Sustainable Transportation for all: An Analysis of Non-Motorized Transport

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Abstract

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As modern urban planners look towards sustainable solutions to combat the effects of climate change, one sector of particular interest has been transportation. Sustainable Transportation seeks to shift away from the automobile dependent habits of the past century, towards transportations options that mitigate the affects of climate change, enhance mobility, and promote equity. One of the key aspects of Sustainable Transportation, Non-Motorized Transport (NMT), has been of particular interest to many cities and planners as of late. This paper provides a comprehensive overview of Non-Motorized Transport, the benefits, challenges, and opportunities of this form of Sustainable Transportation. Three groups of policy strategies for planners to utilize to encourage Non-Motorized Transport are identified. Land use changes encompass long-range transformations to the built environment to increase walkability and cyclability. Infrastructure improvements include various facilities for pedestrians and cyclists to navigate safely and efficiently, and regulatory measures provide legal incentives for non-motorized travel and disincentives to automobile use. Examples of Washington D.C. and

Paris, France are articulated for their utilization of these strategies to promote Non-Motorized Transport in their respective contexts. Lastly, the analysis is used to speculate possible recommendations for the city of Seattle, and how planners might encourage more non-motorized means of transportation within the city.

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Chapter 1: Introduction

Across the world, policymakers are faced with the inevitable truth that has only become more clear: unless actions are taken now to reduce greenhouse gas emissions, human-induced climate change will continue to cause widespread damage and loss, especially to vulnerable communities across different sectors and regions. This fact has been reiterated by the Intergovernmental Panel on Climate Change (IPCC) in every Assessment report, yet we are still seeing slow progress to reducing carbon dioxide and equivalent emissions in our atmosphere. With the prevalence of climate-related impacts increasing in recent years and increasingly louder calls from cities to address this issue, decision-makers are beginning to closely examine policies that reduce their carbon footprints. While the international community has pledged to reduce emissions over the next several decades, urban/city planners must examine how to pursue these goals on the municipal level. Researchers agree that city-level implementation will have the most effective impact on reducing greenhouse gas emissions, because of their access to resources and scale of investment (World Bank, 2021). Of course, while the climate crisis is an incredibly critical issue that demands a large amount of attention in policy, it is not the only topic that decision-makers must concern themselves with. Thankfully, many policies that mitigate greenhouse gas emissions have secondary benefits in other aspects of society. These are commonly referred to as “co-benefits.” As the impacts of climate change will continue to have a greater impact on more vulnerable communities (IPCC, 2021), more emphasis should be placed on the equity implications of such policies and their co-benefits. This is where this paper seeks to place itself, by examining the equitable co-benefits of Sustainable Transportation;

specifically, Non-Motorized Transport. Transportation plays a vital role in our everyday lives and thus, policies that impact mobility and climate must be examined through a lens of equity. This thesis examines the benefits, challenges and opportunities of Non-Motorized Transport and provides a framework for how policy makers and advocates can pursue effective and equitable strategies.

Chapter 2: Methods

This examination is conducted via a landscape analysis of relevant literature as it pertains to climate-related policies that have co-benefits that enhance both equity and mobility. These literary sources are composed of peer-reviewed journal publications, accessed through *the Journal of Planning Literature (JPL)*, *Journal of Planning Education and Research (JPER)*, and other sources, accessed through the University of Washington's digital library. Also, data and statistics from relevant local, federal, and international agencies is included when relevant. This analysis provides an overview of how Sustainable Transportation benefits climate change mitigation, mobility, and equity goals. As a subsect of Sustainable Transportation, Non-Motorized Transport (NMT) is discussed, along with the benefits, challenges, and opportunities of two key aspects of NMT: Active Transportation and micromobility. As is elaborated in the literature review, Deakin (2002) articulates a definition of Sustainable Transportation that requires such programs and policies to equitable community engagement. Thus, after discussing Non-Motorized Transport, a section of this paper is dedicated to exploring equity in the public participation process through two schools of justice: communicative planning theory

and justice. The discussion section then provides three groups of strategies that decision-makers can utilize to promote Non-Motorized Transport and thus, pursue climate policy that has co-benefits for both equity and mobility. Two examples of cities that have utilized these policy areas are presented, along with the impacts of implementing these strategies. The knowledge of this analysis is then applied to provide recommendations for decision-makers in the Seattle area to encourage more Non-Motorized Transport use.

Chapter 3: Literature Review

The term Co-Benefits is generally used when discussing climate policy. The Intergovernmental Panel on Climate Change (IPCC) first used the term in the Fourth Assessment Report in 2007 to describe the additional improvements to additional aspects of society from policies that mitigate greenhouse gas emissions. These included better air quality, reduced waste, more biodiversity, economic growth etc. The term has appeared in all the subsequent IPCC assessments and has been adopted by a number of additional international organizations such as the International Renewable Energy Agency, United Nations Climate Change Conference, and many more. Karlsson et al. (2020) provides an extensive review of 239 peer reviewed articles discussing these co-benefits. Capturing co-benefits can make climate actions more affordable, sustainable, and feasible to policy makers (Mehrotra et al., 2018). The most documented, and often highest valued, co-benefits of climate policies tend to be those that improve public health and reduce air pollution. While it is vital to understand and articulate these public health co-benefits, an extensive body of literature exists on such co-benefits, and

they are often relatively well understood. Moreover, these co-benefits are better articulated by those with a public health background. As my academic background is in urban planning and policy, I set out to understand and identify climate-related policy that has co-benefits related to planning. Two topics of importance to both the field of urban planning and myself personally are mobility and equity. Thus, I aimed to identify a policy or policy area that combats the impacts of climate change that also contains co-benefits that enhance mobility and promote equity. I believe that there is a lack of discussion about how these areas of societal concern interact with one another and that identifying how to address these issues together is of the upmost importance. This brought to my attention the concept of Sustainable Transportation.

3.1 Overview of Sustainable Transportation

Sustainable Transportation is the quintessential union of climate resiliency, mobility, and equity. This concept is derived from the idea of sustainable development, which originally focused solely on development practices that mitigated damage to the environment, especially the greenhouse effect from carbon dioxide and equivalent emissions (Deakin 2002). As of late, there is a growing consensus that a focus on social and economic issues is crucial to qualify as "sustainable" development, rather than just a focus on the environmental benefits. Using the Brundtland definition of sustainability as a starting point, Deakin (2002) defines modern sustainable development as development proposals and policies that improves living standards and quality of life, while enhancing the natural environment and emphasizing local culture and history. This definition encompasses a wide range of possible sustainable development proposals. Recently, many decision-makers that wish to promote sustainable development

have taken a noticeable focus on transportation, as transportation is a prominent issue in both greenhouse gas emissions and social equity. The transportation sector contributed to 29% of greenhouse gas emissions in the United States in 2019 (U.S. Environmental Protection Agency, 2021), with the largest share of these emissions (40.5%) due to routine household travel from passenger vehicles (U.S. Environmental Protection Agency, 2021). Even when the COVID-19 pandemic reduced car use by 13.2 % from 2019 to 2020, transportation still accounted for the largest portion of greenhouse gas emissions by any sector in the United States. Hence, transportation is being viewed as a viable and impactful sector to make a difference in both climate hazard mitigation, and social issues through the promotion of Sustainable Transportation. Deakin (2002) uses her aforementioned definition of sustainable development to define Sustainable Transportation as transportation options that are “safe, of high-quality, accessible to all, ecologically sound, and economical” (Deakin, 2002). To expand on this definition, Sustainable Transportation policies must support the reduction of greenhouse gas emissions, while enhancing mobility and accessibility in an equitable way. These Sustainable Transportation policies must also include equitable public participation via a collaborative engagement process (Deakin, 2002). Thus, a review of equitable community engagement theories that promote equity both in process and implementation is discussed in the section following the analysis on Sustainable Transportation and Non-Motorized Transport. As Figure 1. demonstrates, Sustainable Transportation is the key policy area when identifying climate related policy that has co-benefits in mobility and equity.

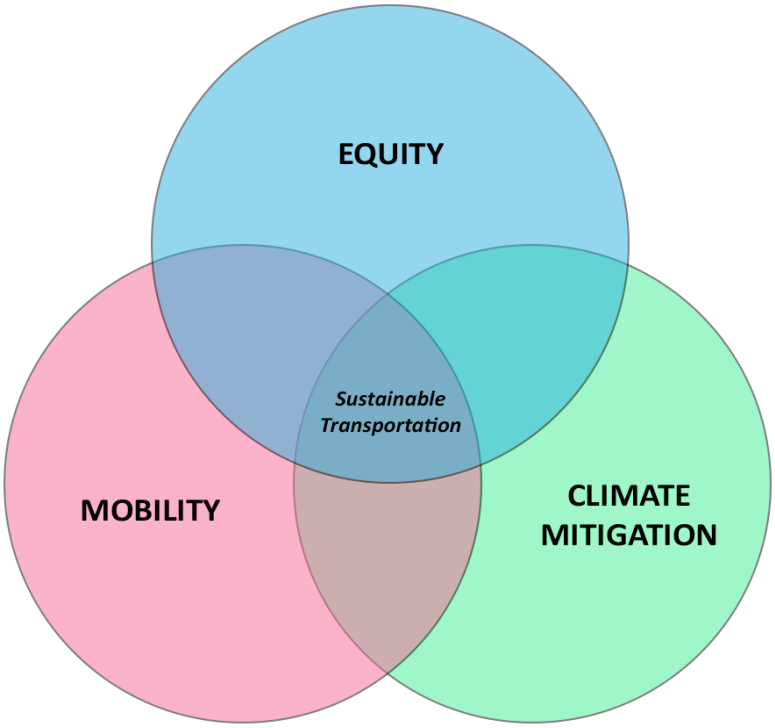

Figure 1: Sustainable Transportation as the Union of Climate Mitigation, Equity, and Mobility,

Some have touted the change of personal automobile fuel from carbon dioxide emitting combustion engines to alternative sources (electric, biofuel, hydrogen, etc.) as a form of Sustainable Transportation. While alternative fuel automobiles do mitigate greenhouse gas emissions, the reliance on a personal automobile presents barriers to low-income populations (Crisp & Gore, 2020) and automobile-based urban transport systems fail to provide mobility for significant segments of urban populations. (Mehrotra et al., 2018). Additionally, alternative fuel personal automobiles cost tens of thousands of dollars and although their prices have been declining over recent years, they still are far more costly than a traditional combustion engine automobile to the consumer (Lutsey, 2019). This presents significant barriers to low-income populations. As stated earlier, Sustainable Transportation must be socially inclusive and

promote social equity, in addition to reducing greenhouse gas emissions. With this in mind, we will not be considering non-C02 emitting personal automobiles as a form of Sustainable Transportation. Thus, Sustainable Transportation can be separated into two remaining categories: public transit, and Non-Motorized Transport (NMT). Sustainable transportation policies that affect transit include both improvements to public transit accessibility, as well as reducing the greenhouse gas emissions of current transit infrastructure. Electrification of existing systems, reduced-fare programs, priority lanes, etc. are all transit policies that benefit both social welfare and the environment. While there are numerous studies and investments into these public transit policies, research into Non-Motorized Transport is significantly less understood and is the focus of this analysis.

