2022

Evaluating Long-Range Transportation Plans for Mainstreaming of Climate Adaptation Among Virginia MPOs

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A thesis submitted in partial fulfillment of the requirements for the degree of Master of Urban and Regional Planning at Virginia Commonwealth University

By

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Richmond, Virginia
May 9, 2022

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Acknowledgements

First and foremost, I would like to express my gratitude to my advisor and committee chair, Dr. Damian Pitt, without whom this would not have been possible. After several setbacks and delays resulting from the Covid-19 Pandemic, Dr. Pitt took on this project in addition to his existing responsibilities and guided me through every step in this (at times difficult) process. I would also like to thank the other two members of my thesis committee, Dr. Meghan Z. Gough and Dr. Ellen Basset, whose contributions helped strengthen both the project and myself beyond what would have otherwise been possible.

I am incredibly grateful to the people in my life who helped me to carry on throughout this journey, including my parents, Holly and Rohan, for their unconditional love and encouragement; my partner, Gabriel, for his endless patience and support; and my amazing friends and colleagues at the Partnership for Smarter Growth, whose mentorship has helped shape me as a planner and better understand the institutions that govern our society.

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Abstract

Despite the strides made towards addressing climate change through greenhouse gas (GHG) emissions reduction strategies, it has become increasingly apparent that attempting to mitigate the crisis in such a manner alone is insufficient. This thesis joins a growing body of research on how our societies must adapt to a changing climate, contributing more evidence on common barriers to adaptation and how they might be overcome. Through an attempt to evaluate the progress made towards mainstreaming, or integrating, climate change concerns into five Virginia MPOs' long-range transportation plans (LRTPs), this study provides support for prior hypotheses around the potential for MPOs to serve as central governing bodies in future regional adaptation planning efforts, and provides direction for future research on how best to expand upon this potential.

Introduction

Anthropogenic climate change is an existential threat to the continued functioning of human societies as well as a generational-scale challenge facing planners, policymakers, and officials in all inhabited regions of the Earth. The manner and intensity of global society's response to the climate crisis have evolved from an initial position of seeking to understand the nature and causes of the threat, to seeking to slow or stop it entirely, to an acknowledgement of its inevitability paired with efforts to adapt to a rapidly changing, often dangerous set of environmental conditions. These efforts to adapt, referred to here as "climate adaptation" or merely "adaptation", are far more complex a task than that of seeking to reduce greenhouse gas (GHG) emissions, and efforts to implement adaptation in practice are still relatively new; this is in part due to the fact that, until major warming-driven natural disasters like Hurricane Katrina and Superstorm Sandy made the threat impossible to ignore, investing in adaptation research or implementation was commonly viewed as undermining the broader society's efforts to mitigate climate change through GHG reductions. Owing to both the novelty and complexity of the subject, much of the existing body of research and knowledge surrounding climate adaptation can be characterized as attempting to document existing adaptation planning and programming efforts, as well as to conceptualize adaptation and its various approaches. Scholars and practitioners have yet to reach consensus on how best to design, implement, or evaluate climate adaptation efforts, but conceptual approaches, particularly as relates to understanding and managing the socioeconomic and governance implications of climate adaptation, have begun to emerge.

Three of these conceptual approaches to climate adaptation, explored at greater detail in the Review of the Literature, are ecosystem-based adaptation (centered around active and sustainable management of natural resources and ecosystems), community-based adaptation (centered around the local scale and the ability of individual communities to adapt and thrive in the context of a rapidly changing environment), and transformative adaptation (in which the root causes of climate change and other crises of the modern age are interrogated and addressed directly, rather than engaging in incremental changes in service of preserving the status-quo). Using these three

conceptual approaches to climate adaptation as a lens through which to examine the activities of five of the fourteen metropolitan planning organizations (MPOs) in Virginia, this study aims to quantify and compare the degree to which these MPOs have mainstreamed (or deeply integrated) climate adaptation concerns into their regular planning duties. This study aims to analyze the activity of MPOs specifically due to their unique role in the American system of distributed governance, particularly their presence in every populated region in the nation as well as their role as convening bodies for often fractious and competitive municipalities, state and federal governments, and stakeholders from all levels of society and government. It is hoped that through analyzing and evaluating MPOs' progress regarding the mainstreaming of adaptation that future areas of research, as well as potential recommendations for policy interventions, can be identified and disseminated.

