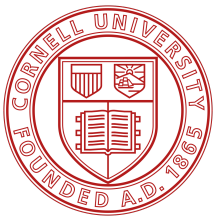
Green Cities

Responding to climate change

Cornell University
2022



Cornell University

This book features individual essays and group essays
written by students in the 3-week “Green Cities” course.

Cornell University Summer College, June 21 – July 8, 2022.

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About
Group essays and individual essays in this book are written by students in Green Cities, a 3-week 3-credit online course offered by Cornell University in summer 2022. The course focused on creating sustainable, resilient, and livable cities, with an emphasis on climate change mitigation. Course participants were pre-college students from several countries, as well as current Cornell University undergraduate students. Whereas about 50 individual and group essays were submitted by the end of the course, this book contains only 4 group essays and 16 individual essays that were formally presented and discussed during the final meeting of this course.

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Disclaimer
All ideas and opinions in this book are students’ own, and may not reflect opinions of the course instructor, teaching assistants, or Cornell University. Students are responsible for correct citations, acknowledgment of others’ work, and proper use of copyrighted materials.

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Part I

General topics related to “green cities” and “climate change”

Public Transportation

Austin Brown, Eric Yan, Morgan Eigel, Tongxun Liu, Xiwen Sun

Public transportation, usually found in dense urban areas, is rising to the forefront of the “green cities” movement, as mass transport is far more energy efficient (and time-efficient, depending on the region) than single-passenger vehicles. Around 27% of carbon emissions from the US can be attributed to the transportation sector, but passenger vehicles such as cars and light-duty trucks account for over half of that (Murphy, 2022). Up to 450 gallons of gas are saved per person per year when public transportation is used consistently and frequently, so city residents have been increasingly encouraged to take advantage of the public transportation options around them (Ohio University, 2021).

Rapid transit, which refers to high-capacity public transportation such as buses and trains, is a frequently utilized method of transportation in urban areas. Traveling by rapid transit has even become regarded as the most environmentally friendly method of transportation in cities, behind walking and cycling, of course. For this reason, countries worldwide are initiating incentives to encourage people to use the rapid transit systems provided in their cities, such as gas car phaseout plans to increase electric vehicle and/or public transportation usage (Joubert, 2022). The common intersections between the electric vehicle and public transportation are electric buses and trains. Electric buses have been widely adopted worldwide because of their significant benefit in reducing 250 million tonnes of carbon emissions by 2030 (UNEP, 2019). In addition, electric buses contribute to the decreasing demand for diesel in 2019 but also accelerate the transition to electric vehicles (GoEV CITY, n.d.). As in New York City, the MTA (Metropolitan Transportation Authority) now deploys 1,300 hybrid gas-electric buses, including 399 that sometimes operate solely on electric power in an “EV mode” and pledges to purchase only electric buses by 2029. New York State budgeted $1.1 billion for buying 500 electric buses in the 2020-2024 capital plan (Kessler, 2022).

Trains are often regarded as an eco-friendly transportation solution because carbon emissions from transport are roughly 80% lower than that from traveling in cars (English, 2021). Technology is being developed to create a new type of train: hydrogen fuel cell trains. Hydrogen reacts chemically with oxygen, so the only emissions are heat and water. Consequently, these vehicles are considered to be zero-emission and non-polluting. In 2016, France’s Alstom introduced the Coradia iLint, the first passenger train powered by hydrogen fuel cells, which began operating in Germany in 2018 (O’Sullivan, 2016). All-electric trains have great potential for growth in the future. Powered by batteries, they would avoid the need for overhead lines or electrified rails. In 2015, the UK tested an electric locomotive for commercial use for the first time in 50 years, a prototype of the IPEMU (Independently Powered Electrical Multiple Unit) projects. It carried passengers as part of a plan for the British rail network to cut its costs by 20% while also curbing harmful emissions into the atmosphere (Nichols, 2015).

In the United States, the majority of people will utilize public transportation if they have to walk less than half a mile to the nearest stop (Federal Highway Administration, 2013). This observation emphasizes the need for people to be close to or have ways to get to the overall transit network. This concept is known as “the first and last mile.” Using the large capacity transportation networks to satisfy the first and last mile problem is unrealistic, so more comprehensive and flexible transportation means are needed. Single-person mode systems have vehicles that accommodate one person at a time, such as electric bikes, electric scooters, and electric car ride-hailing. Cities can shape the

transition to electric-shared mobility by directly cooperating with Transportation Network Companies (TNCs, such as Uber and Lyft) and electric micromobility companies and conducting pilot programs centered around EV adoption, charging, and innovative first/last mile programs. (GoEV CITY, n.d.) This type of single-person system can afford flexibility in terms of scheduling and destination and increasing access to public transportation. Conversely, multi-person mode systems, like buses, carpooling, or ridesharing, have the advantage of being able to move significant quantities of people and potentially reduce spending on equipment. By having an easy way for citizens to get to their main public transit network, they are more likely to utilize public transportation overall and thus contribute to the benefits that can be obtained from it.

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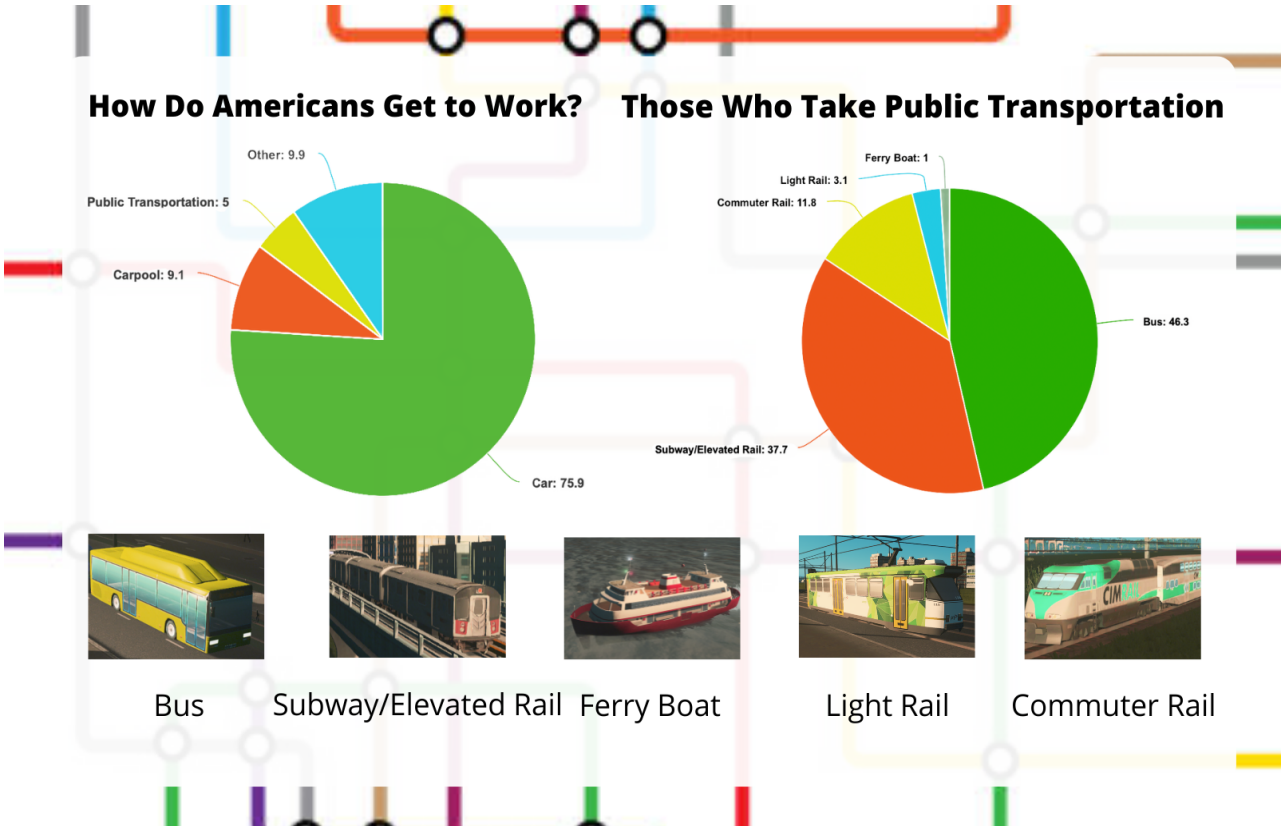

Urban Regeneration: Rebuilding Our Cities

Ryan Kim, Thraa Saleh, Tongyu Dai, Mingle Liang, Roger Fan

As of 2022, 4.2 billion people inhabit cities, a number that can only be expected to increase at an exponential rate. This statistic is of greater concern when accompanied by the alarming rate of urban expansion. With climate change already causing visible alterations to our global biosphere, we find ourselves at a pivotal juncture of the anthropocene where irrevocable ramifications will start pervading our communities without major alterations to cities. Considering such trends, urban regeneration comes to light as a strategy with promising potential. In this essay, we define urban regeneration as applied to modern cities and explore its engagement with the environmental and social dimensions of our urban communities.

Urban regeneration is the redevelopment of certain urban areas that promotes economic growth and brings improvements to society and the environment (Evans, 2004). For example, converting urban factories into environmentally-friendly landscapes serves the community and beautifies the city, contributing to a more habitable and sustainable city. As urbanization increases, recreating the community instead of building new areas is relatively lower cost and can create more accessible green spaces. Based on the benefits that urban regeneration offers to both society and the environment, it is a project worthy of our utmost dedication.

One direct advantage urban regeneration has on the environment relates to the reduction in Greenhouse Gas (GHG) emissions. The effect of reconstructing vegetated areas plays a major role here because plants serve as a sink for CO2 in the atmosphere through photosynthesis. Urban regeneration focuses on industrial areas adjacent to the city center; many projects also involve turning these areas into residential areas. They will enable citizens to commute by walking or riding bicycles instead of driving cars. By combining these two aspects, urban regeneration will reduce up to 14% of GHG emissions (Hou. et al., 2017), which mitigates the Urban Heat Island phenomenon and deters the rate of Global Warming.

Besides its environmental benefits, urban regeneration can also build social cohesion. This is often achieved through the preservation and innovations of cultural heritage. The process promotes connectivity by linking the government to citizens (Cerreta & Rocca, 2021) and, in turn, citizens with each other. For example, Shanghai's government designed the Xintiandi shopping center upon the Shikumen, a traditional Shanghainese building. The preservation of culture connects the past and the present, native and foreign. In this way, urban regeneration bring urban citizens together by preserving cultures that otherwise may be lost.