3.2 Non-Motorized Transport

NMT encompasses walking, cycling, and other non-motorized means of transportation, which account for about half of all trips in many cities (Mehrotra et al., 2018). While these modes of travel long pre-dated the invention of the combustion engine, the last 100 years of urban development in the United States has largely focused around and for the personal automobile. However, with the rise in rethinking how our cities and transportation networks work better out society, there has been a shift that has brought Non-Motorized Transport back into the forefront of Sustainable Transportation policies. The absence of a carbon dioxide emitting source means that these transportation options are very impactful to climate change mitigation. Moreover, focusing on walking, biking, and other non-motorized means is

inherently more focused on the everyday human experience, which creates an important opportunity to concentrate on social equity promotion.

The following section examines the benefits, challenges, and opportunities of non-motorized transport, and is split into two sections: Active Transportation and Micromobility. The recent and swift rise in popularity of shared bikes, e-bikes, and e-scooters, along with the differences in how people use this mode, requires the partitioning of micromobility into its own section. Active Transportation, as is expanded upon, encompasses traveling via walking or *personal* non-motorized vehicle. The purpose of this section is to give examples of how and why policies that support non-motorized, Sustainable Transportation should be encouraged, how they benefit both the environment and users' mobility in an equitable manner, and to elaborate on the implementation barriers that are currently in place. This should provide a comprehensive and feasible overview for policy makers and community groups that wish for cities to pursue this form of Sustainable Transportation.

3.2.1 Active Transportation

As shared micromobility is discussed in its own section, Active Transportation is limited to walking and the use of *personal*, non-motorized vehicles to reach a destination. This also divorces Active Transportation from leisure- and sport- related trips. While using non-motorized means for these purposes should be encouraged, our focus remains on walking and cycling for commuting and other non-recreational purposes. The primary benefit of this mode of transport is the reduction in automobile trips. In urban settings, increased greenhouse gas emissions and the associated extraneities of increased automobile use (congestion, health

impacts, etc.) are often the primary motivating factor behind policies that support Active Transportation. The co-benefits of the public health benefits of walking and cycling are far reaching and well documented. While it seems rather intuitive that more walking and cycling leads to less Vehicle Miles Traveled (VMT), which in turn reduces carbon dioxide emissions, the actual level of reduced emissions can be hard to quantify. In attempt to fill this knowledge gap, Brand et al. (2021) conducted a multi-city analysis of over 10,000 participants to assess these emission reductions. The study found that those that cycled as a primary mode of transportation were responsible for 82% less CO2 emissions than non-cyclists and that switching from an automobile to cycling or walking can reduce an individual's emissions by 7.1 kgCO2 per day (Brand et al., 2021). This proposes a significant of carbon emissions can be mitigated by switching from primarily automobile travel to Active Transportation. Additionally, Active Transportation is a preferable mode of travel because it is accessible to all populations when there is adequate infrastructure and planning for such modes. Owning a personal bicycle or other non-motorized vehicle is significantly less costly than automobile ownership, and walking provides even lower barriers as a travel mode.

While the benefits of Active Transportation sound great on paper, most Americans still use an automobile as their primary source of travel mode. Each American household has an average of 1.88 vehicles, and over ninety percent of all households own at least one automobile (U.S. Department of Transportation, 2019). Seventy percent of commuters drive alone to travel for work, while only 2.65% walk and 0.55% bike to work (U.S. Department of Transportation, 2019). These rates are, in part, the fault of U.S. development patterns. After the invention and adoption of the personal automobile the 20th century, car-centered urban sprawl took over as

the primary development pattern in the United States. Sprawling development accelerated through the post-war period, peaking in the 1990s (Barrington-Leigh & Millard-Ball, 2015). Urban sprawl has a well-documented link with increased vehicle miles traveled and transportation demand (Center for Sustainable Systems, 2021). These development patterns and supporting infrastructure investments are persistent, locking in American urban form into a path-dependent nature of sprawl (Barrington-Leigha & Adam Millard-Ball, 2015). Even as sprawling development patterns have declined in the 21st century, the average population density of a Metropolitan Statistical Area (MSA) in the United States is still only 283 people per square mile (Center for Sustainable Systems, 2021). These low-density development patters present barriers to providing adequate Active Transportation infrastructure.

Another challenge in encouraging more Active Transportation is that increasing rate of pedestrian-vehicle and bicycle-vehicle crashes and fatalities. In the United States, pedestrian fatalities per year increased 46% from 2009 to 2016 (Schneider, 2018). While some believe that higher rates of Active Transportation may have led to the increase in crashes (Sener et al., 2019), there are certainly other factors at play that are responsible for this high number of fatalities other than simply more people walking and cycling on or near the road. Theories include the increased weight in passenger vehicles, an aging population that is more vulnerable to injury, and more distracted drivers due to technological distractions (Schneider, 2018). Nevertheless, safety is an important facet of Active Transportation when considering strategies for implementation.

The biggest opportunity for Active Transportation is to substitute automobile use on shorter trips. However, there are more factors to consider than simply user preference. These

include time and distance constraints, carrying heavy goods, additional passengers, needing the car for subsequent trips, bad weather, and seasonal constraints. (Mackett, 2001, 2003). To capitalize on the benefits of Active Transportation, it must be convenient and preferable for commuters to travel by foot or other non-motorized mode. This requires that the trip between destination and origin must be relatively short and safe. While planners and decision-makers primarily concern themselves with changes in residential patterns to achieve this goal, often overlooked is the dispersal of destinations (Mailbach et al., 2009). The spatial distribution of grocery stores, retail centers, schools, cultural centers, places of employment, and other amenities must be accessible from residential areas, if people are going to switch their mode of transportation from personal automobile to a walking or cycling. Strategies to achieve this goal are outlined in the discussion section.

3.2.2 Micromobility

For the purposes of this paper, micromobility can be defined as shared, human or electric powered, low-speed, light-weight vehicles. This includes both docked and dockless varieties of shared bikes, e-bikes, e-scooters, and so forth. Figure 2 and Figure 3, taken from The National Association of City Transportation Officials (NACTO)'s 2019 report, show the spatial distribution and size of these systems across the United States. As the use and popularity of this mode choice has grown rapidly in recent years, micromobility has shown potential to reduce greenhouse gas emissions by replacing automobile trips with these electric or human powered options. Kou et al. (2020) found that most trips replaced by bike share in eight American cities would have otherwise been automobile tripes. They estimated that bike

share accounted for reductions in greenhouse gas emissions of 287 g CO2-eq/passenger-mile saved in Los Angeles, California, and 353 g CO2-eq/passenger-mile saved in Chicago, Illinois (Kou et al., 2020). Another study in Portland, Oregon document the mode share switch to a private e-bike service. This study found that increasing e-bike mode share from 0 to 15 percent, would result in a 10 percent decrease in automobile trips, resulting in an emissions reduction of 11%, from 8,079 metric tons of CO2 to 7,158 metric tons (McQueen et al., 2019). These studies all provide quantitative evidence of the potential impact of mode share switch from automobiles to micromobility vehicles.

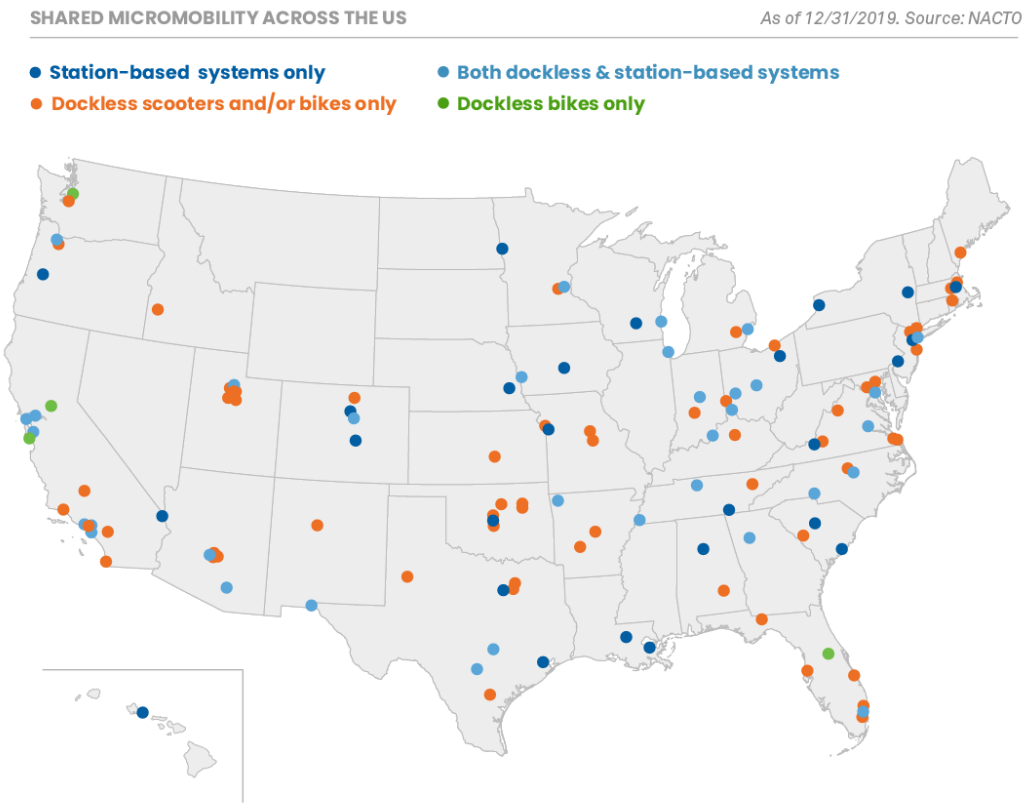

Figure 2: Micromobility Systems Across the US. Source: National Association of City Transportation Officials (2019).

