Voices of Olympia Canada School Competition Edition 2021-2022

Breathe More Green :

Creating an App for Easy Data Collection of Empty Plots for Tree Planting to Combat Climate Change and Empower Women

Sarah Bergevin, Junghyun (Hannah) Kwon, Hyunwoo Park and Victoria Mo, The Study School

© Sarah Bergevin, Junghyun (Hannah) Kwon, Hyunwoo Park and Victoria Mo, The Study, 2022

Lead Instructor : Marie-France Senécal

Date of submission: April 19, 2022

Voices of Olympia Canada

The Study

TABLE OF CONTENTS

Acknowledgements

We would like to extend our gratitude to Professor Sofiane Baba, Ms. Béatrice Bousser, Ms. Emily Coffey, Mr. Laurent Desbois, Ms. Mingyi Ding, Ms. Amalia Liogas, our mentor Mada Liyous, Mr. Bruno Paquet, Ms. Monika Potocki, Mr. Simon Racine, Ms. Rosa Molier, Ms. Céline Juppeau, Ms. Chloe Barnabe, Ms. Marie-France Senécal, Mr. Ben Douek, Mr. Alex Somma, Ms. Julianne Thomas-Drolet and Mr. Michael Petryk. This project would not have been possible without their contributions, and we are deeply thankful.

Introduction

Climate change is the greatest challenge of our generation. Aside from the devastating impacts it wreaks on our climate, it threatens to undo years of progress in advancing gender equality. Climate Change exacerbates inequalities already present in society, often inflicting worse consequences on those most marginalized in their communities, who are disproportionately women and girls. A major issue arising from climate change is the intensification of air pollution, which despite appearances, is an endemic problem in Canada. Air pollution and climate change are inherently linked: air pollutants, such as black carbon, contribute to climate change by warming the earth, and climate change further aggravates air pollution, for example by lengthening wildfire seasons and increasing smog levels, in a vicious cycle. Therefore, this essay aims to demonstrate how air pollution and climate change are closely interconnected and how air pollution leads to severe health issues and further exacerbates the gender inequalities in our society, thereby impacting women disproportionately, before elaborating on a potential solution. This solution aims to mitigate climate change and air pollution simultaneously, alleviating climate inequalities experienced by women in Canada.

Research Question :

This year, Olympes de la Parole challenged us to uncover how climate change disproportionately impacts women and girls in Canada and to propose solutions to mitigate one of these impacts. In keeping with the spirit of this theme, our research question is as follows :
How are climate change and air pollution connected and, furthermore, how does air pollution impact women in Canada?

Method

Our qualitative research consists of an interview with Prof. Sofiane Baba, a professor at the University of Sherbrooke with a research focus in sustainability, Emily Coffey, an eco-consultant at Les Amis de la Montagne, Monika Potocki, an environmental consultant working at Bell, Julianne Thomas-Drolet, an advisor at Développement Canada, Chloe Barnabe, the director of corporate sustainability and environmental policy at Canada Post - all of whom illustrated the necessity of combating air pollution. We also talked with Emily Coffey, member of Les Amis de la Montagne, Simon Racine, the deputy director of SOVERDI, Bruno Paquet, executive on mandate responsible for the urban forestry in Outremont, Michael Petryk, the director of operations at Tree Canada, Rosa Molier, head of community outreach at Lufa farms, all of whom demonstrated an interest in collaborating with our project. This will be further elaborated.

Problem

Air Pollution and Climate Change

Air pollution and climate change are closely interconnected, creating a perpetual cycle where one intensifies the other. The atmospheric warming associated with climate change worsens air quality, and the emissions of pollutants into the atmosphere further contribute to climate change.

The most prevalent type of air pollutant is carbon dioxide, a greenhouse gas that absorbs that heat from the sun and releases it gradually over time. For the past million years or so, carbon dioxide level never exceeded 300 ppm until around 1950 it went over 300 ppm and got to current concentration, 418ppm. As its concentration experienced a drastic increase, carbon dioxide is

responsible for about two-thirds of the total energy imbalance that is causing Earth's temperature to rise and its impacts (Lindsey, 2020).

Earth's temperature has risen by 0.08° C per decade since 1880 as a direct result of climate change, and this rate of warming has only accelerated: since the past 40 years, the rate is now more than twice that at 0.18° C per decade (Potsdam Institute, 2012). This increase in temperature contributes to the production of smog. Smog, or ground-level ozone, engenders adverse health effects in humans. It's formed through chemical reactions between nitrogen oxides (NOx) and volatile organic compounds (VOC) like isoprene in the presence of heat and sunlight, therefore, it's more widespread on sunny days (United States Environmental Protection Agency, 2022). According to Chloe Barnabe, the director of corporate sustainability and environmental policy at Canada Post, "In largest cities…there's a lot of ground-level smog that's created from the combustion by ICE (Internal Combustion Engine) vehicles. When those vehicles idle in traffic, it creates low-level ozone, which is a greenhouse gas that gets trapped in the atmosphere and that contributes to climate change and global warming." Studying the concentration of ozone also includes the analysis of two other data sets: the emission of isoprene, which increases ozone levels, and the intake of ozone via plants, which decreases ozone levels (European Commission, 2010).

Climate change, by warming the Earth, is predicted to nearly double isoprene emissions. Additionally, a warmer, drier climate reduces the intake of ozone by plants, who account for 60% of all ozone level reductions. Furthermore, studies have found that climate change alone will increase summertime surface ozone in polluted regions by 1–10 particles per billion (Jacob & Winner, 2009).

