide pollution data from riders' routes and filters, and raising public awareness about the seriousness of air pollution and the advantages of switching to electric bikes. This informed approach not only guides decision-making but also monitors advancements towards cleaner air routes and behaviours, directly contributing to improved air quality and public well-being.

Fundraising

For **EV**OLVE to materialize this proposal in the real world, it's essential to secure the following revenue sources or support systems enabling its operations in the upcoming years.

Phase 1:

In the project's early stages, our fundraising strategy entails pursuing assistance from a blend of public and private revenues sources.

Generate revenue via partnerships

EVOLVE aims to collaborate with electric bike manufacturers, retailers, and lenders, facilitating sales and rentals through the app and earning a percentage from these transactions. By partnering with industry stakeholders, **EV**OLVE plans to provide enticing discounts and incentives to riders transitioning to electric bikes. The EV Policy not only foresees the proliferation of 500,000 EVs in Delhi but also envisions substantial job creation opportunities. Skill development initiatives across the electric vehicle supply chain will establish a robust after-sale ecosystem, potentially generating various job roles including EV drivers, auto-mechanics, and charging station operators, contributing significantly to Delhi's employment landscape. Target companies:

- **Ather Energy:** Leading the charge in premium electric scooters with advanced technology and design.
- **Ola Electric:** Gaining traction through aggressive marketing and a focus on affordable, connected EVs.
- **TVS Motor Company:** Established player in the two-wheeler market, making significant strides in electric scooters and motorcycles.

Generate revenue via grants and donations

EVOLVE could seek funding from grants and donations from foundations, individuals, and corporations that support environmental sustainability:

- Government Grants and Subsidies: Apply for grants or subsidies aimed at environmental projects or sustainable transportation initiatives.

- Leverage partnerships with non-profit organizations to attract philanthropic donations and sponsorships.

Phase 2:

In a second phase of the project, the revenues will come in the for of the following:

Membership/Subscription Model

Offer a premium membership tier for enhanced app features and benefits, creating a recurring revenue stream.

Advertising and Sponsorships

Allow targeted advertisements within the app and collaborate with sponsors interested in promoting eco-friendly initiatives.

Phase 3:

*Finally, without disregarding the previous income sources, once **EV**OLVE gains traction and public recognition, it can move into a final phase of revenue sources in the form of the following options:*

Investors support

These investors will place a strong focus on supporting **EV**OLVE to make a meaningful impact in line with the principles set forth by the UN's Sustainable Development Goals. The main alignment for these companies will be:

Investors / Rational	Angel Investor	Accele. / Incub.	Crowd fundings	PE / Buyout	Venture Capital	Gov.	Corp.
Growth potential	✓	✓	✓	✓	✓	✓	✓
Diversification	!	!	!	✓	✓	✓	✓
Value creation	✓	✓	✓	✓	✓	✓	✓
Risk Aversion	✓	✓	✓	✓	✓	!	!
Innovative	✓	✓	✓	✓	✓	✓	✓
Early-stage invest.	✓	✓	✓	✓	✓	!	!
Partnership	✓	✓	✓	✓	✓	!	!
Social impact	✓	✓	✓	✓	✓	✓	✓
Support a business	✓	✓	✓	!	✓	✓	!
FIT	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Carbon credits Market

EVOLVE could participate in carbon credit markets by offsetting emissions from combustion motorcycles with electric bikes.

- Quantify the emissions reductions achieved by transitioning riders to electric bikes and participate in carbon credit markets.
- Collaborate with corporations seeking to offset their carbon footprint by sponsoring e-bike adoption through **EV**OLVE.