Review of the Literature

Responding to a Changing Climate

Unlike in decades prior, the question of whether the Earth's climate system is in fact changing as a result of human-driven global warming is no longer up for debate. This is reflected in the Intergovernmental Panel on Climate Change (IPCC)'s most recent assessment of the physical science behind projections for future warming, in which they directly state that it is "unequivocal" that human activity has driven "widespread and rapid" changes to the Earth's physical and natural systems, and that these changes are unprecedented over hundreds to thousands of years (IPCC, 2021). Since the Industrial Revolution, generally marked as the year 1750, human economic activity has led to increasing concentrations of carbon dioxide and other greenhouse gasses (GHGs) in the Earth's atmosphere, primarily due to the burning of fossil fuels. Increased concentrations of GHGs in the Earth's atmosphere trap energy from the Sun in the form of heat, which causes the increase in global temperatures referred to as global warming. These changes to the Earth's climate system have resulted in increased incidence of extreme weather events, (including more frequent and intense heat waves, storms, droughts, and hurricanes) faster rates of glacial melting and sea level rise, and changes in weather patterns, with no inhabited region of the Earth escaping some degree of impact (IPCC, 2021) Beyond shifting weather patterns and sea level rise, the impacts of climate change are far-reaching, including even a slowing of the ocean currents upon which humans rely to moderate temperatures in otherwise inhospitably hot or cold climates. As the global temperature continues to increase, so too will threats to coastal areas, crop failures and food insecurity, loss of vegetation and biodiversity, failure of preexisting infrastructure, water shortages, poverty and disease, highlighting the severity of the threat climate change poses to human health, the built and natural environments, and existing social, legal, and political structures (Bierbaum et al., 2013). As activists and the scientific community have worked to raise awareness surrounding the existential threat of climate change to the future of human society, actors from individual people to world leaders have acknowledged this threat, and have begun to respond to it, though with limited success (IPCC, 2014).

Since the founding of the IPCC by the United Nations Environment Program and the World Meteorological Organization in 1988, considered for the purposes of this paper as the beginning of the response to climate change, it has produced five Climate Assessment Reports (CARs), with a sixth currently in progress. This convening of scientists from around the world and the reports they produce were initiated for the purpose of determining whether climate change was in fact occurring, whether it was being driven by humans, and eventually to report on the contemporary climate situation, project future changes, and predict the impacts these changes will have. (IPCC, 2015). Resulting in part from the identification of climate threats the first two reports provided, the international community, through the United Nations Framework Convention on Climate Change (UNFCCC), adopted the 1997 Kyoto Protocol, the first international agreement to address climate change (UNFCCC, 2019). The Kyoto Protocol, which came into effect in 2005, required developed nations to set and work towards GHG emissions reduction targets, and to periodically report on their progress (UNFCCC, 2019). Around this time, climate science as a scholarly discipline began to receive increased attention, and the actions taken in response to climate change came to be grouped into two primary categories: Climate change mitigation and adaptation (Dhar and Khirfan, 2017). Mitigation refers to "a human intervention to reduce the sources or enhance the sinks of greenhouse gasses," (IPCC, 2014) while adaptation describes "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2014). Of these two broad categories of responses to climate change, mitigation efforts have been the primary focus of scientists, policymakers, officials, and governments at all scales, with climate adaptation generally occupying a smaller portion of overall mitigation plans. This can be exemplified by the Paris Agreement, the 2015 successor to the Kyoto Protocol, in which the primary goal of the treaty is to reduce GHG emissions with the intention of limiting the global temperature increase to "well below 2º Celsius," while simultaneously striving to prevent warming to even 1.5º Celsius (Paris Agreement, 2015). Climate adaptation efforts are addressed within the agreement, but primarily in reference to increasing the resilience and adaptive capacity of developing countries through the targeting of international development aid flows (Paris Agreement, 2015).

As the most recent IPCC report (2021) has confirmed, adaptation to climate change is a much more urgent set of challenges than previously realized. There are three primary explanations for the increased urgency around climate adaptation efforts: (1) the world is on presently track to exceed the warming threshold identified in the Paris Agreement, primarily due to the lack of progress towards emissions reduction by the countries responsible for the most GHG emissions; (2) even under the best-case scenario for emissions reductions offered in the IPCC (2021) report, the Earth's temperature will continue to rise until at least 2050, and global temperatures will exceed both 1.5ºC and 2ºC within the 21st century unless drastic GHG emission reduction measures are implemented within the coming decades; and (3) extreme weather events and climate variations, driven by

anthropogenic climate change, are already occurring with increasing frequency and severity in all parts of the world, and will continue to intensify (IPCC, 2021). Stated otherwise, climate change and its impacts are already occurring, and will continue to increase in severity for the foreseeable future regardless of how much progress is made towards reducing GHG emissions. Given the magnitude of the threats posed by climate change, increased prioritization of adaptation efforts is imperative to preventing large-scale damage, loss of lives and livelihoods, and social unrest (Femia and Werrell, 2012).

Though the global nature of these threats means that all will be affected, those who are already vulnerable to external shocks, including low-income, minority, or otherwise marginalized populations, face the greatest threat to their health, safety, and livelihoods (Tschakert et al., 2013; Shi et al., 2016; Striessnig, 2014; Fieldman, 2011; Hoffman et al., 2020). As will be discussed below, socioeconomic vulnerability, often caused by the same forces responsible for climate change itself (including but not limited to systems of governance and resource consumption that produce both environmental degradation and extreme socioeconomic inequality), is one of many challenges faced by those seeking to respond to climate change. The subject of how best to conceptualize, design, and implement climate change interventions in the face of the climate crisis has been the subject of ongoing research and debate, including on how to situate climate adaptation within the context of planning and urban development.