The intensification of the wildfire season is quickly becoming a defining hallmark of climate change in Canada. Aggravated by growing carbon emissions in the atmosphere and increasing temperature, wildfires significantly worsen air quality. The number of fire spread days could experience a 2-to-3-fold increase under a high CO_2 forcing scenario in eastern Canada, and a greater than 50% increase in western Canada, where the fire potential is already high (Wang et al., 2017). Average particulate matter levels have increased as much as 3 times in some areas in North America during wildfire seasons, greatly impacting human health by causing respiratory issues, such as chronic obstructive pulmonary disease (COPD), and asthma (United States Environmental Protection Agency, 2018). Wildfires also make up 5-10% of global carbon dioxide emissions each year, its increased frequency leading to higher carbon dioxide levels, which in turn escalates wildfires.

Short-lived climate pollutants often coexist as air pollutants and are major contributors to global warming. According to the Climate and Clean Air Coalition, "Short-lived climate pollutants are powerful climate forcers that remain in the atmosphere for a much shorter period of time than carbon dioxide (CO_2), yet their potential to warm the atmosphere can be many times greater." Short-lived climate pollutants, including black carbon, methane, tropospheric ozone, and hydrofluorocarbons, are the second most important contributor to climate change after CO_2 emissions. They are estimated to be responsible for 45% of current global warming (Climate and Clean Air Coalition, 2022).

Black carbon, a major component of particulate matter, is responsible for approximately 15% of temperature increases associated with climate change (United States Environmental Protection Agency, 2021). In a published report titled *Integrated Assessment of Black Carbon and Tropospheric Ozone*, the United Nations Environment Programme (UNEP) stated that "full

implementation of the identified measures [reducing black carbon and tropospheric ozone] would reduce future global warming by 0.5˚C" (UNEP, 2011).

Therefore, due to the interrelation of global warming and air pollution, in order to tackle the problem of climate change, the issue of air pollution must simultaneously be addressed. It can also be concluded that whatever is done to abate air pollution would mitigate climate change as well.

Air Pollution on a Global and National Scale

According to the WHO, air pollution is now the world's fourth-largest risk factor for early death. On a global scale, air pollution is collectively responsible for 7 million premature deaths each year: 4.2 million associated with outdoor air pollution and 3.8 million deaths associated with indoor air pollution (Global Burden of Disease Study, 2019). The WHO also states that 99% of the world's population currently lives in areas where the air quality guidelines levels are not being met. Air pollution rises to the standards of a global affliction, affecting nearly every person and nation alike.

Air pollution often manifests as or increases the risk factor for chronic diseases, otherwise known as non-communicable diseases, which account for 70% of air pollution deaths (Schraufnagel et al., 2019). Air pollution was estimated to be responsible in 2015 for 19% of all cardiovascular deaths worldwide, 24% of ischaemic heart disease deaths, 21% of stroke deaths, and 23% of lung cancer deaths (Schraufnagel et al., 2019).

Now, consider air pollution on a national scale. Health Canada clarifies that the "above-background air pollution, including air pollution from human sources in North America, contributes to 15,300 premature deaths per year in Canada" (Health Canada, 2021). When

considering nonfatal health outcomes, air pollution is estimated to cause 2.7 million asthma symptom days and 35 million respiratory symptom days yearly. Taken together, the total economic cost of the health impacts credited to air pollution yearly is $120 billion. (Health Canada, 2021). Furthermore, according to the Canadian Urban Environmental Health Research Consortium, approximately 86% of Canadians live in areas where the particulate matter levels surpass the updated WHO guidelines (CANUE, 2021).

The research conducted by Health Canada indicates that "While Canadians benefit from relatively good air quality, air pollution continues to have impacts on population health." (Health Canada, 2021). This estimation of air pollution-attributable fatal and nonfatal outcomes is expected to change over time as new scientific information may support or confirm the inclusion of additional causes of death associated with air pollution.

Types of Air Pollution and Their Associated Health Impacts

According to the WHO global air quality guidelines updated in 2020, air pollution can be characterized as one of four main types : particulate matter (PM), ozone (O_3), nitrogen dioxide (NO_2), and sulfur dioxide (SO_2). Particulate matter is a common indicator for air pollution and it generally consists of a complex mixture of solid and liquid particles suspended in the air such as sulfate, nitrates, ammonia, black carbon, mineral dust, and sodium chloride. Particulate matter equal to or smaller than 10 and 2.5 microns (μm) in diameter, PM_{10} and $PM_{2.5}$ respectively, are of particular public health relevance (United States Environmental Protection Agency, 2021) and the focus of this essay. Both $PM_{2.5}$ and PM_{10} are capable of penetrating deep into the lungs while $PM_{2.5}$ can even enter the bloodstream and pose the greatest risk to health. They primarily result

in cardiovascular and respiratory impacts such as bronchitis, lung disease, pneumonia, asthma and more.

Air pollution is often referred to as a ‘silent killer’, largely due to the fact that exposure to fine particles of pollutants exacerbates the risk for conditions that are already leading causes of death. $PM_{2.5}$ and cardiovascular disease are closely interconnected (Lee et al., 2014). This study demonstrated a 69% increase in cardiovascular deaths after being exposed to particulate air pollution. A study of 500,000 teens and adults with a 16-year follow-up revealed that risk of ischemic heart disease, heart failure, arrhythmias, and cardiac arrest increased as the level of $PM_{2.5}$ increased (Lee et al., 2014). Air pollution practically doubled the risk for obesity, hypertension, chronic pulmonary disease, and cardiovascular disease in older people (Centers for Disease Control and Prevention, 2021).