In the face of modern climate change, urban regeneration can optimize our cities by promoting economic and sustainable growth, operating as GHG sinks while bolstering culture and social cohesion. These innovative infrastructures will be integral to our future cities.

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URBAN REGENERA-TION

GREEN CITIES

What is Urban Regeneration

Definition of urban regeneration

Redevelopment of certain urban areas that promotes economic growth or brings improvements to the society and the environment

Multiple benefits of urban regeneration

1. Lower cost development of green urban spaces and regeneration of the community’ s industrial heritages
2. Greater sink of greenhouse gasses and greater resilience against urban temperature fluctuations
3. Landmarks for the consolidation of communities, connecting modern cities to past cultures and traditions

Successful Urban Regeneration Case

Shanghai Xintiandi Project

The Shanghai Government regenerated Shikumen (antiquated houses) and created a shopping center incorporating green infrastructure that caters to tourists, children, and the community alike.

Green Spaces for Health

Zhen Liu, Eddy Poon, Yufan Xu, Yufei Li

The modern trend of a mostly economic rather than environmental trend of rapid urbanization is one of the great factors contributing to climate change and environmental damage. Fortunately, in recent years, awareness regarding the issue has been growing among the general public, and governments all across the world have begun implementing life-style change policies. As a result, it has become necessary to create a sustainable green city, causing increased construction of green infrastructure to create a healthier living environment. In this essay, we will focus on the engagement with Urban Green Space – community areas filled with vegetation that can ameliorate climate change – with environmental and social benefits of the urban community (Heidt & Neef, 2008).

Green spaces are a solution city designers propose to mitigate the environmental damage brought by urban development. Green spaces are open areas which contain vegetation or other recreational facilities that encourage social interaction and relaxation. Sizes and categories of green spaces range greatly, from the larger space of parks to the relatively small pockets of vegetation such as green belts, which all serve the main purpose of the implementation of green spaces.

Green spaces are beneficial to the urban environment. The expansion of surrounding facilities degraded the air quality within cities. However, green spaces can mitigate the effects of such problems. According to an atmospheric chemistry model, an estimated 60 percent of particulate matter could be reduced by roadside vegetation, showing how greenery could act as a natural air purifier for a city (Diener & Mudu, 2021). Additionally, green spaces mitigate the urban heat island effect. Through evapotranspiration, or the releasing of water in plants that have been absorbed prior, the heat will be carried away by the water (Szkordilisz, 2014). Additionally, the quantity of solar radiation could also be reduced with the shading of trees (Szkordilisz, 2014). The combined effects greatly reduce the heat in an urban environment, making it more desirable to live in.

Green spaces also make indirect positive changes to health in different fields. The widespread positive connotations that green spaces possess could be seen in how green spaces could raise land values. According to studies, if there is a green space within 1 kilometer of an apartment, the value of the flat will increase by 4% (Crompton, 2001; Bazyl, 2009). An overall increase in land value entails the appreciation that the whole community has for green spaces, showing the positive benefits green spaces could bring for the mental health of the public. Green spaces also strengthen relationships between people, which improves their mental state. Working and growing-up in a place with green spaces has been proven to increase daily interactions between adults and children (Taylor et al., 1998). From the aforementioned examples, one could see how green spaces lead to the betterment of human health.

All in all, we want to mitigate climate change and environmental damage. For a healthier living environment and the well-being of humankind, let us create a sustainable green city together so that everyone is immersed in the charm of nature.

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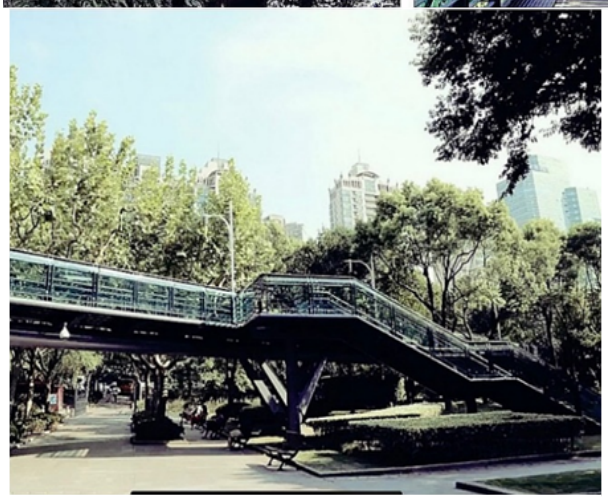

Environmental Economic Regulations

Marie Renaud, Siena Roselli, William Ran, Johanna Rodriguez Osegueda

In recent years, urban populations are finding themselves greatly affected by rising carbon emissions contributing to climate change and reduced air quality. Several approaches are being implemented as a response to such urgent issues. Thus, it is imperative to explore the role economic regulations can play as mitigation measures. The term *economic regulations* encompasses governmental interventions that include direct legislation, administrative price regulation, and control over entry into certain markets or industries (Joskow & Rose, 1989). Here we explore why implementing such policies is important, how urban governments could put them into action, what measures have already been taken, and the green city values that are fostered through them—focusing on climate change.

Traditionally, a number of decision-makers have found themselves reluctant regarding the implementation of eco-economic control programs, as they claim such policies would inevitably bring harmful effects upon nations' economic growth. Nevertheless, this is only the case if such measures are taken without careful organization and continuity. The success of economic regulations depends on the clarity and precision of the objectives established by decision-makers, as well as their compatibility with other kinds of multidimensional policies (Cramton, 1964). For instance, the economies of urban South Asian cities have traditionally relied on fossil fuel importation for the extraction of energy. This history of financial dependence on a contaminating industry has not allowed them to conserve their environmental quality, even while their economies are flourishing (Murshed et al., 2021). However, they also propose enacting environmental-economic regulations to aid the shift toward renewable energy sources. For example, pollution taxes and monetary incentives for conservation strategies and green technologies would improve the local environmental quality while simultaneously redefining an equally successful economy. Using a similar approach to implementing economic regulations in other cities would also allow for eco-economic growth internationally.

Climate change is undoubtedly affecting cities. Leaders need to take immediate action to protect these social-ecological systems from the harms of pollution due to under-regulated commercial activities. With urban populations on the rise along with continued fossil fuel consumption harming the planet, economic regulations must be continuously implemented by city governments to ensure the mitigation of such consequences. As a way of instituting the needed comprehensive planning for the success of these economic regulations, several action plans have been recently proposed to find balance among all sustainable development values, such as equity and conservation.

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ENVIRONMENTAL ECONOMIC REGULATIONS

Command-Control

- Strict and direct governmental laws

+

Market-Based

- Tradable permits
- Emission taxes
- Monetary Incentives

+

Voluntary

- Self-regulated standards

+

Mixed

- Combination of both command-control & market-based characteristics

=

BALANCE IN ECO-ECONOMIC SYSTEMS, MITIGATING CLIMATE CHANGE AND FOSTERING RESILIENCE

Part II

Problems and solutions

Solving Car Dependency with Light Rail

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There are currently over 100 million private vehicles in the United States (USDOT, 2019). While cars afford freedom in terms of mobility, there are problems that arise from overdependence on private vehicles. The populations of cities are continuing to rise, which puts more cars on the roadways (Institute for Transportation and Development Policy, 2021). This increase of vehicles leads to greater congestion on roadways, which causes lower speeds and increases climate-damaging greenhouse gas emissions (Institute for Transportation and Development Policy, 2021). Even by adding additional lanes to roadways, the problem may not be solved due to induced demand (Litman, 2022b). Adding and improving light rail infrastructure is a way local governments can overcome the dependence on private automobiles and the pollution it creates because it can supply faster ways of traveling in the city, provide a safer means of mobility, and allow a cheaper option than car ownership.

Light rail that has dedicated infrastructure has the ability to be faster than driving on roadways. Trains on a separate grade do not have to compete with adjacent cars nor have to wait for right of way. In San Diego, which has multiple light rail lines that stretch across the metropolitan area, trains move at an average speed of 18 miles per hour (San Diego Metropolitan Transit System, 2020). While this average speed may pale in comparison to highway speeds, light rail can be faster in certain situations such as rush hour traffic. While automobiles have to deal with bumper-to-bumper traffic that is representative of rush hour, light rail trains can avoid the chaos if separated from the street level.

Safety is another metric that gives light rail an edge over private automobiles. First, car travel results in 7.28 deaths per billion passenger-miles (Litman, 2022a). Light rail on the other hand only has about 0.24 deaths per billion passenger-miles (Litman, 2022a). Additionally, light rail allows people to focus on tasks that would otherwise be dangerous if a person was doing them while operating a motor vehicle. A survey of US adult drivers has uncovered that 69 percent use cell phones while driving, 67 percent consume food or beverages while driving, and 49 percent attempt to grab objects while driving (Qi et al., 2020). If people have the opportunity to do personal tasks and move around the city without potential death, injury, or financial loss, perhaps they would be attracted to a light rail system.

Additionally, a person that uses light rail instead of owning a car stands to save a lot of money. According to the American Automobile Association, the average American spends over $9,000 dollars on car ownership (Moody et al., 2021). On the other hand, 12 monthly passes for light rail systems can run for under $900 annually (San Diego Metropolitan Transit System, 2021). While these costs are on the surface, there are also potential long-term costs that can be saved through utilizing light rail. Cars have been determined to promote sedentary behavior and poorer overall health (Chakrabarti et al., 2017). These problems can lead to higher lifetime healthcare costs and thus make car ownership more taxing on car-dependent citizens. Light rail systems in contrast promote more movement (Chakrabarti et al., 2017), which improves health and subsequently lowers healthcare costs.

While there are great benefits to be obtained from light rail systems, there can be a common concern as to why buses are not good enough. New or expanding bus systems can be incorporated into current roadway infrastructure, saving time and money. However, there are many benefits that are not afforded with buses. For one, buses that do not have dedicated infrastructure have to deal with the same traffic as citizens in private cars. Thus, buses would likely provide a slower travel time, in part due to bus stops, and may not persuade private car owners to make the switch to public transit. Also,

light rail transit systems have been observed to increase ridership compared to bus transit systems (Werner et al., 2016). So if the overall goal of a transit system is to increase ridership and be faster than existing roadway infrastructure, light rail may be the more suitable option.

Through providing shorter travel times, safer ways of getting around, and saving citizens money, light rail can be a viable solution to automobile dependency. There is much room for improvement when it comes to light rail systems in the United States. Recent figures show 91% of commuting trips are made using private vehicles (Moody et al., 2021). Perhaps many of these trips could be instead made with light rail, which would reduce carbon emissions. Nevertheless, there is still the opportunity for local governments to lay the groundwork for future expansions of light rail networks, as well as brand-new networks in their jurisdictions to ensure diverse mobility for city residents.