Conceptualizing Adaptation

In order to conceptualize the state of knowledge and the central debates surrounding adaptation to climate change, it is important to recognize the relatively recent development of adaptation as a field of study. Despite the knowledge of realities surrounding climate change provided by the first three Assessment Reports of the IPCC, little planning research had been conducted on the subject as recently as 2006. With the Kyoto Protocol having by this time taken effect, the threat of climate change was well enough understood that the need for action was clear, but had yet to be translated into planning research on how best to understand and plan for the impacts of flooding, fires, extreme weather, sea level rise, etc., on urban areas, or how best to understand the role of the planner and planning in the context of these threats (Pizarro et al., 2006). Mirroring the prevailing sentiment of the time, there had been some amount of planning research conducted regarding climate change mitigation through emissions reduction, but little to none regarding adaptation; many in the field considered discussions of adaptation taboo out of fears that efforts to live with the changing climate would ultimately serve to undermine efforts to slow it (Adapt or die, 2008). Adaptation studies became significantly more numerous in the years following 2006-2007, which has been posited to be in response to two main events: Hurricane Katrina in 2006 and the awarding of a Nobel Peace Prize to the IPCC for its work on its Fourth Assessment Report in 2007. Despite the successful establishment of adaptation as a subject for further research within the planning literature, studies focused on mitigation and emissions reduction have continued to outnumber those focused on adaptation, reflecting the relative novelty of adaptation concepts among both academics and practitioners (Dhar and Khirfan, 2017).

Central to the discourse surrounding adaptation to climate change are a number of concepts, including vulnerability, resilience, adaptation, and maladaptation. “Vulnerability” refers to a given system’s “exposure to the impacts of climate change and its baseline sensitivity to those impacts,” and that “both exposure and sensitivity can be influenced by that system’s adaptive capacity.” (Yohe et al., 2007, 814). In practice, this concept can be generally understood in terms of groups, and the disparate level of threat they face from climate change, which is primarily a function of socioeconomic and spatial distribution factors. Vulnerability assessments are generally an essential component of the adaptation planning process, involve the determination of who and what are vulnerable to climate impacts, and are usually measured in terms of inequality of assets and structural or institutional marginalization, especially in terms of access to human rights protection and access to power in the decision-making process (Tschakert et al. 2013). “Resilience,” a concept frequently deployed but that remains the subject of debate, is defined by the IPCC as “The capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganizing in ways that maintain their essential function, identity and structure, while also maintaining the capacity for adaptation, learning and transformation.” (IPCC 2014, 127). This most common understanding of resilience has been critiqued for its emphasis on individual adaptability and as such has been framed as an extension of the logic of neoliberalism, (Joseph 2013) as well as for its lack of a normative orientation and the difficulties involved in neatly mapping concepts from ecology onto socio-political systems comprised of individuals with varying agendas and motivations (Bahadur and Tanner 2014; Harris et al. 2019). Many of these criticisms stem from observations of powerful actors and institutions involved in international development work, as resilience operationalized in that context has at times had the effect of oversimplifying socio-political dynamics to the detriment of achieving equitable and sustainable outcomes (Mikulewicz 2019). For the purposes of this paper, however, the popular understanding of resilience as defined by the IPCC (2014, 127) will be deployed due to its popularity within both the literature and among practitioners.

“Maladaptation,” a concept defined by Barnett and O’neill (2010, 211) as “action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors, or social groups.”, was developed in recognition of the fact that while “successful” adaptation actions can be hard to define for several reasons, some adaptation actions not only fail at their intended goals, but can serve to exacerbate vulnerability across groups, space, and time (O’neill 2010; Adger et al. 2005). O’neill (2010) conceives of maladaptation as taking five forms: actions that compared to alternatives (1) result in increased GHG emissions over time; (2) disproportionately impact the most vulnerable; (3) have unreasonably high opportunity costs; (4) reduce the incentive for actors to adapt through reducing the rewards of adaptive behavior; or (5) reduce the options for adaptive activities available to future generations, often through the development of expensive infrastructure or institutional changes difficult to modify in the future. A simple example of a maladaptation is an increase in the usage

of air conditioning to reduce morbidity and mortality associated with heat waves, despite this increase directly resulting in greater energy consumption and GHG emissions (O'neill 2010; Kovats et al. 2006). "Mainstreaming" of climate adaptation has come to describe the integration of adaptation activities into other, existing policy domains as opposed to or in tandem with the creation of standalone climate adaptation plans or processes (Uittenbroek et al. 2013). In practice, mainstreaming involves the integration of climate change concerns into the creation of disparate plans and policies (Schipper and Pelling 2006), ensuring the long-term sustainability and resilience of investments in the face of climate change and its impacts (Klein et al. 2007). An example of mainstreaming climate adaptation is the inclusion of references to and consideration of climate resilience in ostensibly unrelated transportation or land use plans, or in plans for investment in infrastructure upgrades stemming from a preexisting need. The concept of mainstreaming is vital to understanding the current progress of climate adaptation efforts, as well as the challenges in both documenting and assessing them, discussed at greater length below. The concept of vulnerability is central to any discussion of climate adaptation; as the recent COVID-19 pandemic has demonstrated, large-scale disruptions have a disproportionate impact on those who are already most vulnerable as a result of legacies of marginalization and exclusion.