Exposures to ground-level ozone, derived from industrial facilities, vehicle exhaust, power plants, refineries and chemical plants, over short periods can lead to irritation of the eyes and throat, chest pains, congestion, inflammation of lungs and airways and aggravated respiratory symptoms (United States Environmental Protection Agency, 2021). The most vulnerable to these pollutants include children, older adults, people who are active outdoors and those with asthma (Mackenzie & Turrentine, 2021). Children are often more susceptible to these pollutants as their lungs are still in development, they are more likely to be outside, where they experience increased exposure, and they are more susceptible to developing asthma, it being the most common chronic disease of childhood (United States Environmental Agency, 2021).

Furthermore, if the ambient ozone level is 3 parts per billion higher compared to another location over 10 years, it is associated with an increase in emphysema roughly the equivalent of smoking a pack of cigarettes a day for 29 years (Wang et al., 2019).

The World Health Organization estimates that in 2016, some 58% of outdoor air pollution-related premature deaths were due to ischaemic heart disease and stroke, while 18% of deaths were due to chronic obstructive pulmonary disease and acute lower respiratory infections respectively, and 6% of deaths were due to lung cancer. Air pollution presents a critical danger to public health at large, and its primary causes, as well as the diseases it induces, must be responded to forcefully.

Air Pollution and Inequalities (Gender-Based)

Air pollution, in line with most climate change-related phenomena, often exacerbates inequalities that exist in our society today. It disproportionately impacts women through several mechanisms, an outcome which was confirmed by a peer-reviewed study published in the Global Heart Journal. It stated that "The exposure-response relationships revealed that women were usually more vulnerable to ambient air pollution than men, and the exposure-response curves differed significantly between genders" (Liu G, Sun B, Yu L, Chen J, Han B, Li Y, et al.., 2020). This could possibly be attributed to several outlined factors.

To begin, anatomical and physiological differences between sexes may result in differences in internal exposure of air pollutants. Men have a larger average lean body mass, ranking at 24.5 kg/m^2 for men and 21.5 kg/m^2 for women (Flegal, 2006), and a higher water content, ranking at 60% for men and 55% for women (Ritz et al., 2008). This results in a higher distribution volume for water-soluble substances, and thus a higher dilution for men compared to women. Men process and dilute air pollutants to a greater degree than that of women's bodies, meaning more toxic particles accumulate in women (Butter, 2006). Women are capable of metabolizing air pollutants more quickly than men, leading to a higher level of toxicity within

their bodies (Fuentes, 2017). Another biological difference between men and women is the difference in fat mass. Women have larger relative fat mass, which allows for a larger distribution volume for fat-soluble substances, such as environmental chemicals, increasing their internal exposure to air pollutants (Butter, 2006). Because of this difference, toxic chemicals and pollutants proliferate throughout the body more quickly in women. These differences could explain the following results found indicating discrepancies in mortality and hospitalizations associated with women and particulate matter levels.

Spikes in ambient $PM_{2.5}$ levels were also found to significantly increase hospitalizations in women. A 10 $\mu g/m^3$ increase in daily $PM_{2.5}$ levels was correlated with a 1.13% increased risk of heart rhythm disturbance admissions for women, compared to 0.03% for men (Bell et al. 2015). A 2017 study analyzing the relationship between non-accidental deaths in Shanghai, weather conditions and particulate matter levels, found that for every 10 $\mu g/m^3$ increase in $PM_{2.5}$ concentration, there was a 0.35% increase in mortality and that "After controlling for age, smoking rate and occupations, the mortality risk was about 48% higher in women than in men" (Xin et al,. 2017). Research linking air pollution levels and breast cancer has also been conducted. Premenopausal women exposed to high levels of air pollution were found to have a 30% increased risk for breast cancer (Paul et al,. 2018).

Moreover, women are more vulnerable to air pollution because of adverse reproductive and neonatal impacts. There are many autoimmune disorders that are associated with air pollution, autoimmune diseases tend to be far more prevalent in women, making them more vulnerable to air pollution compared to men (Butter, 2006). Particularly in the case of pregnancy, the female immune response is lowered, and this increases susceptibility to autoimmune disorders - including those caused by environmental pollution.

Furthermore, a study conducted in Canada evaluating the impacts of air pollution on birth outcomes showed outdoor $PM_{2.5}$ exposure had an impact on birth outcomes (Brauer, 2008), contributing to approximately 2.7 million or 18% of all preterm births globally (Davis, 2017). In Canada, The Ontario London Health Sciences Center discovered that women were 30% more likely to have a low birth weight baby and were 20% more likely to deliver preterm if they experienced a high exposure to sulfur dioxide, a major type of air pollutant (Seabrook, 2019). Particulate matter, once in the bloodstream, can begin to behave like tobacco smoke, which is harmful for fetal development, because it triggers inflammation in the blood and decreases the transfer of oxygen and nutrients across the placenta, impacting the growth of the fetus (Doucleff, 2020). Women exposed to chemical pollutants in the air can pass chemical toxins to their children prenatally and through breastfeeding, thus making them disproportionately affected by this problem (Forsey & Bessenova, 2020). Fetal and newborn development is critically harmed by air pollution at a time where such development is essential. This increases the likelihood for long-term conditions that can persist for years. The care and attention demanded for such conditions often fall on women, largely the primary caregivers throughout the world. Air pollution, by impacting the elderly, newborns and children, further deprive women of their agency and burden them with caretaking.