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Electronic Waste Management

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With the recent trends of rapid urbanization and climate change emerged a shift towards greener cities, aimed at reducing cities' transboundary effects and increasing their self-sufficiency. Technological solutions, such as electric cars replacing current carbon intensive methods used in cities such as combustion vehicles are often proposed. Despite technology's potential, the management of electronic waste is far from sustainable, ironically counting against the development of greener cities, and therefore must be addressed before green cities become a viable solution. Globally, only 17.4 percent of electronic waste is properly recycled, while the rest is undocumented, where it will mostly end up being dissected by individuals driven by economic incentives (Forti et.al, 2020). Stripping electronics by hand is terrible for one's health, and also often leads to the electronic waste ending up in landfills where toxic metals from electronics deteriorate and spread into the surrounding environment causing pollution (Forti et.al, 2020). The government could encourage the shift to a more sustainable method of electronic waste management by implementing policies addressing the planned obsolescence of electronics, developing legitimate electronic waste management facilities, and increasing public awareness on the subject.

A major issue regarding electronic waste is planned obsolescence. Planned obsolescence happens when companies intentionally make their products worse or irreparable to encourage frequent purchases of their products for more revenue (Kramer, 2012). For example, Apple, a large tech company, disabled iPhones when repaired by third party repair shops (The Economist, 2022). Repairability is extremely important as repairing a device creates less waste than buying a new one. The role of small scale electronic waste is emphasized with how it accounted for 11.4 percent of the 53.6 megatons of electronic waste in 2019 worldwide (Forti et.al, 2020). Action is already being taken: twenty-seven states in the US are considering Right-to-Repair legislation and the European Union is reinforcing current laws so that devices must last at least a decade (The Economist, 2022). Even though the regulations would reduce the revenue of corporations, it is important to emphasize that money could still be made even if the space is driven by pure economic interest. As a result, regulating planned obsolescence in companies is crucial in reducing the generation of electronic waste.

Another solution to electronic waste is subsidizing legitimate recycling facilities. For example, in China, around 60-80 percent of electronic waste is treated illegally, which is inefficient and harmful to those who perform the resource extraction (Lu et. al, 2014). Not only that, the informal methods generally used such as burning circuit boards, shedding metals with acid, and disposing invaluable materials into the river spread toxic metals into the surrounding environment, causing pollution (Rajesh & Prabaharan, 2022). Therefore the development of legitimate recycling facilities, through sound governmental policies and incentives, is extremely important in reducing the reliance on the informal sector as can be seen when one compares the recycling rate between Asian and European countries. The Asian counterparts with generally immature systems of treatment have low recycling rates, such as India, which only recycled 0.92 percent of electronic waste (Van et. al, 2021). The European Union on the other hand, with a more mature system, the Electrical Waste and Electronic Equipment directive, has a recycling rate of 42.5

percent, which would directly decrease the amount of waste available for the informal sector to treat (Rajesh & Prabaharan, 2022; Forti et.al, 2020). As a result, it is extremely important for governments to subsidize the development of legitimate recycling facilities to reduce the impacts of electronic waste.

Raising awareness about the effects of electronic waste is also important in reducing its impact. With current trends of increasing electronics consumption, consumers are unaware of the disposal procedure and environmental damage that electronics can cause, and there may be little incentive among the public to take action on the issue (Rajesh & Prabaharan, 2022). As a result, awareness is crucial in solving this problem. Possible methods of executing this suggestion include: teaching students in schools, publicizing data regarding the percentage of formal recycling of electronic waste, and the potential health side effects of improper disposal. The change in consumer attitude is important, as they would aim their purchasing power towards long-lasting alternatives and go to greater lengths to dispose their electronic waste safely. This will reduce the generation of electronic waste and increase the amount that will actually reach the recycling centers, thus mitigating the issue. As a result, raising awareness on this topic would be a substantial step in reducing the impact of electronic waste.

In conclusion, by implementing policies regarding planned obsolescence in companies, legitimizing formal recycling facilities, and mandatory education regarding electronic waste, the government would make massive strides towards reducing electronic waste creation, and thereby set up a better foundation for a sustainable future.

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Revitalizing Existing Urban Areas

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In contemporary society, 55% of the global population lives in urban areas. This proportion will continuously increase to 68% by 2050, which could also add approximately 2.5 billion urban residents; the overall growth of the world's population could add another 2.5 billion people to urban areas by 2050. (United Nations, n.d.) You may wonder whether our existing cities can accommodate such a massive increase in population. Along with the influx of people, cities are also expanding into rural areas. Much of this expansion is poorly planned, leading to low-density, auto-dependent development spread out over large amounts of land. It creates a high level of segregation between residential and commercial uses, thus negatively impacting people's lives, ecosystems, and the environment (Everything Connects, n.d.). Once an urban area has been expanded, it cannot be withdrawn. To prevent such negative development and harmful expansion of urban areas in the future, city governments should promote policies that prioritize the promotion and education of smart growth within the existing city limits.

Promoting these policies will foster mixed land-use development from commercial builders, including residential buildings and shops. According to the Ten Civic Ecology Principles, civic ecology practices "start out as local, small-scale innovations and expand to encompass multiple partnerships" (Krasny & Tidball, 2015). By setting up smart growth as standards, builders will consider mixed development as a fundamental principle to rezone inner cities and poorly-planned neighborhoods already sprawled out. As a result, this standard ensures the establishment of compact communities, and it will bring the more frequent movement of people to the given community, as well as the support to businesses, improvement of safety, and increase the vitality of an area (Smart Growth America, 2021). Because of the more compact and centralized living and working spaces, the residents' dependence on cars will decrease significantly, thus reducing pollution and protecting the environment. As is said by a researcher from Ball State University, "When the focus turns from the suburbs and toward the inner city, growth can happen without the pollution and landscape destruction that comes with sprawl." (Rinkesh, 2020)

However, promoting these policies are not enough on their own. Education is also an essential factor for people to accept these changes in their local communities. Due to different backgrounds, such as culture and climate in different regions, urban planning and residents' lifestyles and habits may differ. For instance, Americans usually have huge backyards. In educating communities to understand the benefits of a compact mode of living, local people will eventually accept more dense development as well. As stated by Heberlein, "strong new attitudes can be created by changes in the social milieu or reference groups," which means "immersion in a new social environment can produce fairly dramatic and lasting attitude change" (Ferkany 2014). After feeling the connection of their own close-knit community as well as the convenience of a more compact way of life, just as these policies change how cities are structured, so will they slowly change the attitude of urban residents.

From an economic standpoint, promoting these policies can lead to more sustainable life. Being a compact city means concentrating residential and commercial parts in a centralized area. More concentrated finance and population can lead to government investment in infrastructures, such as green infrastructure and public transportation. For the government, the relative concentration of residential activity areas means less infrastructure is needed, resulting in lower costs. Everything is closer for residents, so they are more likely to choose green travel options, such as walking or public transportation. The reduction in the demand for private cars can vastly reduce fuel costs and carbon

emissions. Since the resources in a compact city are rotated, reused, and shared between different individuals and businesses, a shared economy will evolve as its economic model. This will give individuals in cities a sense of belonging to their communities, eliminate unnecessary investments, have the opportunity to earn additional income, save money and resources, and reduce their environmental impact (Jain, 2022). By reaching a dynamic balance between economic, environmental, and social considerations (URBACT, 2019), sustainability in compact cities will eventually come to life.

One may suggest that such policies may result in gentrification. Many local people will be pushed much further away from the urban core due to increased rent, thus resulting in fewer job opportunities and higher costs to access the inner city. However, the same policies can include regulations or strategies that promote affordable housing and rent control for people who live in this neighborhood for a long time and may need financial aid. For instance, policies can promote "Just-Green-Enough" (JGE) (Curran & Hamilton, 2012) as well, which focuses on achieving environmental improvements without the occurrence of gentrification.

By projections, smart cities can generate approximately 20 trillion dollars in economic benefits by 2026 and improve 30% energy efficiency in 20 years (Pareteum, 2021). With well-planned policies that prioritize smart growth, residents can achieve a win-win situation in the economy and daily life in the existing city. At the same time, the city is able to accommodate the continued influx of people into the city without additional expansion. With the improvements to the original functions and planning of the city, a balance could eventually be achieved between the inhabitants, the society, the economy, and the environment.

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Light Pollution

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Have you ever looked out of the window after dark? Once twilight has completely faded, originally there would be only darkness. In most cities today, countless lights flashing makes it seem like another day. Many citizens underestimate artificial lighting and the impacts it can have, however, "when we try to pick out anything by itself, we find it hitched to everything else in the Universe" (John Muir, as quoted in Turina, 2022). Artificial illumination is related to the central environmental threat of our time - it's ruining the global climate. LED optical infrastructure can reduce light pollution and greenhouse gas emission because it improves lighting efficiency, preserves biodiversity, and controls directionality.

Maximum lighting efficiency can be achieved when conducting green optical infrastructure and cutting down carbon emissions. Most inefficient incandescent bulbs are major CO2 emitters, and while they account for just 1% of world illumination, they account for 20% of CO2 emissions. A project UJALA (Unnat Jyoti by Affordable LED for all) in India showed the implementation of LED light can reduce 19.7 MT CO2 per year (Singhal, 2019). If the government uses LED technology regionally in public infrastructure, carbon emissions tend to decrease sharply. For some vegetation that requires extra light energy, LED technology is applied in greenhouse lighting as a substitution for natural light because its high efficiency provides low maintenance cost. Thus, LED technology carried out in the aspect of urban infrastructure, serves as an effective method in dealing with pollution from lighting.

Modern LED technology decreases creatures' mortality rate, sheltering urban communities from environmental changes caused by light pollution. The green space under artificial illumination ends up producing early leaf out, late leaf loss, and longer growth periods in plants, thereby altering the makeup of the floral community (Hölker 2010). Many light-sensitive animals will become extinct, particularly in or around brightly lit urban areas. Urban optical technology tends to minimize the effect but there is no way to eliminate the harm to biodiversity and the environment. However, due to its versatility, LED technology has enormous potential for creating mitigation techniques. Particularly, LEDs enable chances to tailor light emissions to specific, customized spectra that are least environmentally destructive. They are well-suited to the adoption of variable lighting methods that involve periods of fading or switching off (Gaston, 2012). Therefore, the construction of urban optical infrastructure decreases impairments brought by light pollution.