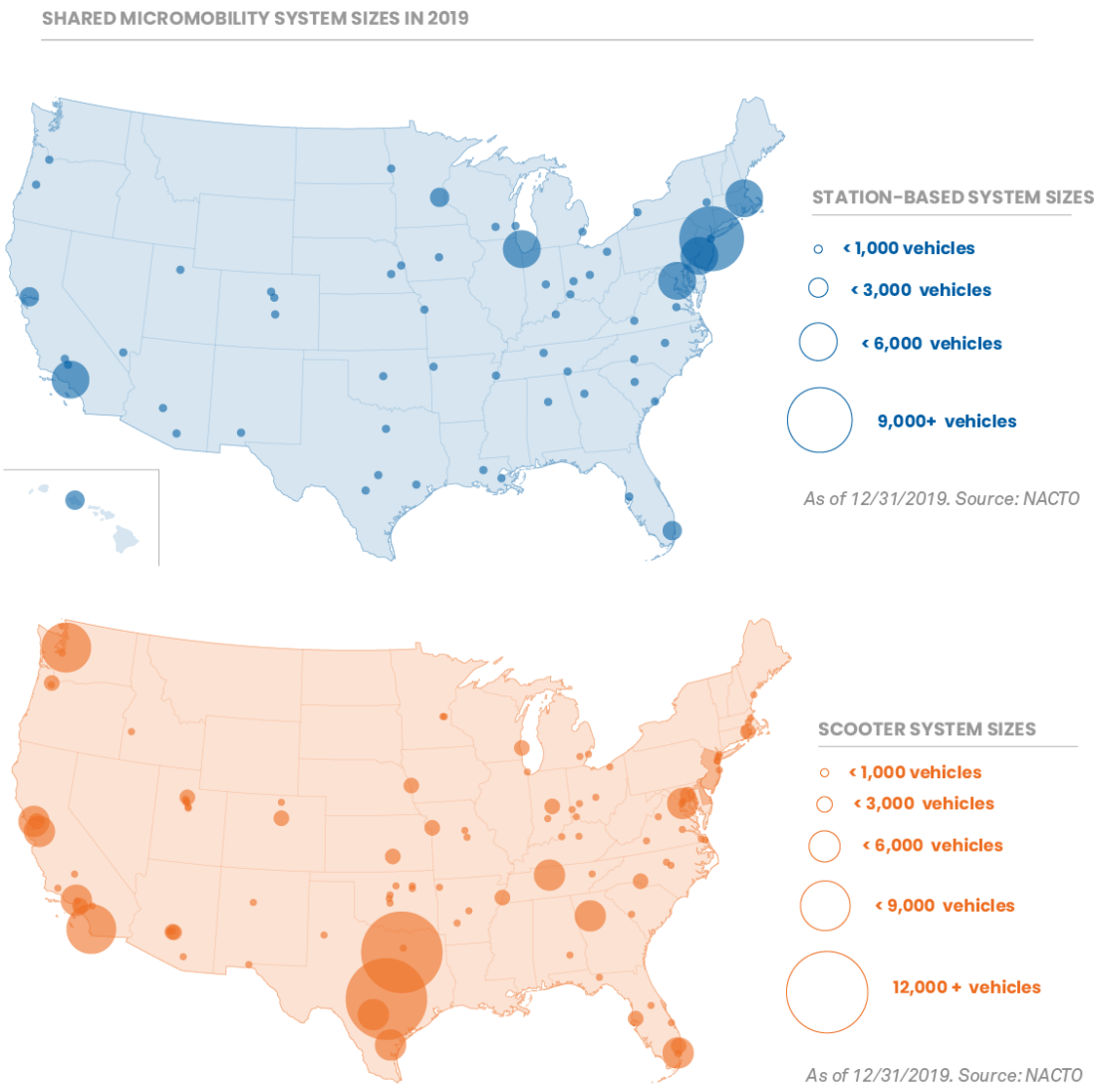

Figure 3: Micromobility System Sizes Source: National Association of City Transportation Officials (2019).

Despite these potential benefits, there are challenges and barriers in implementing effective micromobility systems. Both docked and dockless systems have tradeoffs; docked

bikes provide significantly less geographic variation and variability of destinations, but ease parking concerns for collection. Dockless bikes and scooters allow for more user autonomy and are often less expensive than docked systems (Stowell, 2020). However, more geographic variation brings barriers to collecting, charging, and balancing the system. (McQueen et al., 2021). Furthermore, many studies have examined the safety concerns with dockless systems (Allem & Majmundar, 2019; Badeau et al., 2019; Bresler et al., 2019; James et al., 2019) as the rapid rise in popularity has left the regulatory framework regarding micromobility struggling to catch up (Zou et al., 2020). Zakhem & Smith-Colin (2021) provide an analysis of two major challenges with dockless micromobility usage: parking demand and infrastructure. They argue that a more detailed understanding of how and where people are using these services is fundamental to improving safety, reducing cluster, and enhancing the experience for both micromobility users and pedestrians alike. Their GPS trajectory data method provides an interesting tool that cities may be able to use to identify where the need for infrastructure and parking improvement efforts should be focused (Zakhem & Smith-Colin, 2021).

As with any transportation system, there are also challenges with creating a fluid and efficient micromobility network. Many system operators cited a lack of infrastructure that supports safe and effective bike and scooter usage as an influential barrier to servicing different cities (Howland et al., 2017). Moreover, people are much more likely to use micromobility vehicles when adequate infrastructure supports the use of bikes and scooters. Zhang et al. (2021) found that e-scooter riders traveled 59% longer on bikeways and 28% longer on multi-purpose paths. While there has been a push by policy makers to upgrade infrastructure to support these modes of transportation in recent years, many places (especially in the United

States) still lack the infrastructure that truly supports multi-modal transportation. When this is the case, micromobility trips are often relatively short. McKenzie (2019) documented that in Washington D.C.. average e-scooter trip was 0.4 miles, and Capital Bikeshare trips averaged 1.62 miles. This data supports the idea that micromobility is often not a reliable or preferred choice for longer trips, which are still largely automobile trips. There are concerns that these short trips often replace and/or compete with walking and transit trips, effectively negating the potential for greenhouse has reduction. A study in Portland, Oregon reported that nearly a third of all e-bike trips replaced either walking, traditional cycling, or public transit trips (McQueen et al. 2021). Moreover, studies show that the net lifecycle greenhouse gas emissions associated with e-scooters often exceed net emissions of buses, due to their short lifespans, and emissions related to collection and distribution (Hollingsworth et al., 2019). The rapid rise in popularity, without the necessary infrastructure and integration investments have led to the state of most micromobility systems as a scattered, uncoordinated assortment of electric vehicles that are used primarily for leisure and recreation.

There are also some equity concerns in micromobility usage. Prices and payment systems are often significant barriers for potential users to participate in shared micromobility (Howland et al., 2017). Even when city governments require private firms to supplement this by requiring them to supply vehicles to underserved areas, they were met with mixed results. One of the most ambitious equity requirements was enlisted by the City of San Francisco. Despite trying to combat concerns from a variety of angles, including discounted rates, free rides, integrated payment systems, and identifying communities of concern, participation in their equity program was, unfortunately, quite low (Anderson-Hall, 2019). Additionally, the data

needed to evaluate equity and affordability is often considered proprietary information by private firms, and cities have a tough time when entering data sharing agreements with these companies. Cities that have tried to manage their own micromobility systems have been met with mixed results. In Seattle, the bikeshare program Pronto struggled financially due to a variety of factors. This public-sponsored system was eventually shut down, and the private system that replaced it saw more usage in its first four months that its predecessor did in two and a half years (Peters & MacKenzie, 2019). Capital Bikeshare in Washington D.C. is often considered the most successful example of a municipality-run shared micromobility system and is discussed in detail later in this paper.

Despite these challenges, there is an opportunity for micromobility to expand mobility service as a first-mile/last-mile augmentation to an existing transit network, due to their relative low cost, high levels of flexibility, and negligible transfer time. (Zuniga-Garcia et al., 2022). Smith & Schwieterman (2018) conducted a study of e-scooter usage in Chicago, Illinois. They concluded that by using e-scooters to access the existing transit network, 16% more jobs would become available within 30 minutes in their study areas. Moreover, they determined that trips between 0.5 and 2 miles are more cost-effective and provide strong alternatives to driving. In Austin, Texas, Zuniga-Garcia et al. (2022) found that in the University of Texas Austin campus, every 10% increase in transit use aligned with a 2.5% increase in e-scooter usage as a last-mile option, as 12% of the surveyed population disclosed that they used micromobility as a first-mile or last-mile supplement to their transit trip. Another study in Helsinki, Finland, found that the combination of using a bicycle sharing system and transit saved an average of 6 minutes per trip, which could lead to a reduction of 10% in average travel time for the region

(Jäppinenac et al., 2013). Thus, if micromobility trips serve to replace the time spent walking, or even driving, to reach transit nodes, particularly where there are gaps in service that make transit usage less desirable, it can reduce the overall transit trip time, serving to make transit usage more desirable and competitive with automobile trips. Many cities are aware of this possibility and have placed micromobility stations in locations to optimize transfers to transit networks. This provides for an opportunity for micromobility expansion to enhance personal mobility, reduce car dependency, and mitigate greenhouse gas emissions in the transportation sector.

However, this isn't to say that cities can cut and paste a micromobility system to their network and it will automatically supplement transit usage. A study of 1,968 students at Portland State University documented that the mere existence of e-scooters does not inherently incentivize the use of them. The participants stated that when accessing the downtown area, there were no locations in the entire city of Portland, where using e-scooters to access the light rail was seen as a preferable transportation mode than driving (McQueen, 2020). This demonstrates how cities will have to research and investigate how micromobility can complement the existing transit network.

3.3 A Framework for Equitable Community Engagement

As mentioned earlier, Deakin (2002) provides a definition of Sustainable Transportation requires collaborative and equitable community engagement. This section dissects two theories of advocacy planning and justice that focus on different aspects of equity promotion within community engagement, as well as how they can be used together when practicing equitable

community engagement. As this analysis is articulated through a planning lens, it is important to understand the role that planners play in community engagement and the history of the advocacy planning movement.