Furthermore, social inequalities between men and women constitute a major reason as to why women are disproportionately affected by air pollution. Air pollution spikes in traffic and industrial zones, which are areas in which families of lower socio-economic background tend to live. A national study conducted in the United States stated that single-mother families are overrepresented in large urban areas or in highly polluted urban areas (Downey & Hawkins, 2009). Children in single-parent families are more than four times more likely to live in poverty

than those in married-parent families (Brown et al., 2007) and around half of lone-parent families in British Columbia live in poverty, with 85% of them being female-led (Stack et Meredith, 2021). For single mothers living in polluted regions and are in difficult financial situations, the effects of air pollution become especially disastrous to them and their entire family. Single mothers make up an ever-increasing share of families: There are 1.83 million single parents living in Canada where 81% are headed by women. The median income of a single-parent home is only 47% of that of married-couple families, where 88% of all single-parent homes are headed by woman (Ahuja et al,.1993), making the financial burden on a single-mother home greater than that of a two-parent home (Shudy et al., 2006).

In areas of industrial southwestern Ontario, a study found pregnant women living there were 3.4 times more likely to have a low-birth weight baby and two times more likely to have a preterm birth. At the Ambassador Bridge in Windsor, Ontario, where over 20,000 diesel trucks cross every day, women were diagnosed with breast cancer 16 times more than the general population (McArthur, 2021).

Moreover, if any of their elderly relatives or children become ill due to a disease caused by air pollution, women become disproportionately burdened with their care. 20 % of all new cases of childhood asthma in Canada are now being attributed to traffic-related air pollution (Pattanun Achakulwisut, PhD, Prof Michael Brauer, ScD, Perry Hystad, PhD, Susan C Anenberg, PhD)

Parents of children with an illness have to struggle with the emotional toll of coping with the disease, treatment options, and may encounter financial difficulties. However, the impacts of these issues are even more apparent when considering single parent families (Brown et al., 2007). If the family of single mothers were to become sick, the time needed to care for them is

excessive and limits their opportunities. A study conducted in Santiago, Chile found that for each child in the home, women saw their weekly hours worked reduced, on average, by 1.6 hours per week when PM_{10} increased by 100 $\mu g/m^3$ (Montt, 2018). This burden of care prevents many single mothers from having a break from the routine and the responsibility of caring for the child, often leading to physical exhaustion (Coffey, 2006). Single mothers are already overrepresented among the population living in relative poverty - over 30% live in poverty (Canadian Women's Foundation, 2022). Any issue that further deprives them of their agency is a crisis, and must be responded to effectively by society and policy.

Proposed Solution

Conventional Approaches to Air Pollution

As the world attempts to respond to the public health crisis caused by air pollution, a low-cost, efficient solution is gaining relevance : urban tree planting. Trees substantially improve air quality through several mechanisms, including the removal of air pollutants and the reducing of the temperature (Nowak, 2002).

Trees are particularly effective at filtering air pollution, acting as the "liver" of our environment as well as our "lungs". This filtration happens due to two simultaneous phenomena: dispersion and deposition. Dispersion occurs when clouds of particulate matter scatter upon colliding with trees and other vegetation. Deposition ensues when particulate matter is trapped by the leaves, bark and needles of trees, before being washed into drains by rain. Tiny hairs on plant leaves have proven to play a major role in trapping particulate matter, especially silver birch (79% removal), yew (71%), and elder (70.5%). Furthermore, conifers like pines and cypresses consistently perform as the top filters for air pollutants. This is thanks to its dense

canopy of needle-like leaves and as an evergreen, its capacity to act as year-round filters (Barwise et al., 2020). In one year, a mature tree will absorb around 22 kg of CO_2 from the air, and 1.3 million trees are estimated to remove more than 2500 tonnes of air pollutants, especially particulate matter, (European Environment Agency, 2012).

Moreover, trees reduce the temperature of an area via two mechanisms : shading and transpiration (Tree Canada, 2020). They provide shade by preventing sun-rays from reaching the ground and buildings. This prevents the absorption, and subsequent release, of energy by the surrounding buildings and roads, reducing ozone production. Some cities experience air temperatures that are up to 12°C warmer due to the slow release of heat from sidewalks and roads (Trees for Energy Conservation, 2022). Furthermore, trees release some water back into the air via transpiration, where the surrounding air is cooled as the liquid water evaporates into water vapor and it accounts for about 10% of the moisture in the Earth's atmosphere (Government of Canada, 2010).

Reducing temperature, as elaborated before, can lessen the impact of climate change and decrease the amount of air pollutants in the atmosphere such as ozone and particulate matter.

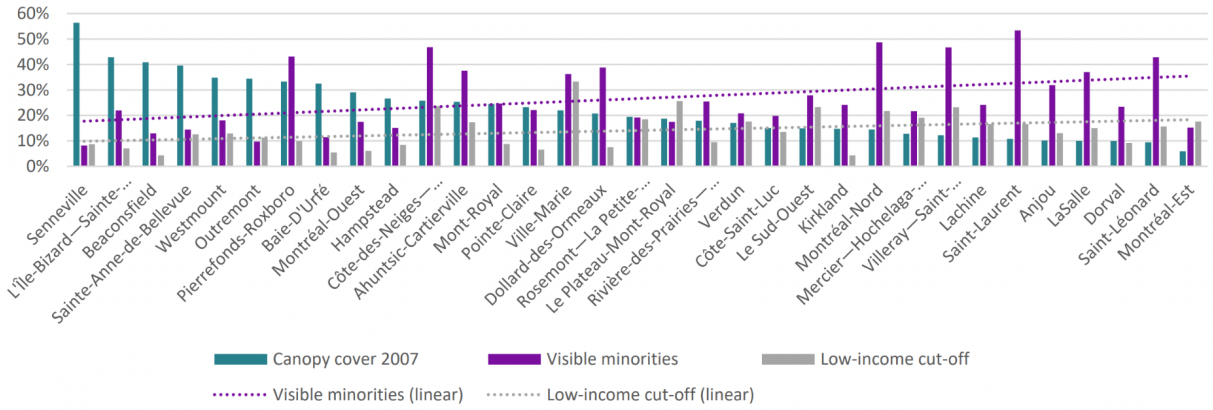
Current State of Affairs

In 2020, the city of Montreal revealed an ambitious climate plan detailing 46 concrete measures it had to undertake in order to meet its carbon targets in the next ten years. One of those measures promised the planting and maintenance of 500,000 trees (Ville de Montréal, 2020), in order to make Montreal 25% canopy cover, as in the proportion of the forest floor covered by tree crowns (Eurostat, 2019).