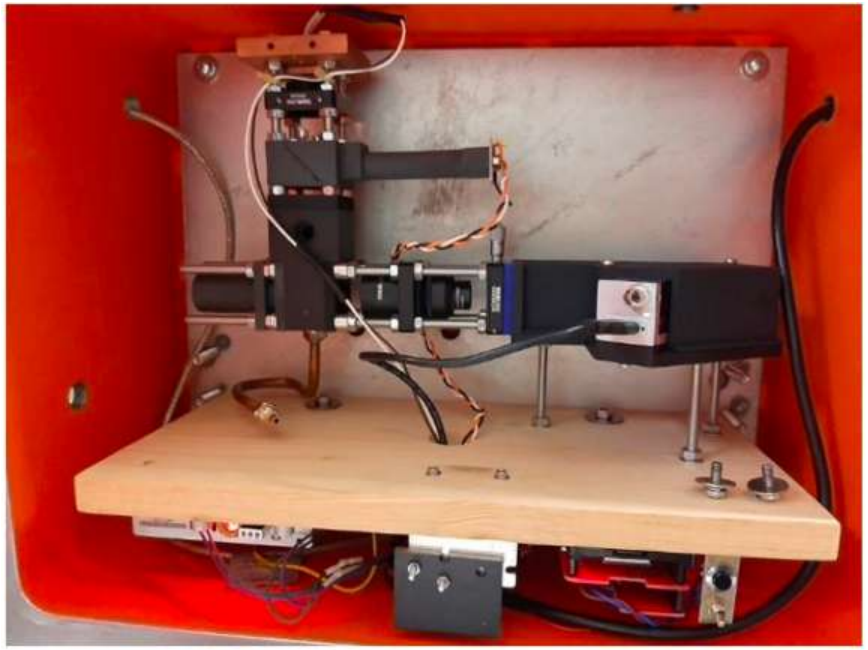
C. Technical Specifications

In this project, technology plays a crucial role. As previously explained, the situation in Delhi has very unique characteristics. In order to monitor the air with the help of citizens, our system is highly powerful. It is realistic yet ambitious, monitoring the air in large cities through the collaboration of many individuals, a concept that has been attempted in various locations. However, in other projects, a common issue arises: the use of many

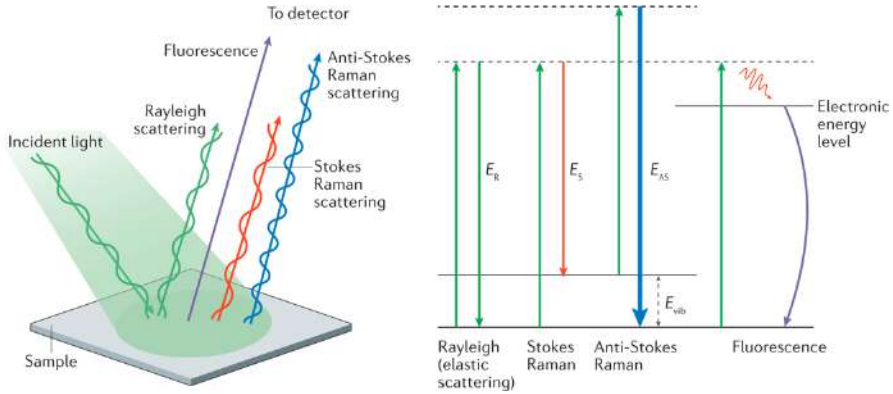
sensors for each component. If numerous sensors are required, they must be affordable to ensure cost-effectiveness. Unfortunately, inexpensive sensors often sacrifice precision, rendering them inadequate for our purposes. This problem does not exist in our project.

PIPE4.0 by ATTRACT Consortium

On the contrary, we face logistical challenges in receiving the filter and trajectory data from each participant. Nevertheless, our technology is robust and intriguing. In this initiative, we leverage the innovative technology developed by ATTRACT known as PIPE4.0, which is anchored in GASRAMAN that uses Raman Spectroscopy. Let's first delve into what Raman spectroscopy in solids entails. This technique identifies and analyses elements, revealing what substances may go undetected when examining a filter exposed to the street pollution of a city like Delhi. It can detect various pollutants and analyse the extent of contamination.



By incorporating Raman spectroscopy, our system aims to overcome the limitations posed by traditional sensor arrays. This method not only enhances precision but also allows us to gain a comprehensive understanding of the types and levels of pollutants present in the air. This strategic approach is pivotal in our mission to create a reliable and efficient air quality monitoring system, and we are committed to addressing the logistical challenges to ensure the success of our project.