The field of urban planning has a complicated history with social equity. Reece (2018) gives a comprehensive review on the history of the relationship between equity promotion and the planning field. One way to view the field is that planners exist as a bridge between local government and its citizenry. Individual planners at different points in time have existed more or less on one side of this spectrum. At one extreme, urban planners that oversaw twentieth-century urban renewal programs viewed themselves as an extension of state power. Their proposals and programs catered towards the wishes of private developers and other powerful stakeholders. These planners had little regard for the affected residents, whom were disproportionately more likely to be an ethnic or religious minority group. On the other end of this continuum, planners that subscribed the school of equity planning, sought to use their position to advocate for those that have traditionally been prohibited from decision-making procedures (Reece, 2018). The equity planning movement began to take shape in the 1970s. As the United States transitioned out of the post-war era, some professional planners began to shift their focus towards an emphasis on advocacy and equity promotion within the planning practice. (Fainstein, 2010; Reece, 2018; Metzger 1996). The failures and injustices of traditional planning practices could no longer be ignored in the face of the outcry from the civil-rights movement. These planner-activists sought to utilize their position within structures of government to influence opportunities and outcomes to underrepresented and marginalized communities via the allocation of resources in the built environment, (Reece, 2018; Metzger,

1996). While ideologically progressive, critics of advocacy planning describe how promoting social change often fell short of its goals during this time. (Reece, 2018) However, the groundwork of the modern equity moment was laid, and the theory continued to evolve. By the 1990s, The American Institute of Certified Planners' Code of Ethics and Professional Conduct identified the role of planners to "strive to expand choice and opportunity for all persons, recognizing a special responsibility to plan for the needs of the disadvantaged groups and persons, and must urge the alteration of policies, institutions, and decisions which oppose such needs." (American Institute of Certified Planners, 1991). From this movement, planners and other decision-makers have reconsidered how to engage with different populations in an equitable way. Dadashpoor & Alvandipour (2020) identity five different schools of thought that have emerged from this movement. Two of these schools, *communicative school of thought* and *just school of thought* are important to dissect, for their pertinence to the community engagement process.

Communicative planning theory began to emerge as a popular belief at the end of the 20th century. John Foster, a professor at Cornell University d escribed communicative planning theory as being grounded on the idea that marginalized communities can be empowered by providing *access* to decision-making processes, as well as related technical information (Reece, 2018). The rise in popularity of this theory, and subsequent practice, led to an increased emphasis on community involvement within the planning process. Through this theoretical lens, equity promotion in focused on the *process* of community engagement; ensuring that a diverse array of stakeholders is democratically involved in the process. This requires those conducting community engagement to go above and beyond the standard requirements, as the

legal requirements of community engagement and public participation in the United States often fall short of this goal (Innes & Booher, 2005). Far too often, disadvantaged populations are left out of the participation process, and their wants and needs are superseded by those with more political and social capital. An intentional inclusion of diverse stakeholders, especially traditionally marginalized populations, must be pursued in order achieve equity within the process of community engagement.

In addition to ensuring equity by including multiple stakeholders throughout the public participation process, another school of thought pursues equity through the outcomes of community engagement. In 2010, Harvard Professor Susan Fainstein published, *The Just City* as a twenty-first century take on equity planning that combines the progressive focus on promoting social equity from the advocacy planning era with a contemporary critique on the dominance of neoliberal policies (Fainstein, 2010). Fainstein argues that the "equity through the process" framework of communicative planning models cannot account for systemic injustices and challenges, and thus, a shift in focus is necessary. Just City Theory states that an equitable community engagement model is one where "public investment and regulation would product equitable outcomes, rather than support those already well-off" (Fainstein, 2010). The point of emphasis here is more on community engagement and public participation strategies that produce just outcomes. These "just" outcomes seek to reduce social and geographical inequities and empower marginalized groups (Dadashpoor & Alvandipour, 2020). While there are several interoperations of justice in the planning school of thought, John Rawls' *A Theory of Justice* is widely accepted as a distinguished articulation of this complex concept. Rawls acknowledges two principles of justice. The first principle states that every individual is

entitled to the same social liberties and rights to basic freedoms. The second, called the difference principle, expresses that just if any inequalities are achieved, they should benefit those less advantaged in society (Rawls, 1971). Utilizing Rawls' principles of justice, community engagement must produce outcomes that enable equal rights and liberties to all those affected, and if there are any who unevenly benefit from said outcomes, it should be traditionally marginalized or disadvantaged populations.

Rather than approach community engagement as a dichotomous choice between these two theories, a truly equitable community engagement process would both employ an equitable process and achieve just outcomes. By combining the framework of communicative planning theory and Just City Theory, a framework for equitable community engagement can be achieved. This framework is one where an intentional inclusion of diverse stakeholders, especially those that are traditionally excluded from the engagement process, leads to just outcomes that promote equity.

Chapter 4: Discussion

With the benefits, challenges, and opportunities of Non-Motorized Transport outlined in detail, we can now look at how decision-makers can successfully implement NMT policies and programs as an aspect of Sustainable Transportation. While there are many potential implementation strategies on the table, these strategies can be grouped into three areas of policy: land use changes, infrastructure Improvements, and regulatory measures. The following section discusses examples of these three policy areas, including potential challenges that

decision-makers might face, along with two examples of cities that have utilized these strategies to encourage more NMT use within their jurisdictions.

4.1 Land Use Changes

A vast number of researchers agree that the design characteristics of the built environment are directly associated with how people travel (Frank et al., 2009). Post-industrial development patterns have actively incentivized (and in some cases, necessitated) the use of the private automobile as the primary or exclusive mode of personal transport. To achieve mode shift, cities must pursue land use practices that increase walkability and cyclability. Some of the key factors of the built environment that are correlated with higher levels of walking are: increased density, mixed-use development, transit accessibility and proximity of nonresidential uses (Saelens & Handy, 2008; Frank et al. 2009). Table 1 includes various land use changes that cities can pursue to increase walkability and cyclability. Increasing urban density is one of the most impactful implementation strategies that cities can pursue, in terms of reducing automobile use. Studies show density greater than thirty-five people per hectare reduces automobile dependency in urban areas (Newman & Kenworthy, 2006) and that doubling population density can reduce carbon dioxide emissions from household automobile use by up to 48% (Lee & Lee, 2014). Frank et al. (2009) also identified higher intersection density as both a positive predictor of increased walking rates, and an inverse predictor of motorized energy consumption. Development that includes a wide diversity of uses also increases walkability and decreases automobile dependency, as mixed use, transit-oriented development has been found to reduce VMT by up to 25% - 40% over time (Cox et al., 2013).

As discussed, the United States' sprawling development, as well as exclusionary zoning and other planning practices, has created left many American cities without the proper density, diversity of uses, and other land use patterns needed to promote Non-Motorized Transport options. However, city-wide, universal densification is not only rather unobtainable, but it may also not be desirable. Thus, strategic approaches to restructure the built environment that focus on increased density, human-scaled design, and increased non-motorized travel will need to be pursued. Recently, many cities have employed principles of New Urbanism, which seeks to place the neighborhood as the basic spatial unit of organization, so that daily needs can be met with relative ease (Pozoukidou & Chatziyiannaki, 2021). New Urbanist principles include promoting Transit-Oriented-Development (TOD), urban villages, transit villages, and other compact neighborhood strategies (Pozoukidou & Chatziyiannaki, 2021). While these implementations certainly promote more walkability and connectivity at the neighborhood level, critics of New Urbanism surmise that these strategies have not helped overcome socio-spatial disparities and even exacerbated existing issues, such as increased gentrification (Pozoukidou & Chatziyiannaki, 2021). Building off New Urbanism principles, the concept of the 15-Minute/20-Minute city (or another similar variation thereof) has emerged in the last decade as an intriguing model for urban form transformation. The 15-Minute City proposes changes to the built environment so that most residents of a city can fulfill their daily needs and activities within 15 minutes of walking or cycling (Moreno et al., 2021) through four planning attributes: walkability, density, land-use mix, and design diversity (Pozoukidou & Chatziyiannaki, 2021). The main contrast from this model from New Urbanism and similar approaches is a focus on proximity, rather than accessibility to basic services (Pozoukidou & Chatziyiannaki, 2021).This

places more of an emphasis on the spatial distribution of services and facilities, rather than the means to access said services. This does not neglect the promotion of accessibility, however, as dense, walkable neighborhoods still require adequate NMT transportation options for the citizens to reach these places.

While the authority figure with the power to implement these land use changes differs from jurisdiction to jurisdiction, these decisions usually fall under the responsibility of a municipal planning department. However, these changes would require support from a wide range of political actors, both governmental and non-governmental. Changes to zoning and design standards take a notoriously long time to implement due to bureaucratic hurdles and review processes, along with by the time it takes for land to be physically developed. Thus, actions in this policy area take the longest time of any of the strategies identified, as it may take years or decades to fully implement these strategies.

Table 1: Discussed Land Use Changes

Strategy	**Description**	**Benefits**	**Challenges for Implementation**
Increased Density	Higher residential density within specific city/neighborhood/area.	Reduces automobile dependency. Creates more walkable/cyclable built environment.	Long time horizon for implementation. Higher density not applicable everywhere. Gentrification concerns.
More Diversity of Uses	Higher concentration of mixed-use developments. Less strict zoning use requirements.	Integration of residential and nonresidential uses reduces potential trip distance between origin and destination.	Long time horizon for implementation. Gentrification concerns.

New Urbanism Practices	Urban village or similar strategy centered around Transit-Oriented-Development.	Reduces automobile dependency by concentrating residents near transit nodes.	Requires high transit network connectivity. Gentrification concerns.
15-Minute City (and similar concepts)	Built environment changes to increase proximity of nonresidential uses so that they are accessible within fifteen minutes of walking or cycling.	Allows for large-scale mode switch to NMT as primary means of transportation for daily life.	May disadvantage people in terms of socioeconomic status or age, based on different needs (Moreno et al., 2020).

4.2 Infrastructure Improvements

Many American cities lack the infrastructure to support Active Transportation. Poor cycling facilities have been linked with higher rates of automobile ownership (Ma et al., 2022). While Non-Motorized Transport usage in the United States is still lacking behind other countries, there has been a push in recent years to increase the mode share of NMT. The number of states with goals to increase cycling more than doubled during the 2010 and federal spending on Active Transportation increased from $6 million to $835 million from 1990 to 2017 (Braun et al., 2019). This has led to a doubling of cycling infrastructure in the fifty most populous American cities from 2007 to 2016 (Braun et al., 2019). Empirical studies show that cities with more infrastructure that supports NMT, have shown positive results of increased use of these modes (Ma et al., 2022; Buehler, 2012; Piatkowski & Marshall, 2015). This includes protected bicycle/multimodal lanes, wider sidewalks, pedestrian bridges, and an array of other public investment into pedestrian infrastructure (see Table 2). Unfortunately, in many instances, these investments have not been made equitably. A study by Braun et al. (2019) found a disproportionately low distribution in access to cycling infrastructure for block groups

with higher rates of Black and Hispanic residents and lower socioeconomic status (low-income, low-educational attainment, higher poverty, etc.) in 22 large American cities. These discrepancies persisted even when controlling for cycling demand, meaning that marginalized populations that were more likely to cycle were still more likely to be further from the nearest bike lane, have lower bicycle lane coverage in their neighborhood, and were less likely to have access to any bicycle lanes at all (Braun et al., 2019). Improved consideration of equity goals within planning and policy must be considered moving forward, to ensure investment in NMT infrastructure is serving diverse populations.