Montreal has outsourced much of the tree-planting to non-profits, like SOVERDI, a charity based in Montreal, who has been entrusted with the planting of over 200,000 trees. (Hachwa, 2022) "To reach private landowners, the City and SOVERDI, a local greening NGO, created the Alliance Forêt Urbaine, a coalition of NGOs dedicated to increase Montreal's canopy cover on private land. The city of Montreal provided more than $4.2M to SOVERDI. Together, these NGOs planted close to 55 000 trees on Montreal's boroughs and cities' private owned land since 2015." (Canadian Institute for Climate Choices, 2020)

As the tree-planting initiatives have been underway, one aspect of the city's project poses a significant challenge : the question of 'tree equity'. Simply put, 'tree equity' is when a community has enough trees to ensure the health, climate and economic benefits that they provide. (Travers, 2021) Unfortunately, the canopy cover for a neighborhood is often closely associated with its socioeconomic status. Examples of this disparity can be found throughout the island of Montreal. The borough of Westmount, with a median household income of $270,000, enjoys a 39% canopy cover. Meanwhile, nearby Côte-des-Neiges, possessing a median income of $34,000, has only 19% (Shingler, Rocha, 2021). Therefore, single mothers, a demographic with over 30% of its members living in poverty, are more severely affected by this inequality.

Figure 1: Montreal's visible minority and low income communities have less trees



(Canadian Institute of Climate Choices, 2021)

In order to combat this disparity, Montreal aims to plant more trees in vulnerable neighborhoods. SOVERDI replicates this focus, concentrating the majority of their efforts in the East End. To accomplish this goal, comprehensive data on available plots to plant trees is vital. Private and institutional land comprise 66% of Montreal's total land area (Hachwa, 2022). Data for these spaces are scarce. City-wide surveys are therefore conducted, but they are not without difficulties. "Unfortunately, many municipalities do not have a clear view of the extent of their canopy and the trees that are within it. Aerial and satellite photography cannot provide the same detail as ground level measurements." (Canadian Institute for Climate Choices, 2021). Due to the time and expense it takes to undertake them, they represent a significant hindrance to tree-planting initiatives.

Comprehensive Analysis of Our Project

BreatheGreen is a prototype for an app our team has created. The map and pinning features - its essential components - have been coded via Thunkable and are functional as of the presentation of this project. With it, members of the public can go around the city and pin on the app empty plots in their communities where trees could be planted. It is a quick and low-cost way for the government and tree-planting charities to utilize data in service of their activities. The users will be rewarded points according to their participation and aiming to advance 'tree equity', it rewards more points for data collection in areas with lower canopy cover percentages as well as areas with higher levels of air pollution.

In order to heighten awareness about air pollution, it offers information on current air quality in detected regions and how to reduce your potential exposure to air pollutants. Furthermore, after data review by the charities, if a tree actually gets planted at the spot that a

user marked down, the user will be rewarded with extra points, serving as an incentive to be cautious before pinning places.

In an attempt to further engage our audience, we have gamefied our app. It includes several features, including a personalized tree avatar. The more a user participates on the app, the more points the user accrues. With their points, the user can grow and customize their personal tree avatar by unlocking different tree colors, leaves, fruits and many more.

Using Amazon's Rekognition Image, an image classification model, as a basis; our app will be able to recognize the difference between barren land and land with soil. In the beginning, it would simply serve as a suggestion for users when they are taking a picture to upload. Once the photos get sent to the database and charities decide whether or not trees will actually be planted, there will be enough data for good or bad planting locations for AI to learn. Then the AI will be able to analyze the characteristics of a good tree planting place by learning of images fed by the users that got approved. Then, it can become an inference engine that actually suggests people good places to go to find a good tree-planting place.

The data collected by BreatheGreen would then be shared with local charities as well as municipal and city-wide governments in order to facilitate tree-planting initiatives across the community.

Influences

We credit the following organizations as being major influences on our proposed solution: Ecovator, the Green Belt Movement, and iCivics. Ecovator is a start-up based in Flanders that proposes solutions that improve green infrastructure, thereby helping the local environment. One of their solutions, Map A Tree, details a plan where citizens could suggest

places in their neighborhoods where trees could be planted; it was then shared to Solar Impulse Foundations, an organization that promotes eco-friendly solutions on their platform so that other communities can implement them. The Green Belt Movement, founded by Nobel Peace Prize winner Wangari Maathai, is a women-led organization dedicated to the conservation of the environment. It was established in Kenya in 1977 and has planted over 50 million trees, demonstrating that fusing grassroots efforts from marginalized communities with a sustained focus on environmentalism can produce incredible results. iCivics is an American non-profit founded by former Supreme Court Justice Sandra Day O'Connor; it aims to broaden civics education by providing free, informative games to students.