LED systemic infrastructure controls the characteristics of directionality to effectively reduce extra light emission. Traditional lighting systems offer nearly 360 degrees of light while LED lights provide 180 degrees of illumination. Because LED lighting improves color perception, it is simpler to identify people and things on the sidewalks and in the streets. Additionally, LEDs are simple to direct so that light is directed toward where it should be and away from undesired areas. The replacement project of LED lights is conducted in the city of Ann Arbor emphasizing the lighting systems are sufficient for citizens to recognize the road, and they avoid extra blazing lights that are both energy waste and interfere with wildlife (Assembly, 2019). This enforcement of LED infrastructure overweighs the previous light system construction and shrinks the consequences of artificial illumination.

It's worth noticing that LED technology is region-based. In a study conducted in Britain, LED technology is compared to both low and high-level sodium light. The results indicated that LED technology is less harmful towards creatures than high-energy sodium light while similar to low-energy sodium light (Rowse, 2016). More studies are required to determine the effects of LEDs on a wide range of species and how ecosystem processes differ across the complete range of existing

illumination technologies. Despite the regional limitations, LED technology is worth employing since it removes more than half of the carbon emissions caused by lighting.

Due to its improved lighting efficiency, preservation of biodiversity, and directionality, green optical infrastructure can lower artificial lighting and greenhouse gas emissions. Citizens should be aware that artificial lighting is hazardous to themselves and their living conditions. Proactively eradicate unnecessary artificial illumination.

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Hydroponics: A Win-Win Solution

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Currently, around 55% of the total world population–4.2 billion people– live in cities. By 2050, the population is projected to more than double its current size (*Urban Development*, n.d.). To accommodate more people, unsustainable urban sprawl will happen, while to ensure food provision, conventional agriculture needs to increase yields by 51% (van Dijk et al., 2021). The two needs, however, conflict with each other. Sprawl adds pressure to resources like water and agricultural land, both of which are the keys to increasing agricultural yields. To enhance climate resilience by aiming toward secure food provision and a sustainable environment, hydroponics, or the soilless cultivation of plants, can be adopted as it uses water efficiently, maximizes space, and produces high yields.

First of all, hydroponics conserves water. Increasing populations in cities and climate change together are worsening water scarcity as demand exceeds availability (He et al., 2021). By 2050, an estimated 1.693–2.373 billion people, nearly half of the global urban population, will face water shortage (He et al., 2021). At the same time, conventional agriculture water use, accounting for 70% percent of total freshwater usage (*Water in Agriculture*, n.d.), will increase when trying to meet growing population needs, but is not an efficient method as much water is lost through evaporation. Hydroponics, on the other hand, uses 97% less water (Bascombe, 2016) as loss of water from evaporation is prevented as water is delivered more efficiently, which means that more water will go to plants' evapotranspiration (Barbosa et al., 2015). Even if some portion of water is not taken up by the plants, water is continuously recirculated (Bascombe, 2016), meaning that it can be recaptured by the plants. As water becomes a scarce resource in the future, hydroponics can play an important role in saving water.

Besides conserving water, hydroponics can maximize space utilization. Expansion of built-up areas is expected to continue as more people live in cities (D'Amour et al., 2016). Most of the land urban expansion overruns are croplands that are 1.77 times more productive than the global average (D'Amour et al., 2017). As a result, suitable land will decline, yet conventional agriculture will need more land to meet the growing population demand for food in cities. Hydroponics can be a way of food production for people in urban areas due to its low demand for space, thus making the system feasible in urban areas with high density and land prices. Locally available materials like discarded tires or plastic containers can be used to build the bed for crops grown, while rice hulls or coconut husks can be used for soilless substrates (HYDROPONICS: Crops without soil, 2010). These characteristics make hydroponics suitable for places like roof-top gardens, balconies, or backyards. In general, hydroponics uses less land than conventional agriculture and can be implemented in the limited space of urban areas.

Even while meeting environmental aims, hydroponics systems still yield prolific crops. Anthropogenic climate change has reduced global farming productivity by 21% since 1960, which is equal to losing seven years of productivity growth (Ortiz-Bobea et al., 2021). Crop growth is likely to further decrease as extreme weather like droughts happens more frequently due to climate change. But hydroponics produces high yields. One acre of hydroponics greenhouses can produce the same amount as 10 acres of arable land (HYDROPONICS: Crops without soil, 2010). Moreover, the consistency of hydroponic production also means food security. Hydroponics is often implemented inside greenhouses with controlled temperature, humidity, and carbon dioxide to maximize production and growth (HYDROPONICS: Crops without soil, 2010), meaning that regardless of the outside weather, a stable condition is ensured for the production of vegetation. This locally-grown food from hydroponics also ensures more people can have access to food as transportation costs can be reduced. Hydroponics, thus, can ensure food security.

Despite these benefits, hydroponics is not without its downside as it requires high investment. Since the process of hydroponics is technical, workers need to be specifically trained to be familiar with procedures such as maintaining optimum temperature, acidity, and light, and balancing nutrients (HYDROPONICS: Crops without soil, 2010). Hydroponics also requires electricity for lighting. These

inputs, therefore, make hydroponics not suitable for the crops cultivated by people like ACP farmers but better for high-value crops (HYDROPONICS: Crops without soil, 2010). Still, hydroponics has a high potential for future production.

It is important to meet the future demand for food in cities and protect scarce resources like water and land. Moving away from traditional methods, vegetation and crops can thrive without soil by using hydroponics in cities due to its water efficiency, space maximization, and high yields. Though its investment may be high, this method of soil-less production not only promotes sustainability of the environment but can also meet the increasing population's food demands. Hydroponics, therefore, can achieve a win-win situation.

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The “Green Vessels” to the Human Heart

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Ecological corridors are often denominated as the “green lungs” or even “green arteries” of cities. Nevertheless, these examples often appear insufficient and single-dimensional in their scope. By definition, arteries solely have the function of carrying away, while lungs simply play a role in respiration. These qualities do not cover all of the multidimensional aspects that are intended to be metaphorized. Moreover, another focal deficiency exists. From the broad context of urban green spaces, Jim and Chen (2006) state that humanity’s meaningful interactions with these areas demand the further involvement of people and their needs in the management of such, as this lack of perception has previously led to the neglect of these spaces from stakeholders. As a result, I have ventured into proposing a new analogy as the title of the present paper: “green vessels.” Just as blood vessels in the body simultaneously carry blood away and toward the heart, ecological corridors create a mutually beneficial connection between nature and humanity, rather than one that follows a single direction. While ecological corridors are considered primarily beneficial for wildlife, urban planners and decision-makers should also draw attention to the social benefits of these spaces, which would result in greater public support for the management of these green vessels.

Further emphasizing the social benefits of green vessels in cities would improve funding for the establishment and redevelopment of these spaces. The appeal to providing this aid can be analyzed through the concept of willingness to pay (WTP), which is the stakeholders’ degree of disposition to pay in view of obtaining a certain gain (Verlynde et al., 2019). From a lens focused on flood mitigation policies, Verlynde et al. (2019) elaborate that the public’s WTP is directly linked to various factors. Among these influences, they emphasize the perceived probability of the situation resulting in an impact people perceive would affect them. This same logic applies to green vessel initiatives. If urban planners and decision-makers further promote green vessels with a focus on matters that closely concern individuals, such as economic profit from eco-tourism, the WTP of governmental and private investors would proportionally increase.

Drawing attention to the social benefits of green vessels would also foster civic ecology practices for the areas’ management. Environmental governance is coordinated by a wide variety of actors. Non-governmental organizations and volunteers make up an essential part of this group. Manatschal and Freitag (2014) argue that a direct relationship exists between volunteering and the expectation for reciprocity, which makes the motivations behind civic engagement both selfless and self-interested alike. While not necessarily for strategic ends, this means that actors are more likely to donate their efforts to causes that are within their interest (Manatschal & Freitag, 2014). On this account, promoting the social benefits that green vessels supply would lead to a rise in the attained levels of civic ecology participation, which would largely contribute to the management of these areas. For instance, green vessels play the role of vegetation carbon stocks for climate change mitigation (Jantz et al., 2014). They can also reduce transportation-related pollution by acting as enjoyable walkable paths. These services provide climate regulation and can contribute to controlling pollution-induced asthma and other health conditions that result from exposure to emissions. Educating people to become aware of this would increase their motivation to participate in conservation efforts for green vessels.

Furthermore, as a result of the focus on green vessels’ social benefits, the sense of place of stakeholders would be cultivated and lead to support. Russ and Krasny (2017) have defined *sense of place* as the perception that each person holds of different places. Within their work, an analysis was

also provided on the variation of sense of place from person to person, stating that it mainly occurs as a result of their distinct experiences. Environmental and social injustice have been identified as contributing factors to the development of a negative sense of place (Russ & Krasny, 2017). Therefore, endorsing environmental justice as a social benefit of green vessels would increase people's support and demand for the conservation of these urban green spaces. For example, campaigns promoting the establishment of green vessels within walking distance from urban areas to battle environmental injustice would strongly connect people to nearby nature who may not have experienced such opportunities before. This would lead to them advocating for more care and implementation of green vessels.

Nevertheless, important questions have been raised regarding the feasibility of the implementation of green vessels. Many consider the state of extreme urbanization of certain cities to be an impediment. However, it is necessary to understand that green vessels are not limited to only forested areas. They encompass all forms of natural habitats that interconnect and continue on for a vast extension, including rivers, canyons, and other landmarks. For instance, a network of ravines runs along the Greater San Salvador Metropolitan Area within the Central American country of El Salvador. While most of the local efforts concentrate on flood prevention (DGPC of El Salvador, 2022, pp. 25), the system already acts as a natural wildlife corridor for native species, such as agoutis, raccoons, and black iguanas. Furthermore, sustainable infrastructures could be built to allow for the crossing of people along these natural passageways, with the objective of motivating their connection and action for nature.

In addition to their contributions to ecological connectivity and the movement of wildlife, the accessibility of green vessels also brings untold social goods that are often overlooked, such as physical well-being, mental health benefits, and environmental justice. Just like veins and arteries in the human body, green vessels carry people to and from natural wonders that hold a special sense of place in the human heart. We need cities covered in green.