Improved cycling infrastructure targets specific populations of those who may be incentivized to travel via bicycle more. Geller (2006) identifies 4 unique "types" of cyclists. Two of these groups will likely not be affected by infrastructure improvements, as ""The Strong and the Fearless" prefer cycling as their main mode of transport regardless of conditions, while the "No Way No How" group is adverse to cycling in its entirety (Geller, 2006). The target group then, is "The Interested but Concerned," whom enjoy cycling as a concept and may even ride a bicycle short distances, but are adverse to switch to use cycling as their primary means of transportation (Geller, 2006). The primary concern of this group is the fear of assimilating with automobile traffic, which can be mitigated by the various improvements discussed in this section. Geller asserts that the majority of urban populations fall into this category and that by making travel safer and more appealing to cyclists, they can move into the "Enthused and the Confident" group; people that enjoy to use non-motorized means as their primary transport mode, but prefer to do so when adequate facilities are provided.

Micromobility infrastructure needs contribute additional complexity to the issue of NMT infrastructure investments. While this mode type benefits from many of the same infrastructure improvements outlined above, micromobility vehicles require storage and often charging infrastructure. The lack of adequate facilities leaves the vehicles clutter sidewalks and bicycle lanes, potentially creating a dangerous environment for other travelers. An effective strategy is to create charging/parking infrastructure along high use corridors and near transit nodes. This helps to both reduce clutter, as well as incentivize micromobility as an augmentation to the transit network. In Arlington County, Virginia, the city added signage and charging stations near the metro entrance (Zou et al., 2020). While this is most applicable for docked vehicles, geofenced parking areas is an emerging idea to apply this concept to dockless versions as well. A geofence is a virtual boundary that limits parking of a dockless vehicle to a specific, geographic area (Cheng et al., 2020). This guides users to a specific location for the terminus of their micromobility trip, essentially bridging the gap between docked and dockless versions of micromobility vehicles. This reduces the potential hazard from the cluttering of dockless vehicles on streets and sidewalks, without the need for the physical dock for the vehicle to park in.

Many of these infrastructure improvements can be implemented by municipal or state departments of transportation, as the land required for these facilities usually falls under their jurisdiction. Some of these investments will require cooperation with other government agencies, especially when locating infrastructure near transit hubs. A benefit to implementing these types of strategies is their relatively short timeframe, as planning and construction often take far less time than large-scale land use changes.

Table 2: Discussed Infrastructure Investments

Strategy	Description	Benefits	Challenges for Implementation
Expansion of On-Road/ Separated/ Off-Road Cycling or Multimodal Lanes	Designated lanes for bicycle or other Non-Motorized Transport means. Can be within the public right-of-way, demarcated by paint, or signage, physically separated by barriers from car traffic, or outside the road network completely.	Incentivizes more cycling use. Separated and off-road lanes provide less safety concerns for cyclists and pedestrians.	Requires either less road space for automobile use, which can be politically challenging, or development outside the public right-of-way, which can be capital-intensive. Gentrification concerns.
Bicycle Parking Facilities	Long- or short-term means to store or park a bicycle or other non-motorized means of transportation.	Increases convenience of cycling to destinations. Can incentivize more transit use if located near station/stop.	Sheltered or long-term parking facilities can be especially capital-intensive investments.
Micromobility Charging and Parking Facilities	Either fixed-docks or designated areas for parking/charging vehicles.	Can complement the existing transit network as a first-mile/last-mile option by providing infrastructure near transit nodes.	Charging/parking stations for docked vehicles are especially expensive. Complex data modeling may be needed to optimize transit augmentation.
Colored Lanes or Other Signage	Paint or other methods to demarcate NMT-only lanes.	May create a safer environment by alerting drivers to the potential of cyclist presence.	Maintenance costs. Requires regulatory enforcement for violators.

4.3 Regulatory Measures

The third way that cities can encourage NMT is through regulatory incentives and deterrences. By increasing the convenience of walking and cycling, decreasing the convenience of automobile travel, or a combination of the two, decision makers may be able to shift

commuters out of their automobiles and onto the street or sidewalk. Municipal development codes can decrease or even eliminate minimum automobile parking requirements mandate bicycle parking facilities. The City of Seattle's municipal code does not have minimum off-street parking requirements for most multi-family and non-residential development in its urban centers and urban villages (Seattle Municipal Code, 23.54). Similarly, the City of Portland requires both long-term and short-term bicycle storage for all commercial uses, with the exception of commercial parking facilities (Code of the City of Portland, Oregon, 33.266.200). As an emerging mode of transportation, micromobility often lacks regulatory and policy framework to address the rapid rise in popularity and use. Some jurisdictions have approached regulating micromobility to minimize parking and congestion impacts by dictating where the vehicles can be parked (Zou et al., 2020). This requires the addition of adequate parking facilities. More research is needed on how cities can incorporate this new transport mode into their existing regulatory framework.

Another regulatory measure that cities can take is by discouraging automobile use via tolling and congestion pricing. There are three main types of congestion pricing: static time-of-day pricing, dynamic pricing, and area charges. The first two are generally used on highways of major thoroughfares for longer commutes. While this can help incentivize transit usage, NMT trips are generally shorter in nature and thus, area charges may be the most effective strategy of congestion pricing to encourage walking and biking. Area charges can be used to toll automobile users on highly populated or pedestrian-oriented places within a city, creating less car traffic and more Non-Motorized Transit trips. One of the famous examples of an area charge is London's ring road. Beginning in 2003, automobile drivers have been charged a fee to

drive within a boundary that encompassed central London's city center. Within the first year of the program's inception, the area saw a reduction of all automobile traffic of about 18%, which translated to 60,000 less vehicles per day (Lehe, 2019). While many commuters switched to transit as their primary way of navigating the city center, a significant proportion of drivers also switched to walking and cycling (Litman, 2005). Similar programs in Stockholm, Milan, Singapore, and Gothenburg all saw comparable decreases in automobile traffic after the implementation of area charge congestion pricing. The equity considerations of these types of programs are dedicated on two factors: who is being charged and how those revenues are spent. While more high-income populations are more likely to drive an automobile and face the charge, low-income residents are more cost-sensitive and have lower values of time (Eliassona & Mattsson, 2006). Rates based on income or wealth may be a strategy for cities to consider when implementing congestion pricing. Similarly, the use of the revenues from congestion pricing should be spent to benefit marginalized populations. Most of these programs use the funds to subsidize transit services, but some should consider NMT infrastructure improvements as mentioned in the prior section. As mentioned earlier, it is also crucial that decision-makers conduct equitable community engagement practices to ensure that these types of congestion pricing, or any regulatory measures that are being considered are wanted and benefit the populations that will be affected.

These regulatory strategies usually take legislative or quasi-legislative approval for implementation, either through statutory modifications or ordinance adoption. Municipal governments vary on the authority to pass such legal changes, and can fall under the authority of the mayor, city council, planning commission, or a combination of these actors. This can add

time and complexity to these issues and will likely take at least a few months, if not years for these measures to be realized.

Table 3: Discussed Regulatory Measures

Strategy	Description	Benefits	Challenges for Implementation
Elimination/Reduction of Minimum Parking Requirements	Amend city development codes to decrease the amount of off-street parking spaces that new or existing developments are required to provide.	Reduces space in cities used for off-street parking, which can be used for more dense development, open space, etc.	Most applicable/ enforceable for new development. Requires updating existing development code.
Incentivize or Mandate Private Development Investment in NMT	Providing benefits to private developer for providing infrastructure for NMT.	Private agent fronts costs for new NMT infrastructure (see Table 2 for specific benefits).	Access to use NMT infrastructure may be restricted. Gentrification concerns.
Congestion Pricing	Fare charged to automobile drivers at either a fixed or variable rate on certain roads or areas within a city.	Discourages automobile use on heavily used roads. Revenues can be used for further investment into NMT promotion.	Collection and enforcement costs and equity concerns. Will likely face initial political opposition.

4.4 Examples of Successful Implementation of NMT

With these policy areas in mind, we now turn to two examples of cities that have utilized these implementation strategies to successfully adopt higher usage of Non-Motorized Transport within their jurisdictions.

4.3.1 Washington D.C.

In 2010, Washington D.C. launched a shared micromobility program, now known as Capital Bikeshare. Capital Bikeshare is now one of the largest government-owned micromobility systems in the country (see Figure 4 for ridership statistics from January 2019 - April 2022) with over 5,000 vehicles and 600 stations (*About Capital Bikeshare,* n.d.). Capital Bikeshare allows single uses, day passes, and a membership that charges users a flat fee of $7.92/month for unlimited riders of 45 minutes or less (*About Capital Bikeshare,* n.d.). By the end of 2013, over a million people had signed up for the membership option. That year's customer survey detailed how Capital Bikeshare had successfully offered as a first mile/last-mile transit augmentation option. 54% of survey respondents reported that their destination or origin when using the service was a metro station, with another 21% traveling to or from a bus stop, and an additional 10% used the vehicles to access a commuter rail station. Of those that reported using Capital Bikeshare to access the metro network, 9% disclosed that they did so more than 10 times a month, on average (Ma et al., 2015). These survey results were backed up by a linear regression model that showed that a 10% increase annual Capital Bikeshare trips leads to a 2.8% increase in metro usage (Ma et al., 2015).

In addition to Capital Bikeshare, several private vendors distribute their own shared micromobility services. JUMP (owned by Uber), Lyft, Skip, and Spin have a combined fleet of 10,000 e-scooters, while both JUMP and Italian-based company Helbiz provide dockless, shared bikes (Stowell, 2020). Planners in the Washington D.C. see these private, dockless systems as a complimentary service to their own, docked Capital Bikeshare bicycles. To capitalize on the spatial freedom of these systems, the city mandated that these private systems deploy at least

400 vehicles to specified “equity zones” throughout the city. These zones are in low-income neighborhoods and communities of color that have lower mobility options (Stowell, 2020). The dockless systems have seen a high level of adoption throughout the city, especially within these communities, as Black and African American residents are using the new systems at a rate 2.6 times that of Capital Bikeshare (Stowell, 2020). This conscious effort to utilize partnerships with private actors has helped planners expand mobility options in an equitable manner.