Future Implementation

We hope to start with implementing this application in the city of Montreal. In order to accomplish this, we've reached out to multiple professionals and several tree-planting charities in Montreal, including Amis de la Montagne, a non-profit dealing specifically with the borough of Mont-Royal, and SOVERDI. Emily Coffey, working at Les Amis de la Montagne, remarked that "[BreatheGreen] may be something my organization might be interested in collaborating with to champion areas needing green zones." Moreover, we contacted SOVERDI, the biggest tree-planting charity in Montreal and Simon Racine, the deputy director of SOVERDI, speaking on behalf of the organization, expressed great interest in this application. He added that "[they] already have an application that geolocates planted trees, so we might be able to connect the two, and that would be really great."

We prepared the grounds for municipal collaboration by talking to Bruno Paquet, the executive on mandate responsible for the urban forestry in Outremont, who, speaking on behalf

of the Mayor, expressed his support for our project and a desire to work with us. “Currently, the canopy cover in Outremont is 34%, and it is expected to increase to 40% by 2040, which implies the planting of several hundred trees, therefore I think it would be interesting to collaborate at that level.”

Furthermore, Lufa Farms, a local urban agriculture company who aims for a healthier, more sustainable local food system, has agreed to sponsor this app by providing gift coupons to users who actively participate in this app, adding to the incentive.

Given that our aim is also to increase community stewardship of the environment, Olympe de La Parole would be vital in connecting us with youth charities and schools whose members could contribute data to the platform.

In collaboration with these corporations and charities, BreatheGreen strives to promote local stewardship of the environment, amplify awareness about air pollution, and alleviate the impacts of such pollution in communities - particularly for women and children - by helping in missions to plant more trees. The city of Montreal is meant to serve as a beta-test for BreatheGreen. Given that the demo version of our app currently has a working interface and map function, we expect the development of BreatheGreen to progress quickly and a finalized version of the app to be achieved within a year. In demonstrating that the app can have a positive impact on tree-planting initiatives, we then hope to share our app with other communities across canada to maximize its outreach. We hope to reduce the disproportionate consequences of air pollution on women and children. We are currently in contact with Tree Canada, the largest national tree planting organization to achieve this in the future.

Conclusion

Our research testifies to the prevalence of air pollution and its ensuing impacts worldwide. It establishes that addressing air pollution is critical in discussions encompassing climate change; we must actively combat it along with the inequalities it provokes. Solutions to air pollution must be advanced on the international, national and regional level.

BreatheGreen, our proposed solution, is designed to combat air pollution through two key mechanisms : firstly, by accelerating and maximizing tree-planting in vulnerable communities by collecting data about empty green plots, and, through public engagement, raising awareness about the dilemma air pollution poses to us. Ideally, to begin, this project would be implemented in the city of Montreal, and then would be shared beyond its borders.

Oftentimes, we cannot see air pollution. Particulate matter is invisible to the human eye - and that has allowed it to thrive. Our collective ignorance of air pollution has contributed to it becoming a global affliction, impacting women and children the most. Ultimately, it is our collective responsibility to ensure that air pollution is a silent killer no more.

Bibliography

Air Quality. (2018, December). In United States Environmental Protection Agency. Retrieved from https://www.epa.gov/salish-sea/air-quality

Ambient (outdoor) air pollution. (2021, September 22). In World Health Organization. Retrieved from https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

Azuma K, Kagi N, Yanagi U, Osawa H. Effects of low-level inhalation exposure to carbon dioxide in indoor environments: A short review on human health and psychomotor performance. Environ Int. 2018 Dec;121(Pt 1):51-56. doi: 10.1016/j.envint.2018.08.059. Epub 2018 Aug 30. PMID: 30172928.

Bell, M. L., Son, J.-Y., Peng, R. D., Wang, Y., & Dominici, F. (2015, July). *Ambient PM2.5 and risk of hospital admissions: DO risks differ for men and women?* Epidemiology (Cambridge, Mass.). Retrieved April 16, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4452416/

Brown, R. T., Wiener, L., Kupst, M. J., Brennan, T., Behrman, R., Compas, B. E., David Elkin, T., Fairclough, D. L., Friebert, S., Katz, E., Kazak, A. E., Madan-Swain, A., Mansfield, N., Mullins, L. L., Noll, R., Patenaude, A. F., Phipps, S., Sahler, O. J., Sourkes, B., & Zeltzer, L. (2008). Single parents of children with chronic illness: an understudied phenomenon. Journal of pediatric psychology, 33(4), 408–421. https://doi.org/10.1093/jpepsy/jsm079

Butter, M. E. (2006, November 1). Are Women More Vulnerable to Environmental Pollution?. In Semantic Scholar. Retrieved from https://www.semanticscholar.org/paper/Are-Women-More-Vulnerable-to-Environmental-Butter/d2bcbcff16d32e6b7549633de9abaeb50897e3d3

Chapter 21. Air Quality, Climate Change and Urban Forests. (n.d.). In Tree Canada. Retrieved from https://treecanada.ca/resources/canadian-urban-forest-compendium/21-air-quality-climate-change-and-urban-forests/#:~:text=Trees%20reduce%20temperatures%20and%20mitigate,their%20leaves%2C%20needles%20a

Coffey, J. S. (2006, January). Parenting a child with chronic illness: A metasynthesis. In Research Gate. Retrieved from https://www.researchgate.net/publication/7205961_Parenting_a_child_with_chronic_illness_A_metasynthesis

Davis, Marion. “Study Links Outdoor Air Pollution with 2.7 Million Preterm Births per Year.” *SEI*, 13 Mar. 2020, https://www.sei.org/featured/air-pollution-preterm-births/.