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Less Heat, More Diverse

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When pedestrians walk on a street without any cover from sunlight, they often suffer from high temperatures and sunlight. Increasing amounts of heat waves, combined with urban heat island effect, challenge the comfort level and sustainability of modern cities. Considering the high effectiveness of urban green space in mitigating urban heat events (Rosenzweig et al., 2009), city governments should take advantage of urban afforestation, creating enough canopy cover areas, which effectively lower temperature and UV level, on streets and other public spaces for citizens. To provide sufficient shade to deal with urban heat waves, city authorities should introduce and promote more diverse plant species in public green spaces.

Planning urban green spaces should include the consideration of local climate and extreme weather. Introducing more diverse species can help city green spaces withstand different climates and improve resilience. In broad terms, resilience, or a resilient approach to sustainability in city management, is the method to build the capacity of urban social-ecological systems to deal with any unexpected changes, to absorb disturbances, and retain back to the same functions or structure (Walker et al., 2004). In cities, there is an increasing amount of unprecedented events, namely sudden heat waves, strong typhoons, urban water logging, or droughts. All of these events create high risks for urban green spaces. As a result, the diversity of urban green spaces is becoming more and more important. It reduces the effect of extreme weather caused by climate change, as well as improves the resilience of the urban ecosystem. An urban forest that has high diversity in species is considered to be more likely to adapt to the unexpected weather events and survive in climate change (Kendal et al., 2014). The municipal government should prevent them from being damaged by weather and changing climate, so introducing more diverse species in urban green spaces is necessary.

Promoting the use of diverse species in urban green spaces can increase the tree layers to provide sufficient shade, both for citizens walking on the streets and seedlings nearby. In cities, most spaces only have a single species of tree, creating holes between branches and separation between individuals, which results in a lack of shade on streets and impairs the capacity of dealing with urban heat waves. Consider the tree structure in a natural forest. Natural forests can be distinguished into four layers, including emergent, canopy, understory, and forest floor. Different layers are composed of diverse species having different heights and covered areas. These forests tend to have a higher capacity to block sunlight, making the lower layers and floor significantly cooler than the tops (Boehnke, 2021). Urban forests can also learn from natural forests. By planting diverse species to provide layers that absorb more sunlight, shaded areas can be expanded and interconnected. Moreover, offering shaded areas can avoid seedlings being hurt by heat waves, as well as prevent moisture loss during the day, which in turn help create healthier urban forests.

For many urban forests, the more diverse species they contain, the more sustainable they will be. By definition, the sustainability of urban forests is to provide the inhabitants with a continuing level of economic, environmental, and ecological benefits (Rogers, 1998). After discussion from an environmental perspective, urban green spaces can also create economic benefits for cities, after the goal of sustainability is achieved. As long as there are returns, the city authorities will have the incentives to promote the construction of urban green spaces. Diversity is the key factor. It is often recommended that no more than 10% of the tree population consist of only one species (Kendal et al., 2014), so that urban forests can achieve sustainability, and create huge profit. Once economic

benefits are ensured, sustainability is achieved, and the long-term development of urban forests can be strongly supported.

While some may say modern technology makes cooling much easier than what trees can do, and using diverse species increases the cost of city management, urban trees are proven to reduce the use of energy, which in turn lowers the costs for citizens and decreases emissions of greenhouse gasses. There is no doubt that modern air conditioning can always do much better than trees. However, the temperature decrease resulting in more shade around will also help conserve energy. In the US, research has shown that trees can significantly save money used on cooling for approximately 778 million dollars each year, having 10% of utility reductions during peak hours, and the numbers are still rising (McPherson & Simpson, 2003). Introducing diverse species can provide more shade to lower air temperature, saving energy and slowing down global warming. Even though it is costly, it is still valuable to the environment and the entire city.

In a review of the benefits clarified in previous research, urban forests should be considered by city authorities. Besides them, this article talks about the benefits of introducing diverse species to green spaces, including improving resilience, providing more shade, and leading to higher sustainability. How to build a habitable and sustainable city in the context of climate change is a long term goal for many authorities. To achieve it, this article recommends authorities plant more diverse species in urban green spaces.

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Urban Environmental Negligence

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Today, 55% of the world's population lives in cities, and that percentage is predicted to grow to 68% of the total population by 2050 (Hood, 2005). This massive trajectory presents urban planners with the issue of how cities will look in the future. This same challenge was posed to American city designers in the 1950s. Their solution was to limit growth by preventing low-income families from purchasing homes, leaving them in the less desirable areas with potentially dangerous pollutants in a practice known as "Redlining." These communities received little in the way of green space, which, coupled with a disproportionate amount of industrial plants built in these neighborhoods, can lead to extreme environmental hazards. Current metrics show that people living in low-income communities are exposed to worse air quality and potentially hazardous materials, lowering their life expectancy and increasing rates of mental illness and poor physical health conditions (Hood, 2005). Such environmental negligence in low-income communities must be combated with a multi-level governance structure, supporting the development of urban green spaces without gentrifying these neighborhoods and displacing low-income families.

The first step in addressing the issue of environmental negligence in disadvantaged communities is for multi-level governance to encourage activism and public forums focused on the abatement of the area's most pressing problems. By involving citizens in local conservation efforts and providing them with backing from local governments, it is possible to motivate citizens and local organizations to take ownership of environmental clean-up efforts. China's river chief system (RCS)–a program that included appointing local stewards and conducting a public messaging/outreach campaign–was successful at both decreasing the amount of pollution in the Yangtze River near the industrial section of Wuxi and increasing local involvement (Ouyang et al., 2020). This approach can negate environmental negligence through community action and responsibility with government oversight and aid.

Another approach to leverage community action to combat environmental negligence in low-income communities is to develop urban agriculture. Urban agriculture can take the form of community gardens placed near schools or community centers to encourage environmental stewardship and community cohesion. When implemented on a larger scale, such as an empty plot of land or rooftop, they can be practical tools for preventing urban runoff, cooling, and increasing food security (Langemeyer et al., 2021). Providing people in low-income neighborhoods with a readily available source of fruits or vegetables provides access to healthy foods, minimizes the distance needed to travel to purchase the food, and reduces packaging waste–ultimately reducing carbon emissions. This makes urban agriculture a vital tool for increasing green infrastructure and combating food scarcity by providing nutrient-rich foods for people who may not have access to them.

Government support is necessary to fund and plan equitable development projects to create green infrastructure without disrupting existing community dynamics. An effective way to accomplish this is by developing streets and roads encouraging walking and biking (Environmental Protection Agency, 2014). This strategy can be implemented by adding vegetation and usable sidewalks to create a buffer between road traffic and green space. Here, people in the community can enjoy nature while also creating a way to decrease groundwater runoff, encouraging walking rather than driving to reduce carbon emissions. Furthermore, this strategy can be built around infrastructure and avoid disturbing the existing community, so long as the government actors work with the local community to find viable streets and areas. Cooperation in this project is paramount as a significant concern is

encroaching on existing societal norms. This requires bottom-up and top-down governance to increase participation in the planning process.

While “green gentrification” is a genuine issue in some communities, proper implementation of green spaces decreases the risk of inflated housing costs and the displacement of pre-existing communities. The Newtown Creek Nature Walk in Greenpoint, Brooklyn, is an excellent example of the “just green enough” strategy. The nature walk–skirting alongside a sewage treatment plant and an important industrial corridor–allows people to get outdoors without forcing the removal of working-class communities (Curran & Hamilton, 2012). The peaceful coexistence of green infrastructure and existing communities must allow all residents access to green spaces to increase a connection to nature while also decreasing urban heat and groundwater runoff.

While the size of low-income communities varies by city and country, on average, 12% of residents who live in cities reside in low-income communities and are at risk of the adverse health effects caused by environmental negligence. Furthermore, the amount of land area within cities lacking green space increases groundwater runoff and urban heat, both of which have detrimental effects on the environment and contribute to climate change. To address the harmful climate effects and health problems, the issues of environmental negligence must be addressed in underserved communities through a multi-level governance approach. Solutions require support from community action and government intervention to create and develop green spaces that benefit the existing neighborhoods and the environment.

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Irreplaceable Neighbors: Pollinators

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The Intergovernmental Panel on Climate Change recently released their sixth assessment report and it is apparent that the ramifications of climate change will begin to pervade our lives on an ever increasing scale. One critical buffer to climate change is a healthy and diverse urban flora, operating as effective greenhouse gas and temperature sinks in our rapidly expanding cities. Despite their integral contributions, our urban flora is often disregarded in infrastructural considerations, left to suffer from the environmental deterioration and habitat degradation resulting from urbanization. This is where urban pollinators operate as irreplaceable neighbors by maintaining a healthy flux of genetic diversity among urban vegetation. Their crucial role in the urban ecosystem is evident, as, for example, even the “loss of a rare pollinator from a small natural habitat in an urban matrix [leads] to pollen limitation for six dependent orchid species” (Harrison, 2015). Despite consensus on pollinators’ efficacy, appropriate approaches in revitalizing pollinator populations have not been outlined. However, it must be noted that “without a comprehensive list of the full range of intervention options, policy-makers are likely to underuse potentially effective intervention options and miss potential synergy gains of combined actions” (Marselle, 2020). Therefore, to address the problem of declining health and resilience among plants in urban habitats, city planners should improve various characteristics of existing public green spaces that support pollinator populations.

The first characteristic of public green spaces that can be modified is the amount of native flora diversity and intensity that encourage pollinator activity. Native plants that have coevolved with the distinct soils, climate and fauna of an urban system are favored by pollinator populations as “exotic plants may not produce the olfactory or visual cues needed by native insects, or because they may not be as palatable as native plants” (Majewska, 2019). Beyond being recognizable, many native species also function to provide unique nutrition for the caterpillar stages in native pollinator populations and have pronounced effects on boosting local population sizes. Furthermore, the replacement of native plants with ornamental plants can harm the pollinators by increasing the “density and richness of spiders” as their urban populations correlate with the “abundance and diversity of ornamental plants in gardens” (Majewska, 2019). Through maintaining a diverse population of local plants, green spaces can effectively cater to the needs of local pollinators, developing a positive feedback loop between the flora and pollinators in the local environment and ultimately contributing to a city that is more resistant against climate change.