Washington D.C. is attempting to capitalize on this trend and increase the amount of non-motorized trips by increasing the city’s NMT infrastructure. The District Department of Transportation (DDOT) has built over 100 miles of bicycle lanes since 2001 and has plans to build an additional 20 miles of protected bike lanes by 2023 (Bicycle Lanes, 2022). The city has also been strategic with the distribution of Capital Bikeshare stations, as nearly half of all stations are within a quarter mile of a metro station (Ma et al., 2015). These infrastructure investments are also supplemented with planning and policy advancements. In terms of American cities, Washington D.C. is relatively dense, with a population density of 9,856.5 people per square mile (U.S. Census Bureau, 2021a). The city’s comprehensive plan, most recently updated in 2020, includes a variety of provisions to drastically expand mixed-use development and further increase density in the city, particularly in former industrial zoned areas. The location and design of some of these mixed-use developments was agreed upon by a coalition of planners and community activists, after a thorough community engagement process centered around racial equity (Koma, 2021). These investments will hopefully increase the walkability of the D.C. area, allowing for a more convenient means to travel by Non-Motorized Transport.

While these improvements have led to more Sustainable Transportation usage, more still needs to be done, as car usage still dominates as the primary commuting mode in Washington D.C. Figure 5, taken from the National Capital Region Transportation Planning Board's Commuter Connection Program 2019 State of the Commute Technical Survey Report, shows that while NMT and transit mode shares have increased from 2007 to 2019, automobile trips still made up about 63% of the commuter mode split in 2019 (TPB, 2019). While this seems grim, the increase in mode shift towards Sustainable Transportation and Non-Motorized Transport over the last decade and a half is still important progress towards mitigating carbon emissions and enhancing mobility options. These increases are indicative of the city's efforts to utilize urban planning strategies to increase NMT usage.

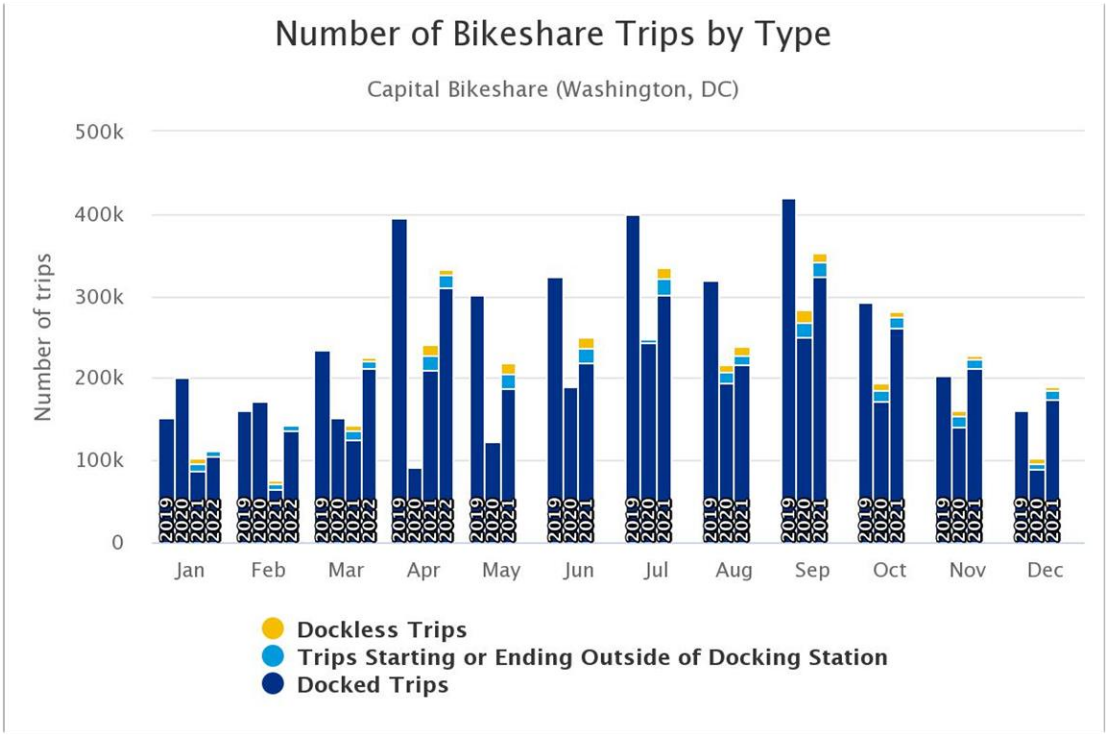

Figure 4: Capital Bikeshare monthly ridership. Source: Bureau of Transportation Statistics (2021).

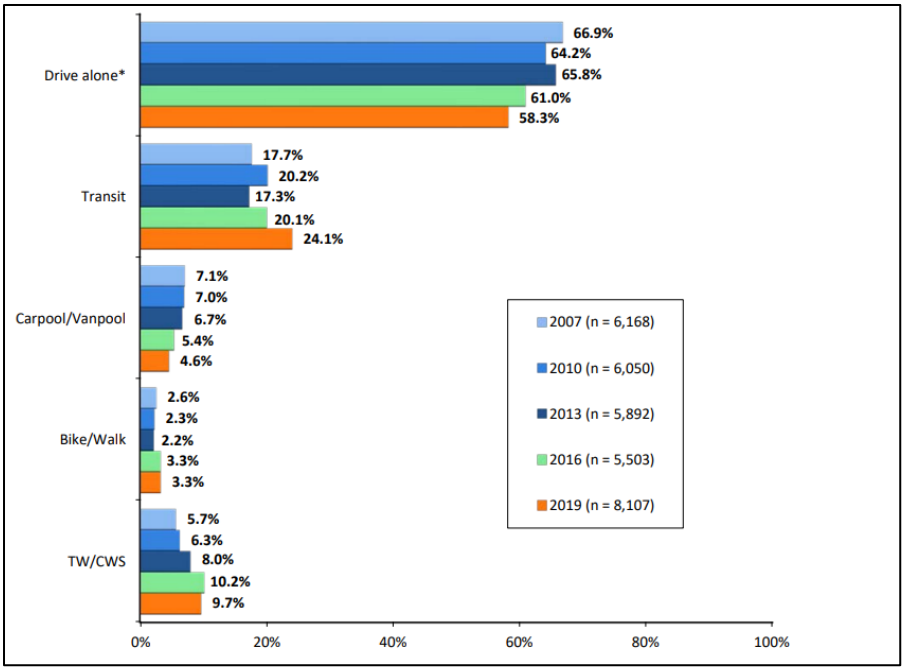

Figure 5: Figure 5: Washington D.C. Commuter Mode Split. Source: National Capital Region Transportation Planning Board, (2019).

4.3.2 Paris, France

Paris, under the leadership of Mayor Anne Hidalgo, has proposed Paris to fully embrace the concept of the 15-Minute City (or "La Ville du Quart d'Heure" [Quarter-Hour City] as it is called in Paris) as a part of the "Paris en Commun" strategy (Moreno et al, 2021). The plan, rooted in the Paris Climate action plan, aims to reduce car dominance, retake space for pedestrians, increase greenspace, and enhance mobility through four policy areas: ecological measures, solidarity-centered ecological transformation, hyper-proximity, and commitment to citizenry (Pozoukidou & Chatziyiannaki, 2021). Paris' implementation of the Quarter-Hour City is rooted in the principles of proximity, diversity, density, and ubiquity to change the built environment so that most residents of the city center can meet their daily needs within 15

minutes of walking or cycling (Pozoukidou & Chatziyiannaki, 2021). To do achieve this goal, Paris aims to localize services so that every neighborhood fulfills six social functions: housing, employment, shopping, health care, education, and entertainment (Moreno et al., 2021).

With about 54,000 people per square mile (Statista Research Department, 2022), Paris already has a very dense urban environment. Additionally, Paris' public transit system is highly robust and well-developed (Pozoukidou & Chatziyiannaki, 2021). The implementation of the Quarter-Hour City is then focused on the pedestrianization of the city to promote more NMT use. To accomplish this, Paris has employed a number of planning strategies to reduce automobile use and encourage more walking and cycling. These strategies include restricting automobile traffic in some neighborhoods to transit, local residents and shop owners, and emergency vehicles, the creation of "children's roads," which ban traffic near schools at the beginning and end of the day, stricter regulations on vacant properties and second homes, adaptive re-use of office space, and perhaps most ambitiously, a massive overhaul of the city's cycling infrastructure (Pozoukidou & Chatziyiannaki, 2021). Paris had already been rapidly expanding their cycling infrastructure in the beginning of the 21st century, as the city tripled its amount of both bike lanes and bicycle parking from 1998 to 2007 (Pucher et al., 2010). This led to an increased mode share of bicycle use from 1% in 2001, to 2.5% in 2007 (Pucher et al., 2010). Additionally, the shared biking service "Vélib' Métropole" launched in 2007, providing over 20,000 bicycles for short-term use (Pucher et al., 2010). Paris' new plans for cycling infrastructure expansion are even greater, as Mayor Hidalgo has pledged to remove over 60,000 automobile parking spaces by 2024 to create an integrated network of cycling lanes

(Pozoukidou & Chatziyiannaki, 2021). With this project well underway, Paris walking and cycling use has surged, with goals to increase the share of NMT modes even further.

A crucial aspect of the Paris en Commun strategy to note is the importance of public participation and empowerment. Paris' leaders have involved citizens in decision-making and implantation of various aspects of the plan and engaged in co-planning practices to give the citizenry real power and authority with a participatory planning budget. As of 2020, 2,428 projects have been put into place from the participatory budget, focused on localizing important services and facilities to each neighborhood (Pozoukidou & Chatziyiannaki, 2021).

While Paris is a shining example of promoting more NMT usage through the implementation of the 15-Minute City concept, it is worth noting that the city's high density and expansive transit network are rather incomparable to most American Cities, save New York City and possibly a few others. Thus, Paris already had a leg up on most American cities when it comes to implementing the practices of the 15-Minute City. However, this examples still shows that even with proper density and transit coverage, investment into NMT infrastructure and regulatory enactments are still required to promote more walking and cycling.

4.3.3 Lessons for Seattle, Washington

Using the examples of Paris, Washington D.C., and various other cities presented throughout this analysis, I will now give my personal recommendations on how decision-makers and planners can utilize the three policy areas to promote more NMT use in the Seattle region. Of course, there are multiple political, economic, and sociocultural aspects of any city that add complexity to implementing these strategies, so these recommendations are mostly speculative

in nature. However, given the multitude of research that I have collected and comprehensive analysis of Non-Motorized Transport that I have presented, these recommendations still serve some merit and are worthwhile to consider. Once again, I would like to reiterate that equitable community engagement practices *must* be utilized, to get a better understanding of if and how residents wish to see these recommendations implemented.