This review will cover three different, but related, ways of approaching adaptation to climate change, and addressing vulnerability (particularly of exceptionally vulnerable marginalized groups) is central to each. These approaches to climate adaptation can be described as ecosystem-based adaptation, community-based adaptation, and transformative adaptation. While deeply interrelated and overlapping in many ways, each of these conceptualizations of adaptation are informative for practitioners seeking to create equitable, sustainable adaptation programs.

Ecosystem based adaptation is rooted in ecosystem-based disaster risk reduction and hazard mitigation, and involves the use of native biodiversity and ecosystem services to help people adapt to the adverse effects of climate change through active and sustainable management, conservation, and restoration (Doswald et al. 2017). As both ecosystems and human societies are threatened by climate change, ecosystem-based adaptation seeks to protect both in a mutually beneficial fashion, based in an understanding that active and sustainable management of biodiversity has measurable benefits for humans, including not only protection from the hazards associated with climate change, but also social, economic, and cultural benefits (Doswald et al. 2017). The low-cost nature of ecosystem-based approaches to climate change adaptation, combined with the economic and social benefits of biodiversity conservation (including but not limited to protection of livelihoods, maintenance of indigenous knowledge, increased food security, improvements in air and water quality), has made this a popular approach to reducing the vulnerability of communities to climate change (Geneletti and Zardo 2016). The large number of co-benefits associated with ecosystem-based approaches has led to a high degree of mainstreaming, with policies and programs that can reasonably be considered adaptation efforts having been integrated across several sectors of planning and infrastructure investment. The degree to which the ecosystem-based approach has

been integrated into other planning concerns is reflected in the emergence of the biophilic city movement, which while focused on the benefits of increased contact with nature on the physical, emotional, and social health of urban residents, touts the benefits of said approach in increasing resilience to climate change and sustainability more broadly (Beatley and Newman 2013).

Much like an ecosystem-based adaptation approach, a community-based adaptation approach emphasizes the strengths of designing adaptation plans at the local level, informed by a given community's particular vulnerabilities, with a focus on strengthening the capacity of local people to adapt and thrive within the context of a changing and potentially threatening environment (Ayers and Forsyth 2009). Community based adaptation approaches emphasize the value of local knowledge gained through participatory planning processes, as the local level is where climate impacts are felt, where adaptive capacity is built, and ultimately where people respond to these impacts (Ayers and Forsyth 2009). Rather than limiting adaptation considerations to physical impacts such as sea level rise, floods, and heat waves, an understanding that socioeconomic vulnerability drives vulnerability to climate change underlies a community-based approach focused on addressing these underlying vulnerabilities in order to increase the ability of individuals and communities to be resilient in the face of disruptions including and spanning beyond climate change (Schipper et al. 2014). The explicit focus on socioeconomic vulnerability reduction for the purpose of increasing resilience to the impacts of climate change could easily be understood as mainstreaming adaptation into broader planning and development efforts, but as Schipper (2007, 7) points out, "mainstreaming will not be effective if existing development trajectories are inconsistent with the objectives of adaptation, i.e. if they explicitly contribute to vulnerability." The influence of the community-based approach to adaptation can be witnessed in the practice of municipal planning departments seeking to create vulnerability assessments based on the lived experience of residents, and the increased effort to engage historically marginalized communities in the process. An example of this can be found in the city of Richmond, Virginia's climate action plan "RVAgreen 2050," currently under development and explicitly focused on addressing the disproportionate impacts of climate change on the city's "historically underrepresented and economically disadvantaged communities" (RVAgreen 2050, 2021).

The need to address underlying vulnerabilities in order to successfully adapt to climate change is taken a step further with the transformative approach to adaptation. This approach is characterized by, rather than incrementally adapting as conditions change, aiming to reduce the root causes of vulnerability to climate change by transforming social-ecological systems into more just, sustainable, and resilient states (Fedele et al. 2019). While this approach can include transforming the social-ecological system by relocating residents from flood-prone areas instead of elevating their homes, it can also include rectifying the long-standing power imbalances and socioeconomic inequalities that lead to minorities and low-income communities living in areas subject to greater vulnerability in the first place. Fedele et al. (2019) characterize responses to climate change as belonging to three major categories: coping responses, incremental adaptation, and transformative