Doucleff, M. (202, October 27). New Study Points To Invisible Killer Of Infants. In NPR. Retrieved from https://www.npr.org/sections/goatsandsoda/2020/10/27/928201367/study-air-pollution-contributes-to-500-000-newborn-deaths-a-year

Duff, H. (2020, July 28). *How trees keep us and our communities cool*. Tree Canada. Retrieved April 16, 2022, from https://treecanada.ca/blog/how-trees-keep-us-and-our-communities-cool/#:~:text=Trees%20slow%20this%20heat%20absorption,do%20something%20similar%20called%20transpiration.

Environmental Health Perspectives. Retrieved from https://ehp.niehs.nih.gov/doi/10.1289/ehp.10952

European Commission. (2010, November). Air Pollution and Climate Change. In *Science for Environment Policy*. Retrieved from https://ec.europa.eu/environment/integration/research/newsalert/pdf/24si_en.pdf

Fang, X., Fang, B., Wang, C., Xia, T., Bottai, M., Fang, F., & Cao, Y. (2017, November 9). *Relationship between fine particulate matter, weather condition and daily non-accidental mortality in Shanghai, China: A bayesian approach*. PLOS ONE. Retrieved April 16, 2022, from https://journals.plos.org/plosone/article?id=10.1371%2Fjournal.pone.0187933

Forsey, Amanda, and Ekaterina Bessonova. “5 Ways Reducing Pollution Can Improve Equality for Women.” *SEI*, 22 July 2020, https://www.sei.org/featured/5-ways-reducing-pollution-can-improve-equality-for-women/.

Canada, H. (2020, December 17). *Government of Canada*. Canada.ca. Retrieved April 16, 2022, from https://www.canada.ca/en/health-canada/services/environmental-workplace-health/reports-publications/climate-change-health/climate-change-health-adaptation-bulletin-number-1-november-2009-revised-december-2010-health-canada-2009.html

Ground-level Ozone Basics. (n.d.). In United States Environmental Protection Agency. Retrieved from https://www.epa.gov/ground-level-ozone-pollution/ground-level-ozone-basics#formation

Guarnieri, M., & Balmes, J. R. (2014). Outdoor air pollution and asthma. Lancet (London, England), 383(9928), 1581–1592. https://doi.org/10.1016/S0140-6736(14)60617-6

Haelle, T. (2021, October 21). Indoor Air Pollution Called a Major Culprit in Preterm Births. In Grow by Web MD. Retrieved from https://www.webmd.com/baby/news/20211021/indoor-air-pollution-preterm-births

Health Effects of Ozone Pollution. (n.d.). In United States Environmental Protection Agency. Retrieved from https://www.epa.gov/ground-level-ozone-pollution/health-effects-ozone-pollution

High Blood Pressure Symptoms and Causes. (n.d.). In Centers for Disease Control and Prevention. Retrieved from https://www.cdc.gov/bloodpressure/about.htm#:~:text=High%20blood%20pressure%20can%20damage%20your%20arteries%20by%20making%20them,Chest%20pain%2C%20also%20called%20angina

Hong, C., Zhang, Q., Zhang, Y., Davis, S. J., Tong, D., Zheng, Y., ... He, K. (2019, August 12). Impacts of climate change on future air quality and human health in China. In PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES. Retrieved from https://www.pnas.org/doi/10.1073/pnas.1812881116

How Poverty Affects Lone Mother Families. (2021, August 14). In *mom2mom*. Retrieved from https://www.m2mcharity.ca/blog/2021/7/21/how-poverty-affects-lone-mother-families#:~:text=Approximately%20half%20of%20lone%2Dparent,affected%20by%20household%20food%20insecurity

Impacts of a 4°C global warming. (n.d.). In *GreenFacts-Facts on Health and environment*. Retrieved from https://www.greenfacts.org/en/impacts-global-warming/l-2/index.htm#:~:text=Warming%20of%204%C2%B0C%20will%20likely%20lead%20to%20a,well%20below%201.5%C2%B0C

Jacob, D. J., & Winner, D. A. (2009). *Atmospheric Environment* (Vol. 43, pp. 51-63). N.p.: Elsevier.

Jennings, A. (1999). Translate Glossary: Canopy cover. In Eurostat Statistics Explained. Retrieved from https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:Canopy_cover

Lee, B., Kim, B., & Lee, K. (2014, December 30). Air Pollution Exposure and Cardiovascular Disease. In SpringerLink. Retrieved from https://link.springer.com/article/10.5487/TR.2014.30.2.071

Lindsey, R., & Dahlman, L. (2021, March 15). Climate Change: Global Temperature. In *Climate.gov science& information for a climate-smart nation*. Retrieved from https://www.climate.gov/news-features/understanding-climate/climate-change-global-temperature#:~:text=August%2012%2C%202021-,Highlights,C)%20per%20decade%20since%201981

Liu, G., Sun, B., Yu, L., Chen, J., Han, B., Li, Y., & Chen, J. (2020, July 8). The Gender-Based Differences in Vulnerability to Ambient Air Pollution and Cerebrovascular Disease Mortality: Evidences Based on 26781 Deaths. In *World Health Federation*. Retrieved from https://globalheartjournal.com/articles/10.5334/gh.849/#:~:text=The%20exposure%2Dresponse%20relationships%20revealed,curves%20differed%20significantly%20between%20genders

Schraufnagel, D. E., Balmes, J. R., Cowl, C. T., De Matteis, S., Jung, S.-H., Mortimer, K., Perez-Padilla, R., Rice, M. B., Riojas-Rodriguez, H., Sood, A., Thurston, G. D., To, T., Vanker, A., & Wuebbles, D. J. (2019, November 9). *Air Pollution and noncommunicable diseases: A review by the Forum of International Respiratory Societies' Environmental Committee, part 2: Air Pollution and Organ Systems*. Air Pollution and Noncommunicable Diseases . Retrieved March 29, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6904854/