However, an effective solution must address more than a single dimension of green spaces. For example, prohibiting certain gardening practices in these spaces is the second change that will help create lasting, pollinator-friendly changes in the urban landscape. Gardening activities in the public green spaces must be precisely regulated as both the timing and type of these practices have significant consequences, often harming the fragile equilibrium of species interactions and microhabitats essential to the life cycles of local pollinators. The nonmobile stages of pollinators are particularly vulnerable to certain activities, as “clearing practices, such as pruning and removal of dead vegetation, affect pollinators by unintentionally removing certain life stages … including eggs and pupae or adults overwintering” (Majewska, 2019). The timing of weeding, clearing, and mulching are also significant. Conservationists recommend “[delaying] the clearing of dead vegetation until later in the growing season, allowing for the emergence of cavity-nesting pollinators and overwintering butterflies” (Majewska, 2019). Moreover, chemicals used in green spaces must also be strictly regulated. Insecticides, herbicides, neonicotinoids and fungicides have all been documented to have

negative correlations with butterfly and bumblebee abundance (Baldock, 2020). The aggregate of these management practices and chemicals in public green spaces accumulate to severe consequences for local pollinator populations, leading to diminished floral diversity and health.

It is imperative we improve upon the ecological dimensions of public green spaces, however, changing the community's perspective on and engagement with these spaces is also critical to creating lasting change within the city's environment. To this end, public green spaces can be modified to improve the community's perception of the local plant and pollinator populations. This is best attained through creating interactive spaces for community engagement. A case in point is the outstanding success of the 'Million Pollinator Garden Challenge,' which recruited "more than a million garden owners across the US to preserve and create a network of gardens and landscapes to benefit pollinators" (Baldock, 2020). By employing similar projects within public green spaces, urban residents can be simultaneously educated and given opportunities for contributing to the local flora and fauna. For example, by providing tools to create artificial nests in these spaces, local populations of cavity-nesting pollinators including carpenter, leaf-cutting, and mason bees can be significantly bolstered by the community, contributing to healthier urban vegetation populations (Majewska, 2019).

Despite the benefits of improving upon the characteristics of green spaces, the costs involved with these solutions is still a hurdle. These solutions will require additional funding, but these costs can be addressed through integrating green infrastructure - such as green roofs - into the public green spaces. By using rooftops for gardens, green roofs are able to save 84% energy use and have twice the average lifespan when compared to conventional roofs (Manso, 2021). These additions will guarantee a decrease in maintenance costs that will compensate for the funding required in the initial changes to the public green spaces.

Cities are notorious contributors to the global climate crisis, but many are quick to overlook their potential in addressing climate change. Through a comprehensive modification of public green spaces, we can create an environment that is advantageous for our local pollinators, ultimately fostering a healthier city flora that can better combat climate change.

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Climate Change Education in Urban Schools

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Climate change (CC) affects 85% of the population across 80% of the world's land area (Callaghan et al., 2021) especially people in urban cities, thus CC education needs to be improved in schools. This must be implemented from the top-down with better professional development and more complete guidelines for teachers regarding CC. In 2020, the National Center for Science Education and the Texas Freedom Network Education Fund graded each state's teaching on CC. Fourteen states that use nationally established science standards ended up with a C + or worse on addressing CC, three received an F, and only 27 states received a B + or better (NSTA, n.d.). In order to foster youth resilience and empowerment, inspire attitude and behavior changes, and reduce carbon emissions in urban communities, state school board officials must improve their guidelines and teaching about CC.

The more students are knowledgeable about the effects of CC, the possibility of youth resilience and empowerment become attainable. For example, a Norwegian study exploring the changing CC education values in Norway's Oil dependent cities of Stavanger and Oslo, showed how "climate change education in the formal school system has been key, as there has been a clear emphasis in the Norwegian curriculum on environmental issues and anthropogenic climate change in particular," which has resulted in significant adjustments in student attitudes and preferences towards CC solutions (Hjelleset, 2020, p. 93). In these areas not only did the improved CC focused curricula educate students, but they empowered students to become more active citizens by promoting climate strikes and demonstrations, therefore promoting more genuine engagement.

After education is possible, attitude and behavior changes have the ability to not only change teachers and students' minds, but entire communities' minds. Heberlein (2012) discussed the importance of the three fixes—technological, cognitive, and structural. His ideas encompass the true power of improving how CC is taught in schools in order to engage students and empower them to have an impact in their future. The technological fix in this case is unifying the curricula standards involving CC education and improving the techniques to allow teachers to better understand the existing problems and the solutions to creating a greener world. The cognitive change lies in the hands of how this technological change is ingested by students, shown in both their attitude and personal behavioral change. The last piece of this puzzle is in the structural changes, which are indicated by student activism after students are educated and empowered. For example, once the students in the educationally adjusted schools in Norway tailored for teaching about CC rather than fossil fuels, more students took part in protests and climate marches (Hjelleset, 2020). Young people are the future of all urban cities, especially as urban densification increases, so they have the power to inspire community members to take part in active behavior improvements and create wide-scale positive environmental impacts, and it all starts with improved public education, especially in cities where CC consequences are most heavily seen.

By empowering and educating students and communities, the potential to reduce carbon emissions in urban communities is possible. According to a study that analyzed the role of CC education on individual lifetime carbon emissions by surveying students at least five years after they took an intensive one-year university course about global CC, the majority of course graduates reported pro-environmental decisions (i.e., type of car to buy, food choices) that they attributed at least in part to experiences gained in the course. The researchers concluded that these decisions reduced the individual's carbon emissions by 2.86 tons of CO2 per year (Cordero, et al., 2018). This study

proved how impactful CC education is on sparking civic engagement and promoting pro-environmental activism.

Implementing improved professional development and more complete guidelines for teachers about CC may be difficult for states due to political implications involving the discussion of CC—some people believe CC is a hoax, or not impacted by humans. This response could be alleviated by including discussions on what makes reliable and unreliable research and implementing action-oriented learning techniques into the curriculum to allow both teachers and students to understand the research they are consuming. It would be crucial to also discuss CC in an interdisciplinary manner including how the path toward a green future impacts healthcare, the economy, jobs, and more. This would allow for a greater connection with material in areas where the fossil fuels industry provides many benefits for the community. Thus, allowing the community to benefit from education on how to effectively transition from the fossil fuel industry to the green energy industry.

Although there are difficulties in implementing an improved CC curriculum, giving students in urban cities a wide-range of opportunities to allow for student empowerment and civic activism involving environmental rights is imperative. Also, to give growing cities a chance at lowering rising temperatures due to immense carbon emissions released into our atmosphere, educators need to inform and provide opportunities for students to lower their carbon footprint. Although it may be difficult, the benefits of this type of education outweigh the struggle of implementation.

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Small Buses, Enormous Potential

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Public transportation has long been regarded as an essential solution to reduce urban carbon emissions and slow climate change caused by the Greenhouse Effect. Nevertheless, after hundreds of years of development, one of the most important components of this framework–the bus system–seems to have now hit its plateau. The stable pattern for its operation that relied on those old-fashioned 12-14 meter long buses has resulted in excessive carrying capacities and low flexibility. The problem of the inefficiency in today's bus system can be primarily addressed by the simple action of complementing large-sized buses with smaller ones 6-8 meters long (also called ”minibuses”), which will easily secure the bus system's role in reducing contemporary global warming issues and stimulating more people to start a more eco-friendly traffic mode.

To begin with, the most fundamental potential benefit of employing minibuses is to maximize energy utilization via an optimized bus dispatching system with stronger "adaptability." While today more than 80% of urban buses are electric-powered, operating a 12 meters full-sized bus indirectly requires a lot of energy– a considerable portion of electric power is generated through thermal power that still discharges tons of Greenhouse Gas (GHG), which threatens the stability of climate. Moreover, the critical problem here is that the passenger flow (PF) is ever-changing within a day. In large metropolises like Dalian, China, the capacity of buses could be well utilized for 80%-100% during the rush hours but plunges to only 20% when it comes to those non-rush periods (Zuo et al., 2019), which means the rest of the carrying capacity is merely wasting energy, indirectly releasing unnecessary GHG into the atmosphere. Thus, a more feasible mode could be that full-sized buses are used during high-PF periods, while the minibuses could be used for low-PF periods. A study of Route 55 in Shanghai shows that 27% of the wasted carrying capacity will be saved by using buses that have multiple sizes, which leads to an estimated 30% reduction in energy for operation as well as a significant diminution in related GHG emission (Sun et al., 2015).

The further effect of small buses comes from social and psychological perspectives, because instead of the private cars, residents would prefer more convenient short-distance service provided by minibusses’ stronger “flexibility". This aspect later contributes to environmental improvement as well. For many cities with subway systems or Light Rail Transit (LRT) with enormous carrying capacity, the dependence on buses as the primary vehicle for transport has been extenuated (Wei et al., 2020). Nevertheless, new challenges emerge when people face how to commute for the "last mile" between their homes and the subway or LRT stations (Kong et al., 2018). If most people still drive this distance, the eco-friendly contribution of taking the subway will be mostly offset. While the concept of "Shuttle Routes" was proposed long ago, it’s actually impossible for full-sized buses to drive along intricate alleys between buildings. For the smaller bus models, take the 6-meter one as an example, they can be used to open hundreds of “shuttle routes" that might penetrate and cover more than 80% of urban alleys around subway stations (Wei et al., 2020). Setting stations within the community, the shuttle buses could provide more convenient services for commuting, which will eventually help build a greener city.

Last but not least, the small-sized buses are not limited to solving today’s problems; more importantly, they pave the way for people to go further, bringing people a brand new prospect of "Customized Bus(CB)". One significant aspect for CBs is that fewer routes will be fixed to a chain of unchanged stations. Instead, the destination of routes and the path it takes could be varied based on the passenger's demand and preference. Small buses meet the criteria for offering this service, as

they are highly flexible and CB routes usually will not take much carrying capacity. Also, attempts to construct the CB system failed in the past because the CB system will require more vehicles to operate and cover a wide area (Wang et al., 2019). From an economic perspective, the cost of purchasing each smaller bus will be 30-40% lower than that of their larger counterparts, which offers the transport bureau some freedom to buy more. The edge CB service has over traditional public transportation is that it significantly improves the experience in terms of the travel time, travel speed, and the number of stations—very ideal as an advanced solution to public transportation (Wang et al., 2019).

Some people might argue that implementing smaller buses will not work or will even aggravate the problem of insufficient transport capacity during rush hours in metropolises. Admittedly, this is also a noteworthy paradox because it is another extreme of urban transportation. Shifting from larger-sized buses to smaller vehicles, however, does not mean we will discard the full-sized buses' important roles. In fact, the “absolute capacity” provided by those full-sized buses is essential as well. Oppositely, the scheme of adding minibuses will only focus on the "relative efficiency" of the bus system, because it will lessen the excessive carrying capacity in off-rush periods and attract people's attention to public transport. These effects help to achieve maximized efficiency of the bus system’s operation with a minimal influence on passengers' experience.