adaptation; they demonstrate the concept through considering how farmers might respond to the impacts of climate change, with said farmers having the options of either coping through replanting damaged crops, incrementally adapting through building irrigation systems to reduce future risks of crop failure, or transforming the fundamental characteristics of their livelihood through adopting agroforestry or reforestation practices (Fedele et al. 2019). It is important to note that in this example and among other adaptation efforts, the extent to which coping, incremental, or transformative change is possible or required is dependent on the severity of the impact and the capacity of a given actor to respond, meaning that not all coping strategies or incremental adaptations are inferior to transformative adaptations, particularly if the alternative course of action is taking no action at all. Fedele et al. (2019) concede this fact, and recommend a transformative approach to adaptation under circumstances in which climate impacts are expected to dramatically and imminently increase, when dramatic changes in social-ecological systems have already occurred, or when incremental adaptation strategies are reaching their limits of usefulness. When considering the national-scale response to climate change, Shi and Moser (2021) argue that anything short of transformative change is no longer adequate, given the cascading and overlapping crises of health, economic, social (racism and marginalization), and climate, and that "deliberately and fundamentally changing systems to achieve more just and equitable outcomes" should be prioritized over "climate-proofing" existing systems and infrastructure (Shi and Moser 2021).

Adaptation and Theories of Planning

The aforementioned approaches to climate adaptation hold in common a normative orientation towards addressing the disproportionate impacts of climate change on already vulnerable populations, and the inclusion of the expressly stated goal of improving the material and socioeconomic conditions of those same groups. These theories of adaptation also emphasize the importance of integrating local knowledge into decision-making processes, expanding participation in democratic processes, and shaping systems of governance that address the root causes of the vulnerabilities they have been developed to address. In these factors, adaptation, a field of study not limited to planning or planners, is aligned with the ethics of the planning profession as stated by the American Planning Association (particularly as relates to the serving of public interest), and is reflective of the evolution of planning theory over the course of the last generation (APA, 1992). The "Just City" theoretical framework advanced by Fainstein (2010) is relevant when considering the linkages between the normative goals of planning and the goals, processes, and context of addressing climate change and its impacts. Fainstein (2010) argues that equity, diversity, and democracy are the primary components of justice in an urban context, that pressuring for "nonreformist reforms" from within the establishment structure can lead to incremental reforms that in aggregate can alter the trajectory of a system towards justice, and that the aforementioned reforms when combined with political mobilization can produce meaningful change. This view is in keeping with the transformative view of climate adaptation, in that transformative adaptation can be the result of a series of incremental adaptations, that broader participation and expansion of institutional goals to include the material interests of marginalized

groups can reduce structural inequities and vulnerabilities, and that working towards fundamentally changing existing systems is necessary to achieve just and sustainable outcomes.

Fainstein's (2010) Just City framework is further aligned with the ecosystem based approach to climate adaptation, in that it advocates for increased scrutiny on large-scale infrastructure or economic development projects, particularly as relates to the benefits conferred to low-income communities through employment, tax revenue to fund public services, and public amenities. The ecosystem based approach to climate adaptation mirrors this sentiment, highlighting the expensive and inflexible nature of large-scale infrastructure designed to protect against climate impacts, preferring instead the context-sensitive, inexpensive route of protecting and conserving natural resources and biodiversity for both their climate protection properties and their associated benefits to human wellbeing. In addition to the Just City framework, the sustainable development approach is instrumental for planners seeking to mainstream adaptation efforts within their planning practice. To understand how, it is useful to recall the Brundtland Commission's (1987) definition of sustainable development, "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Both portions of this statement, regarding meeting the needs of both the present and of future generations, are critical in understanding the utility of the sustainable development approach to planning. Given that the needs of the present are not currently being met (creating the socioeconomic marginalization that drives vulnerability to climate shocks), sustainable development must by definition actively work to meet those needs while simultaneously working to create the conditions under which future generations will be able to meet their own needs. It has been argued that the primary focus of adaptation processes should be reducing longstanding vulnerabilities in order to increase communities' adaptive capacity in the face of climate change, and thus should foreground addressing development issues such as poverty, access to opportunities, protection of livelihoods, creation of a safe and healthy built environment, etc. (Lisa 2007; Ayers and Forsyth 2009; Schipper et al. 2014; Shi and Moser 2021). In practice, this would render climate adaptation initiatives virtually indistinguishable from planning oriented around these principles of sustainable development.

It can be concluded from the literature on theories of both sustainable development and of planning that a number of principles are held in common between the two separate but often overlapping fields of study and practice. "Good" planning and "successful" climate adaptation efforts should both involve a great deal of citizen participation that actively seeks to engage historically marginalized populations in order to gain access to localized knowledge about a given community's assets and vulnerabilities. These participation efforts should ideally be designed in such a manner that a significant degree of control over decision-making ultimately resides with the public itself, rather than creating circumstances under which the public plays an advisory role but in which the decisions made are ultimately determined by whether those in power choose to heed their advice. As stated by Burby (2003, 44), "greater stakeholder involvement [leads to]