Home to about 734,000 people (U.S. Census Bureau, 2021b), Seattle has seen rapid population growth, especially in the twentieth century. However, outside of the downtown core and the city's urban villages, most of the city is zoned exclusively single family (Office of Planning & Community Development, 2020). Seattle's population density is less than that of Los Angeles; a city widely known for urban sprawl and car-centric development patterns. Additionally, Seattle's geographic- and weather-related constraints make cycling an unattractive option for many people (although it should be noted that many people do cycle as a primary means of transportation throughout the city). It is vital that Seattle transforms into a more walkable neighborhood, if more non-motorized travel is desired. To to achieve this goal, the city must continue upzoning and allowing for more diverse uses throughout the region. For many years, city planners have employed new urbanism tactics, by concentrating density and population growth into urban centers and urban villages (Office of Planning & Community Development, 2020). While these areas are certainly more accessible by non-motorized means than the rest of the city, problems with affordability, displacement, and gentrification have rendered these areas unlivable for many residents. I believe that Seattle needs to rethink its land use strategy and employ techniques of the 15-Minute City. This would include allowing for more less-intense commercial uses in residential neighborhoods, so that residents can easily

walk or cycle to get their groceries, go to the dentist, access local restaurants, and in some cases, commute to work. Furthermore, more diverse housing typologies, such as duplexes, triplexes, and townhouses, should be allowed in areas that are currently zoned exclusively single-family, especially near transit nodes. These land use strategies should allow the city to incorporate density in an effective manner that allows people to use their personal automobile less for daily activities.

While the hills and rain that Seattle is famous for disincentivize cycling and other non-motorized travel use to a certain extent, the city's cycling infrastructure could certainly use an upgrade. To enhance the ambitious mass transit expansion and robust bus service that the city offers, these improvements should be concentrated around major transit nodes. The recent addition of a multitude of micromobility services could also be optimized by a strategic investment in NMT infrastructure by co-locating these facilities near future and existing light-rail stops and major transit hubs.

One of the discussed regulatory measures that may be applicable for Seattle is congestion pricing via an area charge for accessing the city core. Seattle already engages in a variety of tolling and congestion pricing on various highways and bridges throughout the area and could benefit from limiting automobile traffic to the downtown area. As discussed earlier, cities such as London and Milan have seen positive results from similar regulations, and the revenue collected from an area charge could be used to fund more NMT infrastructure, or to supplement the existing transit expansion budget. This congestion pricing would discourage automobile use in these dense urban areas, and incentivize more NMT trips for daily use.

Chapter 5: Conclusion

For a large mode shift from automobile use to occur, short-term solutions, such as incentive programs, expanded multimodal lanes, strategic parking/charging locations for micromobility, and so forth must be accompanied by long-range land use and planning implementations, such as densification, more mixed-use development, and expanded transit systems. Cities that have seen higher usage rates in micromobility and Active Transportation have shown to have good network density, connections with other multimodal systems, partnerships with local groups and businesses, and overall transparency in the planning process (Audikana et al., 2017). These are all formidable issues that take strenuous amounts of time and effort for cities to implement. Moreover, not all these strategies are applicable in every context. To best understand which of these solutions are the most effective and applicable, decision-makers or community groups that advocate on behalf of citizenry *must* perform equitable community engagement via inclusion and the pursuit of just outcomes. Through this process, citizens can advocate for the types of changes in their community that they would like to see implemented. Some may prefer more cycling infrastructure, while others may advocate for more mixed-use development and less parking. Understanding the wants and needs of the citizenry is crucial in finding solutions to promote Non-Motorized Transport. Together with the proper investment, research, and dedication, NMT may serve as a successful implementation that can both combat the effects of climate change, while enhancing personal mobility in an equitable and accessible manner.

References

About Capital Bikeshare. (n.d.). Capital Bikeshare. Retrieved May 22, 2022, from http://ride.capitalbikeshare.com/about

American Institute of Certified Planners. (1991) *AICP code of ethics and professional conduct*. Washington, DEC: American Institute of Certified Planners.

Allem, J.-P., & Majmundar, A. (2019). Are electric scooters promoted on social media with safety in mind? A case study on Bird's Instagram. *Preventive Medicine Reports*, *13*, 62–63. https://doi.org/10.1016/j.pmedr.2018.11.013

Anderson-Hall, K. (2019), January 13–17. Governing Micro-mobility: A Nationwide Assessment of Electric Scooter Regulations. In: Transportation Research Board 98th Annual Meeting. Washington D.C.

Audikana, A., Ravalet, E., Baranger, V., & Kaufmann, V. (2017). Implementing bikesharing systems in small cities: Evidence from the Swiss experience. *Transport Policy*, *55*, 18–28. https://doi.org/10.1016/j.tranpol.2017.01.005

Badeau, A., Carman, C., Newman, M., Steenblik, J., Carlson, M., & Madsen, T. (2019). Emergency department visits for electric scooter-related injuries after introduction of an urban rental program. *The American Journal of Emergency Medicine*, *37*(8), 1531–1533. https://doi.org/10.1016/j.ajem.2019.05.003

Bicycle Lanes. (2022). District Department of Transportation. https://ddot.dc.gov/page/bicycle-lanes

Bresler, A. Y., Hanba, C., Svider, P., Carron, M. A., Hsueh, W. D., & Paskhover, B. (2019). Craniofacial injuries related to motorized scooter use: A rising epidemic. *American Journal of Otolaryngology*, *40*(5), 662–666. https://doi.org/10.1016/j.amjoto.2019.05.023

Barrington-Leigh, C., & Millard-Ball, A. (2015). A century of sprawl in the United States. *Proceedings of the National Academy of Sciences*, *112*(27), 8244–8249. https://doi.org/10.1073/pnas.1504033112

Brand, C., Götschi, T., Dons, E., Gerike, R., Anaya-Boig, E., Avila-Palencia, I., de Nazelle, A., Gascon, M., Gaupp-Berghausen, M., Iacorossi, F., Kahlmeier, S., Int Panis, L., Racioppi, F., Rojas-Rueda, D., Standaert, A., Stigell, E., Sulikova, S., Wegener, S., & Nieuwenhuijsen, M. J. (2021). The climate change mitigation impacts of active travel: Evidence from a longitudinal panel study in seven European cities. *Global Environmental Change*, *67*, 102224. https://doi.org/10.1016/j.gloenvcha.2021.102224

Braun, L. M., Rodriguez, D. A., & Gordon-Larsen, P. (2019). Social (in)equity in access to cycling infrastructure: Cross-sectional associations between bike lanes and area-level sociodemographic characteristics in 22 large U.S. cities. *Journal of Transport Geography*, *80*, 102544. https://doi.org/10.1016/j.jtrangeo.2019.102544

Buehler, R., & Pucher, J. (2012). International Overview: Cycling Trends in Western Europe, North America, and Australia. *City cycling*, 9-29.

Center for Sustainable Systems, University of Michigan. (2021). "U.S. Cities Factsheet." Pub. No. CSS09-06

Cheng, G., Guo, Y., Chen, Y., & Qin, Y. (2019). Designating City-Wide Collaborative Geofence Sites for Renting and Returning Dock-Less Shared Bikes. *IEEE Access*, *7*, 35596–35605. https://doi.org/10.1109/ACCESS.2019.2903521

Cox, L., Hansen, V., Andrews, J., Thomas, J., Heilke, I., Flanders, N., Walters, C., Jacobs, S. A., Yuan, Y., Zimmer, A., Weaver, J., Daniels, R., Moore, T., Yuen, T., Payne-Sturges, D. C., McCullough, M. W., Rashleigh, B., TenBrink, M., & Walton, B. T. (2013). *Land Use: A Powerful Determinant of Sustainable & Healthy Communities* (p. 212). U.S. Environmental Protection Agency. https://www.epa.gov/sites/default/files/2016-09/documents/fy13productnheerl4121land_use_synthesis.pdf

Crisp, R., & Gore, T. (2020). Tackling transport-related barriers to employment in low-income neighbourhoods. *People, Place and Policy Online*, *14*(3), 290–293. https://doi.org/10.3351/ppp.2020.6647385462

Dadashpoor, H., & Alvandipour, N. (2020). A genealogy of the five schools of justice in planning thought. *Habitat International*, *101*, 102189. https://doi.org/10.1016/j.habitatint.2020.102189

Deakin. (2002). Sustainable Transportation U.S. Dilemmas and European Experiences. *Transportation Research Record, 1792*(1), 1–11. https://doi.org/10.3141/1792-01

Eliasson, J., & Mattsson, L.-G. (2006). Equity effects of congestion pricing. *Transportation Research Part A: Policy and Practice*, *40*(7), 602–620. https://doi.org/10.1016/j.tra.2005.11.002

Fainstein, S. (2010). *The Just City*. Cornell University Press.

Frank, L. D., Greenwald, M. J., Winkelman, S., Chapman, J., & Kavage, S. (2010). Carbonless footprints: Promoting health and climate stabilization through active transportation. *Preventive Medicine*, *50*, S99–S105. https://doi.org/10.1016/j.ypmed.2009.09.025

Giambrone, A. (2019,.). *Driving alone remains the most popular way of commuting in the D.C. area*. Curbed DC. https://dc.curbed.com/2019/9/19/20873247/dc-commuting-traffic-driving-metro-transportation-survey

Geller, R. (2006). *Four Types of Cyclists*. Portland Bureau of Transportation. http://www.portlandoregon.gov/transportation/article/264746

Hollingsworth, J., Copeland, B., & Johnson, J. X. (2019). Are e-scooters polluters? The environmental impacts of shared dockless electric scooters. *Environmental Research Letters*, *14*(8), 084031. https://doi.org/10.1088/1748-9326/ab2da8

Howland, S., McNeil, N., Broach, J., Rankins, K., MacArthur, J., & Dill, J. (2017). *Breaking Barriers to Bike Share: Insights on Equity from a Survey of Bike Share System Owners and Operators*. Portland State University. https://doi.org/10.15760/trec.173

Innes, J. E., & Booher, D. E. (2005). *Reframing Public Participation: Strategies for the 21st Century*. https://escholarship.org/uc/item/4gr9b2v5

IPCC. (2007) Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Pachauri, R.K and Reisinger, A. (eds.)]. IPCC, Geneva, Switzerland.

IPCC. (2021) *Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., et al. (eds.)]. In Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pd

IPCC, (2021). *Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. MassonDelmotte, V., P. Zhai, A. Pirani, S.L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M.I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 3−32, doi:10.1017/9781009157896.001.