Raman spectroscopy provides detailed information about molecular vibrations:

- When monochromatic light (usually from a laser) interacts with a sample, most of the scattered light has the same energy (frequency) as the incident light. However, a small fraction of the scattered light has different energies due to interactions with molecular vibrations or rotations in the sample.
- Inelastic scattering results in the energy of the scattered photons being either higher or lower than that of the incident photons. This energy difference corresponds to the energy of the vibrational or rotational transitions in the molecules.
- The Raman spectrum is a plot of the intensity of the scattered light as a function of the energy difference between the incident and scattered photons. Peaks in the Raman spectrum correspond to specific vibrational or rotational modes in the molecules, providing a unique "fingerprint" for different substances.
- It doesn't require extensive sample preparation, making it suitable for a wide range of materials.

In the context of air quality monitoring, Raman spectroscopy can be employed to analyse filters that have been exposed to pollutants. In the project context, utilizing Raman spectroscopy allows for a more nuanced and detailed analysis of air quality, offering a comprehensive understanding of the types and concentrations of pollutants present in the environment.

Some examples of solid particles that could be identified include:

- Particulate Matter (PM): Raman spectroscopy can help identify different sizes and compositions of airborne particles, such as PM2.5 and PM10, which are key indicators of air quality.
- Soot (Carbon Black): Soot particles, often originating from incomplete combustion of fossil fuels, can be detected using Raman spectroscopy.
- Mineral Dust: Mineral dust particles, including compounds such as silicates and carbonates, can be identified by their unique spectral signatures.
- Heavy Metals: Metals like lead, copper, zinc, or other heavy metals present in fine particles can be detected by Raman spectroscopy.
- Organic Compounds: The presence of organic compounds adsorbed onto particles can be analysed, providing insights into organic pollution in the air.

- Inorganic Compounds: In addition to organic components, Raman spectroscopy can reveal the presence of inorganic compounds such as salts or minerals.
- Ash and Combustion Residues: The formation of ash and residues from combustion can also be detected, contributing to an understanding of pollution sources.

MCE Membrane Filter

The filters, evolving into our samples as the kilometres accumulate, constitute a pivotal component of the project. The MCE Membrane Filter, 0.22µm Pore Size, MF-Millipore®, filter diam. 13mm, hydrophilic, white has been selected as the most suitable filter for three primary reasons. Firstly, its porosity is adept at capturing particles of interest while maintaining an optimal flow rate, enabling the driver to breathe comfortably. Secondly, its size—specifically the diameter—creates an optimal surface for functionality and design. Lastly, its outstanding quality and reputation for widespread use in other air monitoring projects make it a reliable choice. For detailed specifications of the filters, please refer to this link: [Filter Specifications].

Fourier Slice Theorem

The Fourier Slice Theorem is a fundamental concept in medical imaging and signal processing. It plays a crucial role in reconstructing two-dimensional images from their one-dimensional projections. Below, we have a brief explanation of how it is applied in medical imaging, and then, how we apply the same concept for our project.

Fourier Slice Theorem in Medical Imaging

The Fourier Slice Theorem establishes a mathematical relationship between a two-dimensional image and its one-dimensional Fourier transform along lines parallel to a specific direction. In the context of medical imaging, it allows for the reconstruction of cross-sectional images from projections obtained along different angles.

- Data Acquisition

In medical imaging, data is acquired through a process such as computed tomography (CT), where X-ray projections are taken at various angles around the patient.

- Fourier Transform

The acquired data undergoes Fourier transformation, converting the spatial information into frequency domain information.

- Slice Reconstruction

The Fourier Slice Theorem enables the reconstruction of image slices perpendicular to the direction of projection. Each slice is reconstructed from its corresponding set of projections.

- 3D Image Reconstruction

By combining multiple slices obtained from different orientations, a three-dimensional image of the internal structure is reconstructed.

Application to Pollution Gradient Mapping:

If we have pollution filters identified with integrated pollution levels at the end of specific trajectories, along with the trajectory data, we can leverage the Fourier Slice Theorem to construct a pollution gradient map for the city of Delhi:

1. Data Collection

Pollution filters along with integrated pollution levels at the end of trajectories and the corresponding trajectory data are collected.

2. Mapping Trajectories

Each trajectory is mapped in a two-dimensional space, forming the basis for the Fourier Slice Theorem application.

3. Applying Fourier Slice Theorem

The integrated pollution levels act as the intensity values, and the trajectories serve as the direction along which projections are taken.