comprehensive plans [that] are stronger, and proposals made in plans are more likely to be implemented." Beyond leading to the creation of stronger plans with greater likelihood of implementation (which is always a goal when conducting a planning process), stronger citizen participation processes that actually place some degree of decision-making power into the hands of communities are less likely to perpetuate the policies, practices, and systems responsible for marginalization in the first place. The role of citizen participation is to facilitate the redistribution of power from established officials and elites towards average residents who are historically excluded from social and economic systems for the purpose of giving them the means to change said systems so that they can share in the benefits of society (Arnstein 1969). This conceptualization of citizen participation, which has become central to the theory and practice of planning, is consistent with the transformative approach to climate adaptation, which ultimately aims to shift the trajectory of social-ecological systems towards more just and equitable outcomes, and in doing so seeks to redress the root causes of vulnerability rather than the manifestations of it (Giacomo et al. 2019).

As Berke and Stevens (2016) point out, the unique combination of skills that planners possess can be harnessed to help guide the development of plans and policies designed to facilitate communities' adaptation to climate change through the ability to engage a diverse range of stakeholders, navigate climate uncertainty, and holistically integrate the interdependent goals of both climate mitigation and adaptation. The contemporary focus of the planning profession on ensuring procedural and distributive justice makes planners particularly suited to pursuing the transformative equity goals articulated in adaptation theory while simultaneously carrying out their mandate of guiding communities towards safer, healthier, and more economically viable futures (Berke and Stevens 2016). With a focus on place-based resilience building, rooted in theories of both planning and climate adaptation, planners can facilitate the strengthening of local adaptive capacity through the course of their everyday responsibilities in addition to explicit climate action planning processes.

Climate Adaptation Progress in the United States

As discussed above, research on climate change and what to do about it has historically prioritized identifying and mitigating the sources of GHG emissions, with attention to adaptation needs emerging only relatively recently and accelerating dramatically following the impacts of Hurricane Katrina and Superstorm Sandy in 2006 and 2012, respectively (Pizarro et al., 2006; Dhar and Khirfan, 2017). Efforts to respond to climate change among practitioners, policymakers, and governments have followed a similar trajectory, with Hurricane Katrina, Superstorm Sandy, and the intense drought experienced in the Western United States since 2000 increasing awareness of local vulnerabilities and the need to initiate adaptation planning processes to address them (Vogel et al. 2016; Bierbaum et al. 2013; Lioubimtseva and Cunha 2020). Attempts to characterize the nature of adaptation efforts in the United States have been made since at least 2010, with state-of-the-practice reviews having been conducted by government agencies (NRC 2010), scholars (Bierbaum et al. 2013; Melillo et al. 2014), and professionals (Vogel et al. 2016, Hansen et al.

2013), with each drawing conclusions about the state of progress, best practices and successful strategies, and common barriers identified. Opinions differ on the extent to which progress has been made on adaptation efforts in the United States. Bierbaum et al. (2013) asserted that few measures had been implemented or otherwise progressed past initial scoping stages as of 2013. This contrasts with Vogel et al.'s (2016) argument that the former's assessment misses progress made towards reducing communities' vulnerability to both climate-driven extreme events and the long term risks associated with climate change. This difference in approaches to evaluating progress is reflective of the difficulties involved in determining what climate adaptation is and is not, given the degree to which adaptation activities can and have been mainstreamed into other policy domains, and the fact that efforts to address other social and economic priorities can lead to reductions in vulnerability. Independent of the means by which climate adaptation efforts have been evaluated, however, there is a general consensus that those that have taken place fall short of the comprehensive and transformative efforts needed to adequately address the challenges ahead (Bierbaum et al. 2013; Vogel et al. 2016; Hansen et al. 2013). A number of common observations have nonetheless been made regarding the processes by which adaptation takes place, including motivations behind adaptation efforts, identification of successful strategies and best practices, and frequent barriers to adaptation faced by governments, organizations, and individuals.

While adaptation efforts can and do occur at all levels of government, the local and regional contexts are the primary scales at which adaptation efforts will be considered for the purposes of this thesis. Federal action is important, and state-of-the-practice studies have recognized federal contributions towards adaptation efforts, which include the creation of the UGCRP and the encouragement of climate adaptation through executive orders, agency planning, and disaster recovery grant requirements (Bierbaum et al. 2013). In spite of these contributions, federal action on climate change has been inconsistent over the last twenty years, lacking a comprehensive approach to adaptation or the dedication of adequate funding for climate adaptation activities and resulting in a high degree of fragmentation between levels of government and across jurisdictional boundaries (Shi and Moser 2021). Though much attention is given to the international and national scales of climate change response, the local and regional levels are fundamental to the work of climate adaptation in part because of the degree to which the federal government has abdicated its responsibility for guiding a national-scale climate strategy. Even if the federal government were willing and able to act, the functions most relevant to climate action (in terms of the actual distribution of governance in the United States), including land use planning and regulation, transportation planning, management of water resources, enforcement of environmental regulations, public health, and coastal management are all traditionally under the purview of state and local governments, so federal action cannot comprehensively address the situation on its own (Hansen et al. 2013). Further, the locality and the region are where people experience the impacts of climate change, where they build adaptive capacity, and where they respond; it is also where participatory processes that prioritize stakeholder involvement and local knowledge of community assets, vulnerabilities, and priorities can occur (Ayers and Forsyth 2009). By focusing on the local

and regional levels, the knowledge that is produced can then be shared in order to help inform actors on how they might proceed with adaptation efforts within their own local contexts.