The problem faced by today's bus system is complex because it has multiple facets and cannot be easily handled at once. However, introducing the small buses will doubtlessly solve one of them. With the direct environmental impact, as well as the social benefits of encouraging more people to implement an eco-friendly traffic mode, small buses will offer good remediation for the 21st-century urban bus system by boosting its ability to cope with today’s climate crisis, and building a foundation for its future development.

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Dismantling the Vehicle-First Mentality

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A pure white bicycle on the busy intersection of Prince Edward street. This is one of the eight bikes created for “Ghost Bikes”, a public art exhibition that commemorates the death of eight cyclists in transport-related accidents. Hong Kong has always had a contentious relationship with its transportation. As the city continues to develop, the “vehicle-first” mentality continues growing amongst its citizens. According to Hong Kong’s Transportation Department, more than 3,249 accidents occurred involving bikes, with at least 8 of them being fatal for cyclists (Lee, 2022). As the amount of carbon emissions from transportation continues to rise, we must begin to dismantle the “vehicle-first” mentality and work towards promoting cycling and public transport usage through improving infrastructure such as cycling lanes, promoting public transportation systems and providing rental stations for easy access to bikes.

The most challenging obstacle standing in the way of progress toward more bicycle-oriented roads is Hong Kong’s lack of safe alternative transport infrastructure. The number of collisions with bicycles will only increase as more bikes are used. However, after a certain number of bikes are on the road with adequate infrastructure, the collisions will decrease again because the mindset of the city will adjust (Yao & Loo, 2016). Despite not being very large, Hong Kong is still separated into many regions, as such, it is only logical to use a local approach to this problem. As of 2021, Hong Kong Island has 0.3km of cycling lanes, having received no expansions in 9 years, and no planned increases either. Since 2011, some areas like Kowloon have even faced a 100% decrease in bike lanes (Research Office Legislative Council Secretariat, 2021). In cities like Victoria, Canada the government committed to building large-scale bicycle infrastructure across communities in 2016. Since this change, there was a roughly 15% increase in cycling (Winters et al., 2018). The researchers noted that an increased feeling of accessibility and safety from the residents encouraged cycling. Learning from Victoria’s approaches, the renovation of Hong Kong’s busy streets to include bicycle-friendly infrastructure is likely to foster a similar increase in bikes on the road.

Expanding upon the need for infrastructure such as cycling lanes, the next logical step will be the introduction of bicycle rental stations. In Beijing and Shanghai, companies have set up electronic bicycle rental stations. For a set fee between 3 to 10 RMB, citizens can rent a bicycle until they return it to the electronic locking stations. With over 4000 such stations in larger cities, there was a noticeable increase in bicycle riders. Of those who began using this system, nearly 60% swapped from riding buses, and 10 to 15% from riding motorcycles (Tang et al., 2011). Hangzhou, Shanghai and Beijing all saw significant increases in cycling and higher regard for cycling in these studies. Similar systems are already appearing in the New Territories of Hong Kong. With over 3 million of the population living there, there is nearly 225km of cycling track, most of them in this area. Even without data from researchers, day-to-day observations show a higher percentage of cyclists in areas with better infrastructure like New Territories.

Besides promoting cycling, lowering the number of vehicles on the road by promoting public transport also helps reduce the “vehicle-first” mentality. From 1998 to 2017, there were 32,709 incidents where cyclists were injured in collisions with vehicles, accounting for around 8% of all transport-related accidents (Xu et al., 2019). The increase in fatalities aligns roughly with a time when private vehicles became a symbol of wealth and similarly became more accessible. Given Hong Kong’s convenient public transport system, the increase and continued use of private vehicles stem from the mindset of citizens and not infrastructure. Through continued promotion and education about

the public transport system, citizens can be encouraged to move away from private vehicles and the "vehicle-first" mentality.

Despite these ideas being put into use in other cities, there is one major challenge. Hong Kong's lack of space. Beijing is 15 times larger than Hong Kong, with wider roads and more room to develop bicycle infrastructure. With roads barely large enough to accommodate 2 vans side by side, adding bicycle lanes would disrupt the flow of traffic and public transportation. Residents too, lack space to house their bikes. Without rental stations, biking will not be possible for many. Some areas in Hong Kong also lack public transport and generally house richer residents who prefer owning their vehicles. While these solutions would work well with other cities, Hong Kong's lack of space and relationship with wealth make dismantling the "vehicle-first" mindset even more difficult.

The "vehicle-First" mentality is a concept deeply ingrained in the wealth-oriented mindset of Hong Kong. Combined with the city's lack of space, dismantling this mentality is incredibly difficult. However, by developing infrastructure, making bikes more accessible and encouraging the use of public transport to lower the number of cars on the road, such a mentality can be dismantled, ultimately leading the city towards an environmentally friendly future.

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Credit Trading For Urban Emission Reduction

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Currently, the energy emission of urban areas has occupied a large portion of total carbon emissions. The International Energy Agency estimates that urban areas contributed 67% and 71%, respectively, to the global primary energy demand and energy-related CO2 emissions for the year 2006 (Dhakal, 2010). To control the carbon emissions of citizens in urban areas, it is feasible to use a credit trading method, which allows citizens to save the credits for reducing emissions during daily life and use the credits to buy products from the industry, then the reduced emission is accounted to the industry. This would aim at the most easily reduced portion of urban emissions, promote the renovation of old infrastructures, and stimulate the flourishing of consumer economics.

First and foremost, in contrast to the difficulty of reducing urban industrial emissions, the part emitted by citizens would be much easier to reduce through many methods. For example, Bin & Dowlatabadi (2005) show the relatively high carbon intensity of electricity used in homes leads to a relatively higher share of home energy in CO2 emissions than in energy use. They also found that the total emissions from consumer expenditures account for 10% of US CO2 emissions. Thus, when the industries have spent much funding and time on updating equipment and researching new technology to reduce their carbon emissions, motivated people's action would easily cut off much of the carbon emissions in the city if everybody joins and takes action under the influence of the credit trading practice. They may achieve this by using less light, riding bicycles more or buying local products.

Secondly, the practice would help with green building transformation. Green infrastructure is a means for simultaneously advancing environmental sustainability, smart growth, and now climate adaptation goals in urban settings with a goal of creating more resilient metropolitan communities (Cameron et al., 2012). However, the popularization of green infrastructure is mostly promoted by giving subsidies. According to an article in The Economist, "in Italy, you can claim the full cost of green home renovations, plus an extra 10% through generous tax credits worth up to €100,000 (US$104,000) per home. An eye-watering €21bn has been paid out under this scheme since its launch in July 2020, often to wealthy homeowners" (2022). With the help of these practices, however, people would include carbon emission into their consideration and tend to add equipment like heat pumps instead of fossil-fuel boilers, and use natural sunlight instead of electric light bulbs. That way they may get more credits for emitting less greenhouse gas and exchange the products they want.

The next point is about the stimulation of the economy that the credit practice would achieve. For low-class families, it is hard for them to afford the cost of buying new furnishings, electric devices, or new vehicles that may be necessary for their life. However, those families usually have the lowest carbon emissions, which means they may receive more credits for that. As industries in all fields would be likely to participate in the project to relieve the burden of emission reduction and to vend unsalable products, people in the lower classes may find the credits a useful tool for getting necessities and filling budget insufficiency. This would to some extent help with social injustice. Families using fewer resources would receive credits in return and make a better living if they help with green infrastructure construction, for example, contributing to urban agriculture.

Admittedly, the idea may seem a bit unapproachable because of the difficulty to actualize it. It would be hard for all the governments and industries to come up with a unified regulation for measuring the carbon emission of every family. Another difficulty is guaranteeing the accuracy of the measurement, preventing people from using loopholes to make a profit. This problem could be primarily solved by inventing an online bank, which connects with the electricity meter of the house

and calculates carbon emissions due to the local electricity generation method. The bank would link to the public transportation payment system and give credits. People can also get certifications for participating in environmental-friendly activities and get corresponding credits, which would motivate citizens to do more environmental protection.

In conclusion, initiating a carbon credit trading system would help motivate people to live in a more environmentally-friendly way. The best point about this practice is that citizens will not feel pushed because they are getting a profit by caring for their community and protecting the whole environment. As only requiring urban industries to reduce their emissions may be ineffective, it is a brand new idea for policy-makers to consider the influence normal people could achieve when their demands are also put into the market.

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Vertical Greening Systems: City Thermostats

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Rapid urban development has caused huge environmental issues throughout the world, which compromise human welfare and the sustainability of cities themselves. Among them, the most severe and well-known one is climate change, mainly due to carbon emissions. This article introduces a type of green infrastructure that mitigates carbon emissions and urban warming by absorbing CO2 in urban areas, called Vertical Greening Systems (VGS). VGS consist of vertical structures that spread vegetation that may or may not be attached to a building facade or to an interior wall (Luis Pérez-Urrestarazu, 2016). VGS matches the conditions of many modern cities well, as most of them have tall buildings, dense populations and limited open spaces. To address the problem of urban temperature rise, all actors in the city should work together and install more Vertical Greening Systems, using commercial and residential buildings.

Promoting Vertical Greening Systems within urban communities have large social implications, since they are very suitable for urban areas, and serve as an innovative and rapidly developing field towards sustainable and environmental construction (Bass and Baskaran, 2001). Considering urban spaces are much denser than before, and the fact that development and expansion of cities has traditionally been guided by the criterion of maximizing the constructed area to increase profitability (Luis Perez-Urrestarazu, 2016), enjoying open green areas is a difficult task for dwellers of many cities. VGS provides a perfect solution to solve this problem. The use of the outer surfaces of buildings offers the possibility of increasing the vegetation presence in densely-built urban areas that have a minimum of traditional horizontal green spaces (Luis Perez-Urrestarazu, 2016). Moreover, VGS provide a place for recreation and retreat where people can enjoy quiet moments amidst dense urbanity (Yuen and Nyuk Hien, 2005), which shows both ecological and aesthetic value.

One major environmental benefit of Vertical Greening Systems is the mitigation of urban warming by absorbing carbon dioxide in the atmosphere. Urban areas are known to be major concentrators and emitters of multiple contaminants resulting from human activities within the built environment (Diamond and Hodge, 2007). As a result, carbon dioxide (CO2) and harmful toxins such as Volatile Organic Compounds (VOCs) frequently reach damaging atmospheric levels in some metropolitan areas (OMS, 2011). Carbon dioxide is used by plants for the photosynthesis process creating oxygen and biomass; nitrogen and sulfur dioxides are converted into nitrates and sulfates in the plant tissue. The fine dust particles (PM) are mainly adhered to the outside of the vegetation parts (Ottelé et al. 2010; Stemberg et al. 2010). Therefore, vegetation is a perfect sink for airborne particles.