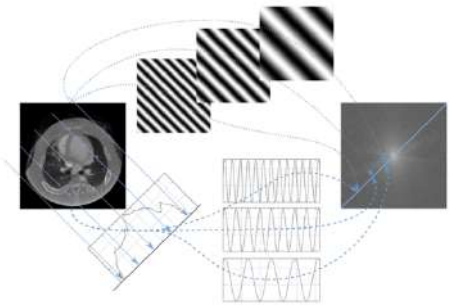
4. Reconstruction

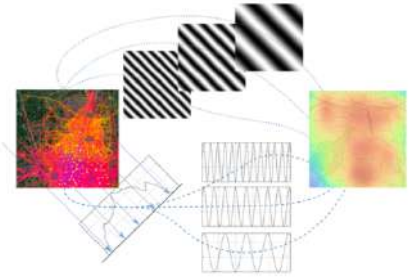
The Fourier Slice Theorem is applied to reconstruct two-dimensional slices perpendicular to each trajectory, creating a map of pollution gradients.

5. Combining Results

By combining the reconstructed slices from various trajectories, a comprehensive pollution gradient map for the city of Delhi is generated.

This approach allows for a spatially informed representation of pollution levels across the city, providing valuable insights for environmental monitoring and urban planning.





D. IDEAS FOR POSSIBLE EXPANSION IN THE FUTURE

As the **EV**OLVE project seeks to pioneer a shift towards electric vehicles and mitigate air pollution in New Delhi, its forward-looking approach opens numerous avenues for expansion and improvement. The project's adaptability and focus on the future make it a candidate for broader application and collaboration. Two key paths for potential expansion include:

Application in Other Cities

The success of the **EV**OLVE project in New Delhi serves as a testament to its efficacy, making it a prime candidate for implementation in other urban centres globally. The modular nature of the **EV**OLVE filter and its compatibility with any helmet design provide a scalable solution adaptable to diverse urban environments. By customizing the project to suit the unique vehicular landscapes and pollution challenges of different cities, we can extend the positive impact of **EV**OLVE beyond New Delhi.

Why this Project is Transferable?

Many metropolitan areas worldwide grapple with high levels of air pollution, especially in densely populated regions. **EV**OLVE's focus on addressing pollution at the source—two-wheelers—makes it relevant for cities facing similar challenges.
The flexibility of the **EV**OLVE filter technology allows it to be seamlessly integrated into the existing infrastructure of various cities, accommodating different traffic patterns and emission sources.
Despite cultural diversity, the common thread of vehicular pollution connects cities globally. **EV**OLVE's mission aligns with the shared goal of improving air quality and public health, making it a universally applicable initiative.

Collaboration with Government Transition Plans

To further bolster the impact of **EV**OLVE, a strategic partnership with government bodies aiming to transition towards electric vehicles can be explored. By aligning with these plans, the project can provide valuable data to assess the effectiveness of such initiatives while ensuring compliance with pollution control measures. This collaboration could take the form of a data-sharing agreement, where **EV**OLVE becomes an integral part of the monitoring and evaluation system.

What are the benefits of Government Collaboration?

The **EV**OLVE project can offer real-time, granular data on air quality and vehicular emissions, aiding governments in making informed decisions and refining their transition plans.
By integrating **EV**OLVE into government initiatives, we can track the progress of transitioning to electric vehicles and assess the actual impact on reducing pollution levels.
EVOLVE's data collection capabilities can serve as an independent tool for verifying whether implemented measures align with environmental goals and standards.

By exploring these options, the **EV**OLVE project not only stays important now but also becomes a forward moving and positive influence in the worldwide work to fight air pollution and encourage eco-friendly transportation.

4. Conclusion and Learnings

Our project has followed a well-defined path. Right from the start, we had a clear objective and have remained steadfast in our pursuit: addressing air pollution in Delhi. We embarked on an extensive investigation into the various factors contributing to this significant issue and discovered numerous causes. Among the prominent themes were indoor air quality, stubble burning, factories and power plants, and vehicle emissions. Over the course of the first two months, we conducted thorough research and consulted with experts.