Mackenzie, J., & Turrentine, J. (2021, June 22). Air Pollution: Everything You Need to Know. In NRDC. Retrieved from https://www.nrdc.org/stories/air-pollution-everything-you-need-know

Malley, C. S., Kuylenstierna, J. C., Vallack, H. W., Henze, D. K., Blencowe, H., & Ashmore, M. R. (2017). *Environment International* (Vol. 101, pp. 173-182). N.p.: Elsevier. Retrieved from https://www.sciencedirect.com/science/article/pii/S0160412016305992#bb0060

McArthur, J. (2021). *Dichotomies, Transcendence and Power: Investigating Women's Narratives of Breast Cancer Risks*. Proquest. Retrieved April 18, 2022, from https://www.proquest.com/openview/564852168f02885b07af13b262c0800d/1?cbl=18750&diss=y&pq-origsite=gscholar

Montreal. (2020, December 10). Montreal unveils an ambitious plan to meet its climate targets. In Projet MTL. Retrieved from https://projetmontreal.org/en/news/montr%C3%A9al-d%C3%A9voile-un-plan-ambitieux-pour-atteindre-ses-cibles-climatiques

Montt, G. Too polluted to work? The gendered correlates of air pollution on hours worked. IZA J Labor Econ 7, 7 (2018). https://doi.org/10.1186/s40172-018-0067-6

Nitrogen Dioxide. (2020, February 12). In American Lung Association. Retrieved from https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/nitrogen-dioxide

Roshan "Bob" D. Ahuja and Kandi M. Stinson (1993) ,"Female-Headed Single Parent Families: an Exploratory Study of Children's Influence in Family Decision Making", in NA - Advances in Consumer Research Volume 20, eds. Leigh McAlister and Michael L. Rothschild, Provo, UT : Association for Consumer Research, Pages: 469-474.

Seabrook, J. A., Smith, A., Clark, A. F., & Gilliland, J. A. (2018, December 31). *Geospatial analyses of adverse birth outcomes in Southwestern Ontario: Examining the impact of environmental factors*. Environmental Research. Retrieved April 18, 2022, from https://www.sciencedirect.com/science/article/abs/pii/S0013935118307035?via%3Dihub

Society, / American Physiological. “Why Does Air Pollution Affect More Women than Men?” *I Spy Physiology Blog*, 5 Dec. 2019, https://ispyphysiology.com/2017/10/26/why-does-air-pollution-affect-more-women-than-men/#:~:text=The%20exact%20reason%20remains%20unclear,men%27s%2C%20resulting%20in%20higher%20toxicity.

Shudy, M., Almeida, M. D., Ly, S., Landon, C., Groft, S., Nicholson, G. E., ... Jenkins, T. L. (2006, December 1). Impact of Pediatric Critical Illness and Injury on Families: A Systematic Literature Review. In American Academy Of Pediatrics. Retrieved from https://www.publications.aap.org/pediatrics/article-abstract/118/Supplement_3/S203/28963/Impact-of-Pediatric-Critical-Illness-and-Injury-on?redirectedFrom=fulltext

The Canadian Institute For Climate Choices. (2021). Growing Forest In A City. Retrieved from https://institute.smartprosperity.ca/sites/default/files/Urban%20Trees%20study_EN.pdf

Travers, J. (2021, September 3). Tree Equity. In Ecologist Informed by Nature. Retrieved from https://theecologist.org/2021/sep/03/tree-equity

Trees help tackle climate change. (2012, January 6). In European Environmental Agency. Retrieved from https://www.eea.europa.eu/articles/forests-health-and-climate-change/key-facts/trees-help-tackle-climate-change

Villeneuve, Paul J.a,b,*; Goldberg, Mark S.c; Crouse, Dan L.d; To, Teresae,f; Weichenthal, Scott A.g; Wall, Clausf; Miller, Anthony B.f Residential exposure to fine particulate matter air pollution and incident breast cancer in a cohort of Canadian women, Environmental

Epidemiology: September 2018 - Volume 2 - Issue 3 - p e021 doi: 10.1097/EE9.0000000000000021

Wang M, Aaron CP, Madrigano J, et al. (2019, August 13). Association Between Long-term Exposure to Ambient Air Pollution and Change in Quantitatively Assessed Emphysema and Lung Function. In JAMA. Retrieved from https://jamanetwork.com/journals/jama/fullarticle/2747669?guestAccessKey=cfba7399-ed6b-4ff3-abcd-260039916cd9&utm_source=For_The_Media&utm_medium=referral&utm_campaign=ftm_links&utm_content=tfl&utm_te

Wang, X., Parisien, M., Taylor, S. W., Candau, J., Stralberg, D., Marshall, G. A., ... Flannigan, M. D. (2017, February 2). Projected changes in daily fire spread across Canada over the next century. In IOP Science. Retrieved from https://iopscience.iop.org/article/10.1088/1748-9326/aa5835/meta

WHAT ARE SHORT-LIVED CLIMATE POLLUTANTS?. (n.d.). In *Climate & Clean Air Coalition To Reduce Short-Lived Climate Pollutants*. Retrieved from https://www.ccacoalition.org/en/science-resources

Why we need to act now. (n.d.). In *Climate & Clean Air Coalition To Reduce Short-Lived Climate Pollutants*. Retrieved from https://www.ccacoalition.org/en/content/why-we-need-act-now

Young, L. (2021, October 7). 86% of Canadians live in areas where air pollution exceeds WHO guidelines: researchers. In Global News. Retrieved from https://globalnews.ca/news/8250831/canada-air-pollution-guidelines/