Additionally, Vertical Greening Systems can reduce excessive heating caused by solar radiations and the urban heat island (UHI) phenomenon, and thus cooling high temperatures. Greening façades and roofs absorb great quantities of solar radiation thanks to the growth of plants and their biological functions. There are many studies illustrating their significant contribution in reducing temperature. Field measurements, conducted in Germany by Bartfelder and Köhler (1987a, b) on a wall covered by plants in comparison to a bare wall show a temperature reduction in a range of 2–6° on green façades (Katia Perini, 2013). Onishi et al. (2010) also show that in areas covered by trees temperature is lower by 2–4° than in areas without this kind of protection. These statistics all demonstrate the ability of VGS to reduce temperatures and positively affect buildings' insulating properties. Moreover, the use of vertical greening systems could reduce the energy demand for air conditioning significantly, leading to less energy waste and more sustainable development in cities.

However, Vertical Greening Systems' major drawback is that they are hard to maintain. They need to be pruned regularly. In addition, the current cost is high because of the difficulty of training people in this job and this type of technique is not advanced. My best solution to this problem is for the government to develop the industry of pruning VGS while advancing them. The government can encourage companies to develop businesses specializing in VGS management by issuing subsidies and other means. This encouragement might also lead to increased job opportunities for individuals. If there is a stable and thriving industry chain, more and more people will be engaged and specialized in this work, and corporations may compete with each other so that the cost will be lowered.

Taken together, VGS are novel green infrastructures that meet the goal of increasing sustainability of densely built urban areas. A few months ago, I learned from the news that a community in Changsha, China mismanaged its VGS, and the plants swelled to cover the entire building. After learning about this, I began to think what I would do if I were a relevant organization in Changsha. Upon learning a lot about VGS these days, I eventually thought that the best solution is for the government to educate citizens about the importance of VGS, and beyond that, the idea that building Biophilic cities is not only the responsibility of the government, but all citizens.

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Electric Vehicle Policies

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Climate change has a huge impact on citizens' life, including increases in temperature and sea level due to the increased levels of greenhouse gasses like carbon dioxide. Transportation accounted for the largest portion (27%) of total U.S. GHG emissions in 2020. Light-duty vehicles accounted for the largest portion (57%) of total U.S. Transportation Sector GHG emissions in 2020 (US EPA, 2022). By introducing more electric vehicles (EV), carbon emissions will be reduced. Also, the environmental problems are more severe in urban areas than rural areas. However, some urban residents do not believe electric vehicles are practical. First, electric vehicles cannot travel so far since they need to be recharged after a certain distance. In fact, there are a limited number of electric chargers in urban areas since there is little space for parking lots. But for most people, there are only 15 to 20 miles for them to commute, which can be managed by a single battery charge. These problems can only be solved at the government level, so the urban government should create some policies that provide practical and economic incentives to mitigate the issue that urban residents are not willing to purchase and use electric cars.

If the government takes charge of the land, it will have access to construct facilities, and there will be more EV charging stations for urban areas. In this way, it will be convenient for residents to find a place to charge their electric vehicles. For example, in the US on November 15, 2021, President Biden signed the Bipartisan Infrastructure Law, which contains significant new funding for EV charging stations. There are two programs: The National Electric Vehicle Infrastructure Formula Program ($5 billion) and Program for Charging and Fueling Infrastructure ($2.5 billion). Both of them provide funding to states to strategically deploy electric vehicle charging infrastructure (US DOT, 2022). More and more EV charging stations and infrastructure will be constructed. In Shanghai, July 2020, the government unveiled plans to add 100,000-200,000 public and private EV charging points over the next three years. Beijing is on track to build at least 50,000 new EV charging points and around 100 battery exchange stations before the end of 2022 (Argus, 2021). Residents with electric vehicles can easily find an EV charger, which solves the problems of limited miles that electric vehicles can run. As a result, urban residents will have practical incentives to purchase electric vehicles and utilize them.

Urban governments have enough power and money to support policy. Also, they can create appropriate policies that meet residents' strong desires. In order to encourage the use and purchases of environmentally-friendly vehicles, Shanghai CIty government provides free special license plates (green-coloured) to new consumers of electric vehicles. Special license plates in Shanghai are not subject to the license rationing system, which helps reduce the gasoline vehicles.(Argus, 2021) This is good news for Shanghai residents since if they purchase electric vehicles, they will save a huge amount of money and time on license plates. As a result, the sales rose for the seventh consecutive month to 179,000 units in January, hitting an all-time high in monthly sales.

With the policy of subsidies, the price for electric vehicles will decrease, which will be affordable for all income groups. China's expensive incentive programme has been credited with creating the world's largest EV market. To encourage the adoption of EVs, the Chinese government started providing generous subsidies for EV purchase in 2009, as EVs were costlier than conventional internal combustion engine vehicles. Since then, the central government has spent more than RMB 200 billion on EV subsidies, with local governments supplementing an additional RMB 100 billion or US$47 billion in total. In 2014, China announced its plan to extend these subsidies as part of continued efforts to jump-start plug-in sales and reduce air pollution. That investment paid off. In 2016,

for example, the combined sales of EVs and PHEVs in China increased 62 percent to 336,000 units, making it by far the biggest market for hybrid vehicles worldwide, with a share of 44 percent of global sales (Giulia Interesse, 2022). As a result, subsidies are effective for providing residents with economic incentives.

Although subsidies will provide residents with economic incentives, it is unfair for poor residents. Subsidies will help companies to reduce their production cost, which in turn reduces the price for electric vehicles. The vehicles will be affordable for people from low income groups, but rich people can also purchase an electric vehicle at a lower price. In this way, rich people pay a lower fraction of their income, while the poor pay a higher fraction of their income. This will increase the wealth gap between the poor and rich.

In urban areas, because of some reasons like limited charging stations and high cost, residents are not willing to purchase and utilize electric vehicles. The government needs to create policies to address this problem and provide residents with economic incentives. In this way, there will be more electric vehicles on the road, emitting fewer greenhouse gasses. As a result, climate change will be slowed down, and residents will have a greener life.

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Light Pollution Control in Urban Areas

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Benefiting from the invention of lights, people can prolong their activities to night. Because of urban sprawl in modern society, citizens use more artificial light in urban areas. Greater areas are exposed to light at night, which can cause light pollution: excessive artificial light occurring in dark conditions. Artificial lights may alter natural light regimes in terrestrial ecosystems, influencing the behavior and communities of species and resulting in biodiversity loss. It may also hinder astronomical observation and disrupt human sleep (Longcore & Rich, 2004). The issue of light pollution is becoming increasingly severe today. In China, two-thirds of the population experience light-polluted nights, and one-third never see the Milky Way, and this trend will escalate in the future (You Li, 2018). To address the issue of light pollution, the government should establish more targeted and universal policies on light pollution, which can change the current materials of illumination lamps, enhance the education level on light pollution, and regulate more sectors to cooperate in light pollution mitigation.

To begin with, a new policy could modify the current lightbulb manufacturing method, which can make up for shortcomings in existing policies and propose more effective ways of light usage. Many countries have implemented policies to promote the broad adoption of LED (light-emitting diodes) light in most urban areas. Applying LED lights in specific scenarios can save energy, for they “have the ability to produce high luminous flux with low radiant heat output and maintain their light output efficacy for years” (Singh et al. 2015). However, because of high luminous efficiency, LED lights can produce much more visual brightness than other sources, resulting in over-illuminating. By contrast, sodium lamps produce less brightness (Luginbuhl et al., 2014). Therefore, instead of maintaining broad adoption of LED lights, the new one which encourages the LED lights usage in scenarios that require enough illumination to increase efficiency, such as streetlight illumination, with an additional design of specific protection layers put around the LED lights to avoid over-illuminating, and promote the usage of sodium lamps when little light is needed, such as the light of advertising boards at night, can be more effective in achieving the optimum solution for light pollution mitigation. This policy makes up for flaws in current policies and can hit two birds with one stone by ensuring both energy efficiency and light pollution mitigation.

In addition, the policy can enhance the environmental education level, which can also help address the issue of light pollution. Higher education level is an essential factor in addressing light pollution. More advanced ecological education can “present significantly positive effects on environmental awareness.” Students with better environmental awareness present more positive attitudes toward environmental protection (Yang Li, 2018). This cognitive fix must be considered and tested no matter how simple its assumptions are (Heberlein, 2012). Environmental education should be compulsory (Gifford, 2014). However, in China, the regulations are limited to broadly impacting the practice of environmental education in schools (Yang Li, 2018), and few teenagers realize the importance of addressing light pollution. Thus, establishing a new policy that requires schools to include compulsory courses about light pollution mitigation for teenagers and fines the school if they don’t follow the policy will enable more teenagers to engage in addressing light pollution. Learning about light pollution at school allows teenagers to raise awareness of light pollution mitigation. Thus, civic engagement increases, effectively managing the light pollution problem.

Besides raising education levels regarding light pollution, the policy can also include regulations that call on different sectors to mitigate light pollution. Besides individuals, the role of

Non-Government Organizations (NGOs) in addressing light pollution cannot be ignored. NGOs can provide independent science-based advice on light pollution mitigation. Currently, little cooperation occurs because individuals may not trust the NGOs. “They are seen as lobbyists against governments or even competitors” (Al Mubarak & Alam, 2012). However, by recognizing the NGOs’ contribution to light pollution mitigation in a nation’s law policies---such as their suggestions on the design of protective layers around the LED light or their efforts in advocating the importance of light pollution mitigation---citizens will trust them because they think legal authorities are honest and act in ways that have citizens’ best interests at heart (Tyler & Jackson, 2013), and thus develop a harmonious relationship in cooperating.

It can be difficult for the central government to supervise the progress of policy implementation. In China, there are so many provinces that a central government doesn’t have enough time and effort to manage policy supervision in every region. However, this problem can be solved by dividing the supervision tasks and assigning them to the local government. The provincial government then can report the local situation to the central government, including technological progress, education enhancement, and the process of cooperation. Thus, policy implementation can be more precise and effective in mitigating light pollution.

To sum up, light pollution is a severe problem in urban areas. Current regulations on light pollution mitigation are not enough. Establishing a combination of new policies that direct using different light sources in different situations, giving education programs, and requiring cooperation can help solve the problem because it can both make up for current policies and increase the efficiency of addressing light pollution.

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