James, O., Swiderski, J., Hicks, J., Teoman, D., & Buehler, R. (2019). Pedestrians and E-Scooters: An Initial Look at E-Scooter Parking and Perceptions by Riders and Non-Riders. *Sustainability*, *11*(20), 5591. https://doi.org/10.3390/su11205591

Jäppinen, S., Toivonen, T., & Salonen, M. (2013). Modelling the potential effect of shared bicycles on public transport travel times in Greater Helsinki: An open data approach. *Applied Geography*, *43*, 13–24. https://doi.org/10.1016/j.apgeog.2013.05.010

Karlsson, M., Alfredsson, E., & Westling, N. (2020). Climate policy co-benefits: a review. *Climate Policy*, *20*(3), 292–316. https://doi.org/10.1080/14693062.2020.1724070

Koma, A. (2021). *It took five years, but D.C. has a new comprehensive plan. Here's how it will change development in the city.* Washington Business Journal. https://www.bizjournals.com/washington/news/2021/05/18/dc-comprehensive-plan-amendments-pass.html

Kou, Z., Wang, X., Chiu, S. F. (Anthony), & Cai, H. (2020). Quantifying greenhouse gas emissions reduction from bike share systems: a model considering real-world trips and transportation mode choice patterns. *Resources, Conservation and Recycling*, *153*, 104534. https://doi.org/10.1016/j.resconrec.2019.104534

Lee, S., & Lee, B. (2014). The influence of urban form on GHG emissions in the U.S. household sector. *Energy Policy*, *68*, 534–549. https://doi.org/10.1016/j.enpol.2014.01.024

Lehe, L. (2019). Downtown congestion pricing in practice. *Transportation Research Part C: Emerging Technologies*, *100*, 200–223. https://doi.org/10.1016/j.trc.2019.01.020

Litman, T. (2005). London Congestion Pricing – Implications for Other Cities. *CESifo DICE Report*, *03*(3), 17–21. https://www.econstor.eu/handle/10419/166849

Lutsey, N. (2010). Cost-Effectiveness Assessment of Low-Carbon Vehicle and Fuel Technologies. *Transportation Research Record: Journal of the Transportation Research Board*, *2191*(1), 90–99. https://doi.org/10.3141/2191-12

Ma, T., Liu, C., & Erdoğan, S. (2015). Bicycle Sharing and Public Transit: Does Capital Bikeshare Affect Metrorail Ridership in Washington, D.C.? *Transportation Research Record: Journal of the Transportation Research Board*, *2534*(1), 1–9. https://doi.org/10.3141/2534-01

Ma, T., Aghaabbasi, M., Ali, M., Zainol, R., Jan, A., Mohamed, A. M., & Mohamed, A. (2022). Nonlinear Relationships between Vehicle Ownership and Household Travel Characteristics and Built Environment Attributes in the US Using the XGBT Algorithm. *Sustainability*, *14*(6), 3395. https://doi.org/10.3390/su14063395

Mackett, R. L. (2001). Policies to attract drivers out of their cars for short trips. *Transport Policy*, *8*(4), 295–306. https://doi.org/10.1016/S0967-070X(01)00025-7

Mackett, R. L. (2003). Why do people use their cars for short trips? *Transportation*, *30*(3), 329–349. https://doi.org/10.1023/A:1023987812020

Maibach, E., Steg, L., & Anable, J. (2009). Promoting physical activity and reducing climate change: Opportunities to replace short car trips with active transportation. *Preventive Medicine*, *49*(4), 326–327. https://doi.org/10.1016/j.ypmed.2009.06.028

McKenzie, G. (2019). Spatiotemporal comparative analysis of scooter-share and bike-share usage patterns in Washington, D.C. *Journal of Transport Geography*, *78*, 19–28. https://doi.org/10.1016/j.jtrangeo.2019.05.007

McQueen, M., MacArthur, J., & Cherry, C. (2019). *The E-Bike Potential: Estimating the Effect of E-Bikes on Person Miles Travelled and Greenhouse Gas Emissions*. Transportation Research and Education Center (TREC). https://doi.org/10.15760/trec.242

McQueen, M. (2020). *Comparing the Promise and Reality of E-Scooters: A Critical Assessment of Equity Improvements and Mode-Shift*. https://doi.org/10.15760/etd.7439

McQueen, M., Abou-Zeid, G., MacArthur, J., & Clifton, K. (2021). Transportation Transformation: Is Micromobility Making a Macro Impact on Sustainability? *Journal of Planning Literature*, *36*(1), 46–61. https://doi.org/10.1177/0885412220972696

Mehrotra, S., Zusman, E., Bajpai, J. N., Fedirko, L., Jacob, K., Replogle, M., Woundy, M., and Yoon, S. (2018). Urban transportation. In Rosenzweig, C., W. Solecki, P. Romero-Lankao, S. Mehrotra, S. Dhakal, and S. Ali Ibrahim (eds.), Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network. Cambridge University Press. New York. 491–518

Metzger, J. T. (1996). The Theory and Practice of Equity Planning: An Annotated Bibliography. *Journal of Planning Literature*, *11*(1), 112–126. https://doi.org/10.1177/088541229601100106

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the "15-Minute City": Sustainability, Resilience and Place Identity in Future Post-Pandemic Cities. *Smart Cities*, *4*(1), 93–111. https://doi.org/10.3390/smartcities4010006

National Association of City Transportation Officials. (2019). *Shared Micromobility in the U.S.: 2019*. https://nacto.org/wp-content/uploads/2020/08/2020bikesharesnapshot.pdf

National Capital Region Transportation Planning Board. (2019). *2019 State of the Commute Survey: Technical Survey Report*. https://www.mwcog.org/documents/2020/06/17/state-of-the-commute-survey-report--carsharing-state-of-the-commute-travel-surveys/

Newman, P., & Kenworthy, J. (2006). Urban Design to Reduce Automobile Dependence. *Opolis*, *2*(1). https://escholarship.org/uc/item/2b76f089

Office of Planning & Community Development. (2020). Seattle 2035 Comprehensive Plan. http://www.seattle.gov/opcd/ongoing-initiatives/comprehensive-plan

Peters, L., & MacKenzie, D. (2019). The death and rebirth of bikesharing in Seattle: Implications for policy and system design. *Transportation Research Part A: Policy and Practice*, *130*, 208–226. https://doi.org/10.1016/j.tra.2019.09.012

Piatkowski, D. P., & Marshall, W. E. (2015). Not all prospective bicyclists are created equal: The role of attitudes, socio-demographics, and the built environment in bicycle commuting. *Travel Behaviour and Society*, *2*(3), 166–173. https://doi.org/10.1016/j.tbs.2015.02.001

Pucher, J., Dill, J., & Handy, S. (2010). Infrastructure, programs, and policies to increase bicycling: An international review. *Preventive Medicine*, *50*, S106–S125. https://doi.org/10.1016/j.ypmed.2009.07.028

Pozoukidou, G., & Chatziyiannaki, Z. (2021). 15-Minute City: Decomposing the New Urban Planning Eutopia. *Sustainability*, *13*(2), 928. https://doi.org/10.3390/su13020928

Rawls, J. (1971). A theory of justice. Cambridge, MA: Harvard University Press.

Reece, J. W. (2018). In Pursuit of a Twenty-first Century Just City: The Evolution of Equity Planning Theory and Practice. *Journal of Planning Literature*, *33*(3), 299–309. https://doi.org/10.1177/0885412218754519

Saelens, B. E., & Handy, S. L. (2008). Built Environment Correlates of Walking: A Review. *Medicine & Science in Sports & Exercise*, *40*(7), S550–S566. https://doi.org/10.1249/MSS.0b013e31817c67a4

Sener, I. N., Lee, K., Hudson, J. G., Martin, M., & Dai, B. (2019). The challenge of safe and active transportation: Macrolevel examination of pedestrian and bicycle crashes in the Austin District. *Journal of Transportation Safety & Security*, *13*(5), 525–551. https://doi.org/10.1080/19439962.2019.1645778

Schneider. (2018). "Complete Streets" Policies and Eliminating Pedestrian Fatalities. *American Journal of Public Health (1971)*, *108*(4), 431–433. https://doi.org/10.2105/AJPH.2018.304317

Smith, C. S., & Schwieterman, J. P. (2018). *E-Scooter Scenarios: Evaluating the Potential Mobility Benefits of Shared Dockless Scooters in Chicago*. https://trid.trb.org/view/1577726

Stowell, H. G. (2020). Making Micromobility Equitable for All. *ITE Journal*, *90*(2), 46–49.

U.S. Census Bureau (2021a) *QuickFacts: District of Columbia*. https://www.census.gov/quickfacts/DC

U.S. Census Bureau (2021b) *QuickFacts: Seattle*. https://www.census.gov/quickfacts/seattlecitywashington

U.S. Department of Transportation, Bureau of Transportation Statistics. (2019). *National Transportation Statistics*. https://www.bts.gov/browse-statistical-products-and-data/state-transportation-statistics/commute-mode

U.S. Environmental Protection Agency. (2021). *Inventory of U.S. Greenhouse Gas Emissions and*

Sinks 1990–2019. https://www.epa.gov/ghgemissions/us-greenhouse-gas-inventory-report-archive

Statista Research Department. (2022). *France: population density of Paris region by department*. Statista. https://www.statista.com/statistics/1047176/population-density-ile-de-france-paris-region-by-department-france/

World Bank. (2021). *State of Cities Climate Finance 2021 Part 2: The Enabling Conditions for Mobilizing Urban Climate Finance.* © World Bank. License CC BY 3.0 IGO

Zakhem, M., & Smith-Colin, J. (2021). Micromobility implementation challenges and opportunities: Analysis of e-scooter parking and high-use corridors. *Transportation Research Part D: Transport and Environment*, *101*, 103082. https://doi.org/10.1016/j.trd.2021.103082

Zhang, Y., Lin, D., & Mi, Z. (2019). Electric fence planning for dockless bike-sharing services. *Journal of Cleaner Production*, *206*, 383–393. https://doi.org/10.1016/j.jclepro.2018.09.215

Zou, Z., Younes, H., Erdoğan, S., & Wu, J. (2020). Exploratory Analysis of Real-Time E-Scooter Trip Data in Washington, D.C. *Transportation Research Record: Journal of the Transportation Research Board*, *2674*(8), 285–299. https://doi.org/10.1177/0361198120919760

Zuniga-Garcia, N., Tec, M., Scott, J. G., & Machemehl, R. B. (2022). Evaluation of e-scooters as transit last-mile solution. *Transportation Research Part C: Emerging Technologies*, *139*, 103660. https://doi.org/10.1016/j.trc.2022.103660