As we delved into each cause, we encountered pre-existing but unsuccessful solutions, leading us to recognize that there was no single remedy for such a colossal problem. We realized that a systematic approach was necessary. Consequently, we concluded that we must propose a solution that involves multiple stakeholders and, most importantly, fosters a change in people's mindset. The citizens of Delhi are either unaware of the gravity of the air pollution problem or, even if they are aware, they are uncertain about the actions they can take to effect change. There exists a profound lack of awareness.

After careful consideration, we decided to focus our efforts on the issue of vehicles, specifically targeting two-wheelers, which are major contributors to pollution and are predominantly used by the middle and lower classes—most of the population. Within the idea to adopt a systematic approach, we conceived the concept of integrating helmet filters with a dedicated mobile application. This innovative solution aims to actively engage individuals, empowering them to be part of the solution and take ownership of their environmental impact, and by doing so, incentivise people to transition to electric vehicles.

As a reflection on the entire process, initially, we might have felt a bit lost with the abundance of information. We were primarily focused on concrete solutions. However, through brainstorming sessions and with the guidance of our professors, we managed to broaden our perspective and began considering the idea of monitoring driver data through the helmet, protecting them from inhaling polluted air while also ensuring their safety. Later, we conceived the idea of developing an APP to take it a step further, complementing the helmet with a tool that allows users to visualize their own impact and motivates them to improve.

This systematic solution aims to encourage the citizens of Delhi to view electric vehicles as a better transportation alternative. We aspire to foster a positive shift in their perception and promote the adoption of greener transportation options.

The idea of having multidisciplinary teams has helped us approach the problem from different perspectives, with each team member contributing their expertise from their respective disciplines. Simultaneously, we have all had the opportunity to learn from one another. Moreover, this project has allowed us to develop skills in communication, problem-solving, design thinking, and systems thinking. It has been a comprehensive project that has taught us how to approach problems from diverse viewpoints, pushing us out of our comfort zones.

5. References

1. Rumi Aijaz, "Electric Vehicles in India: Filling the Gaps in Awareness and Policy," ORF Occasional Attribution: Archit Lohani, "Countering Misinformation and Hate Speech Online: Regulation and User Behavioural Paper No. 373, October 2022, Observer Research Foundation.
2. Electric Vehicles are Poised to Create a $100B+ Opportunity in India by 2030. Copyright © 2022 Bain & Company, Inc. All rights reserved.
3. Balachandran, M. (2022, July 8). Not just Tata motors, Mahindra too has now built India's most valuable electric vehicle company. Forbes India. https://www.forbesindia.com/article/take-one-big-story-of-the-day/not-just-tata-motors-mahindra-too-has-now-built-indias-most-valuable-electric-vehicle-company/77945/1
4. Delhi Road Crash Report - 2021. (2021). Accident Research Cell of Delhi Traffic Police. https://traffic.delhipolice.gov.in/sites/default/files/uploads/2021/Delhi-Crash-Report-Final-2021.pdf
5. Delhi, India Metro Area Population 1950-2023. (n.d.). Macrotrends.https://www.macrotrends.net/cities/21228/delhi/population#:~:text=The%20current%20metro%20area%20population,a%202.94%25%20increase%20from%202020
6. Delhi: Plans in place to tackle dust pollution in NDMC areas | Delhi news - Times of India. (2022, October 4). The Times of India. https://timesofindia.indiatimes.com/city/delhi/plans-in-place-to-tackle-dust-pollution-in-ndmc-areas/articleshow/94629040.cms
7. Dutta, A. (2023, March 21). 35% drop in vehicles since city banned 'overaged' automobiles: Delhi economic survey. The Hindu. https://www.thehindu.com/news/cities/Delhi/35-drop-in-vehicles-since-city-banned-overaged-automobiles-delhi-economic-survey/article66643142.ece
8. Emissions in Delhi - Road transport. (n.d.). UrbanEmissions.Info - Repository of Air Pollution Information -. https://urbanemissions.info/delhi-india/emissions-delhi-road-transport/
9. Jain, P. (2022, October 6). Delhi govt launches anti-dust campaign to curb dust levels at construction sites. India Today. https://www.indiatoday.in/india/delhi/story/delhi-govt-launches-anti-dust-campaign-to-curb-dust-levels-at-construction-sites-2009183-2022-10-06