Climate adaptation actions can be said to be either reactive or anticipatory; they can be taken in response to past or current experiences with extreme weather or other climate-related events, or they can be taken before severe impacts are experienced based on projections of future conditions (Adger et al. 2005). As identified in the state-of-the-practice studies referenced above, most of the adaptation activity that has occurred in the United States to present have been reactive, in that they have been motivated by experiences with past or current experiences with extreme weather events or other impacts of climate change, including recurrent and increasingly severe flooding, increasing rates of precipitation and stronger storms, and longer-lasting drought conditions in the American West, among others (Bierbaum et al. 2013; Vogel et al. 2016; Hansen et al. 2013). In Vogel et al.'s (2016) study of contemporary climate adaptation efforts, they found that a community's experience with extreme climate impacts was the most common motivating factor for initiating adaptation activities, with more communities initiating adaptation efforts as climate change accelerates and as its impacts are felt more broadly across regions.

The actual process of adaptation planning activities, when pursued as discrete processes and when mainstreamed into other policy domains, tends to follow a pattern similar to what can be considered standard procedure for planners more broadly. Bierbaum et al. (2013) identify the process of adaptation planning (consistent across sectors and scales) as consisting of identifying risks and understanding vulnerabilities; planning, assessing, and selecting options; implementation; monitoring and evaluation; and revising strategies and sharing lessons learned. Hansen et al. (2013) identify the process as consisting of conducting impact assessments; conducting vulnerability assessments; planning; implementation; and monitoring and evaluation. The stage in the process centered on the identification of risks can include actions by others in society, most commonly by the networks of scientists and officials responsible for producing and disseminating information about climate change, its effects, and projections for the future (i.e. the IPCC), as decision-makers at all scales necessarily rely on information about climate change to plan for its effects. While both emphasize different factors of the process and their relative importance, both frame the process as a cycle, rather than as a linear process from beginning to end. This can be attributed to the uncertainty regarding future climate change and its impacts, and the need to design adaptation processes that are adaptive in and of themselves (Bierbaum et al. 2013; Hansen et al. 2013). This is consistent with efforts to avoid maladaptive outcomes as discussed above, as actions that reduce the flexibility of future generations' decision-making capacities are generally considered to be maladaptive in nature (Barnett and O'Neill 2010). The articulation of an ideal process for designing and implementing adaptation activities is in recognition of the fact that adaptation activities can and do happen autonomously on the part of individual actors within society as prevailing conditions change; this observation leads to the conclusion that such a framework is necessary to prevent maladaptive outcomes (Hansen et al.

2013). Based on the discussions of the normative goals of adaptation efforts above, an ideal cycle for adaptive processes to adhere to would be some combination of the two, one that equally emphasizes the importance of ongoing vulnerability assessments, constant revision of strategies, and the sharing of information gathered throughout the process with peer organizations and groups.

Through reviewing the progress of adaptation efforts to present, a number of factors common to successful projects can be identified. Vogel et al. (2013) have found that interventions designed narrowly to address one specific risk factor (i.e. recurrent flooding due to sea level rise and increased precipitation, increased incidence of heat waves, droughts, etc.) are likely to be considered successful by their proponents, due to the complexity of comprehensively forecasting and responding to local effects of climate change. They further characterized these efforts as more likely to be implemented due to the nature of responding to specific disaster threats as being politically neutral good-governance when climate change adaptation can be a politically loaded subject in some regions of the country. These efforts, generally aimed at responding to previous and contemporary climate variability and extreme weather events, and that respond through established policy tools and institutional structures are among the easier adaptation strategies available to policymakers; however, their orientation towards responding to past and current threats makes them more vulnerable to losing effectiveness over time, especially as climate impacts continue to increase in severity (Vogel et al. 2016). Hansen et al. (2013) have found that adaptation actions on the part of local or state governments targeted at addressing the vulnerabilities of direct government assets (vehicle fleets, buildings, personnel, infrastructure, institutions) are often an effective way to both increase resilience and build support for further adaptation efforts among the community more broadly, while through the process building institutional capacity through providing the opportunity for officials, staff members, and involved community members to learn. They find that this limited scope of action is one way in which governments have acted on climate adaptation needs despite their limited authority and resources (Hansen et al. 2013). Vogel et al. (2016) have found that these and other community adaptation strategies, despite falling short in terms of the normative goals of transformative adaptation, have been successful in tangibly reducing their vulnerability to climate variability, extreme events, and climate change. The majority of implementation efforts they have documented have been explicitly aimed at reducing their community's sensitivity to shocks and increasing their adaptive capacity. However, they have also found that these vulnerability reductions are limited in temporal or spatial scale, and often fail to reduce their overall exposure to climate impacts in that they do not address long-term drivers of vulnerability or are only temporary in nature (Vogel et al. 2016).