10. Mathur, A. (2023, June 25). 42 new sites in Delhi to get electric vehicles charging points | Delhi news - Times of India. The Times of India. https://timesofindia.indiatimes.com/city/delhi/42-new-sites-to-get-ev-charging-points/articleshow/101248649.cms

11. Sekar, A., Binoy, B. V., Alshetty, D., N, M. K., Kuttiparichel Varghese, G., & Varma, R. (2023). Health risk associated with exposure to particulate matter and volatile organic compounds among two-Wheeler delivery personnel in Ghaziabad, India. Atmospheric Pollution Research, 14(7), 101806. https://doi.org/10.1016/j.apr.2023.101806
12. Vehicular pollution in Delhi | Transport department. (n.d.). Transport Department Government of NCT of Delhi. https://transport.delhi.gov.in/transport/vehicular-pollution-delhi
13. What's polluting Delhi's air? (2023, March). Urban Emissions.Info - Repository of Air Pollution Information. https://urbanemissions.info/blog-pieces/whats-polluting-delhis-air/

Data base:

1. Statista: es.statista.com

6. Appendix

A. Expected Impact (20 years)

Data per Year		2023	2024	2025	2030	2034	2038	2039	2040	2044
PM2.5 (µg/m3)	Delhi (Total)	200	196	195	190	179	167	165	162	153
	No Vehicles	120	118	117	114	107	100	99	97	92
	%	60%	60%	60%	60%	60%	60%	60%	60%	60%
	Vehicles	80	79	78	76	71	67	66	65	61
	%	40%	40%	40%	40%	40%	40%	40%	40%	40%
# Vehicles in Delhi	Total Vehicles (Milions)	12.9	13.2	13.5	15.3	16.9	18.6	19.1	19.6	21.6
	2w (Milions)	9.0	9.2	9.5	10.7	11.8	13.0	13.4	13.7	15.1
	EV 2w (#)	1.8	2.0	2.2	3.2	6.1	8.9	9.7	10.4	13.2
	Var. # EV	0.6	0.2	0.2	0.2	0.7	0.7	0.7	0.7	0.7
	% total Vehicle	14%	15%	16%	21%	36%	48%	51%	53%	61%
	No EV 2w (#)	7.2	7.2	7.3	7.5	5.7	4.1	3.7	3.3	1.9
	% total Vehicle	56%	55%	54%	49%	34%	22%	19%	17%	9%
PM2.5 No EV 2w		45	43	42	37	24	15	13	11	5
PM2.5 (µg/m3) per 2w out	1	6E-06	6E-06	6E-06	5E-06	4E-06	4E-06	3E-06	3E-06	3E-06
	100,000	1	1	1	0	0	0	0	0	0
	150,000	1	1	1	1	1	1	1	0	0
	250,000	2	1	1	1	1	1	1	1	1
	500,000	3	3	3	2	2	2	2	2	1
	1,000,000	6	6	6	5	4	4	3	3	3
	5,000,000	31	30	29	25	21	18	17	17	14
	7,000,000	44	42	40	35	30	25	24	23	20
	1	-	-	-	-	-	-	-	-	
	100,000	1%	1%	1%	1%	2%	2%	3%	3%	5%
	150,000	2%	2%	2%	2%	3%	4%	4%	5%	8%
	250,000	3%	3%	3%	3%	4%	6%	7%	8%	13%
	500,000	7%	7%	7%	7%	9%	12%	13%	15%	27%
	1,000,000	14%	14%	14%	13%	17%	24%	27%	30%	53%
	5,000,000	69%	69%	69%	67%	87%	100%	100%	100%	100%
	7,000,000	97%	97%	96%	93%	100%	100%	100%	100%	100%

B. Miro board Link

https://miro.com/welcomeonboard/WkRPOU5vQnZET3ZUdUZOcER3SjRKbjBYbzBEZnlnSUdaODBIR2lubTFBT25raXlmaG5wVlBQTGlueWJwRm9HbnwzNDU4NzY0NTQ0MzU3Njk1NDk1fDI=?share_link_id=513208754845.

C. Interview recording and transcripts

https://urledu.sharepoint.com/:f:/s/CBI2023-CBI2023Team5/EstApD0xAfxAoNV-cccUKrABmiMydbdjKcHRswy6Kr4FBg?e=7Y4xjV