A common finding across all of the state-of-the-practice studies referenced in this section is that despite being harder to document and evaluate, mainstreaming of climate adaptation concerns has made considerable progress across the United States, often taking the form of climate-conscious capital investment strategies, including climate projections into hazard mitigation planning and land use planning, and the creation of climate-focused guidelines applicable across municipal

departments (Vogel et al. 2016; Bierbaum et al. 2013; Hansen et al. 2013). Based on their analysis of climate adaptation plans from a large number of both American and French municipalities, Lioubimtseva and da Cunha (2020) characterize successful adaptation efforts as having three main factors involved in their success: inclusion of a wide diversity of stakeholders, a local history of environmentalism, and the broader political and material context of the region and state within which they are situated. Among these factors, the first is reflective of the importance of genuine public participation discussed above, and the latter two are factors that are generally outside the control of local actors; however, these two factors demonstrate the importance of building public support for climate action and tailoring climate adaptation strategies and the communications surrounding them to the local context in which they are presented.

Given that the general assessment of adaptation progress in the United States to date can be summarized within the title of Bierbaum et al.'s 2013 article, "*more than before, but less than needed,"* all of the articles reviewed on the subject have dedicated considerable effort to documenting the challenges and barriers facing adaptation efforts among communities, which allows for a thorough understanding of what still needs to be researched, improved upon, or implemented in support of further progress. One of the primary difficulties involved in both the study and practice of climate adaptation, noted as early as 2001 (Yohe et al. 2007) and reaffirmed as recently as June 2021 (Shi and Moser 2021), is that conceptualizing how to evaluate adaptation efforts has remained elusive. This has been extensively discussed within the literature, and can be attributed to a wide range of factors, including but not limited to the uneven distribution of adaptive capacity with and between communities (Yohe et al. 2007); the relatively recent emergence and continually developing nature of climate adaptation as a field of study (Bierbaum et al. 2013); the diffuse nature of adaptation efforts and the fact that said efforts are not always explicit, due to both mainstreaming and the fact that many ostensibly separate social, economic, and environmental programs contribute to vulnerability reduction (Vogel et al. 2016); and the simple fact that planning horizons for climate adaptation efforts are long, and have not been around long enough to comprehensively evaluate their long-term impacts (Ford et al. 2011).

Extensive efforts have been made to create evaluation metrics (Barnett and O'Neill 2010; Beilier and McNeil 2016; Hughes 2015; Lioubimtseva and da Cunha 2020; Mees 2014; Uittenbroek et al. 2013), but these attempts have resulted in frameworks that are either not universally applicable due to their basis in a particular regional context or fall short of a comprehensive evaluation due the elusive nature of adaptation efforts in general referenced above (Vogel et al. 2016). An additional challenge frequently referenced in studies of adaptation progress, both in the United States and abroad (Lioubimtseva and da Cunha 2020), is that existing efforts have lacked attention to equity concerns, social vulnerability, and the influence of non-climatic issues on vulnerability (Hughes 2015). Decision-makers in the adaptation process have primarily focused on protecting infrastructure, buildings, and other aspects of the built environment from the effects of climate impacts through expensive physical interventions at the expense of the social, economic, and

political reforms that would begin to address the root causes of vulnerability; the danger in this approach is that prioritizing the protection of capital investments has the potential to create areas that are safe from climate impacts but that are exclusionary and displacing of those who are most vulnerable (Shi et al. 2016). Based on the normative assumptions of climate adaptation, in which the goals of adaptation are to fundamentally change social-ecological systems to achieve more just and equitable outcomes rather than protecting status quo systems and structures from climate change, it is imperative that equity concerns take a much more prominent role in adaptation efforts across the board (Shi and Moser 2021). When it comes to addressing concerns about equity in climate adaptation processes, another frequently cited challenge for planners is a lack of concrete policy guidance on how to actually carry out adaptation efforts without exacerbating existing socioeconomic vulnerabilities (Shi et al. 2016). This is compounded by the political challenges facing individuals and organizations seeking to implement incremental or transformative adaptation strategies, as the fundamental reforms to social and economic systems frequently cited as the way to address long-standing vulnerabilities are redistributive in nature, and as such are highly contested by those who benefit from existing systems, including those with whom power and authority to enact said changes rests (Holland 2017). The establishment of climate change as a political issue has implications for perceptions of vulnerability and risk among stakeholders, which can complicate decision-making around broader planning priorities and public investment (Beilier and McNeil 2016). Implicated in the complexity of building support for climate adaptation efforts among decision makers and the general public is the issue of knowledge transfer, another frequently referenced barrier to adaptation discussed in the literature (Adger et al. 2011; Bierbaum et al. 2013; Dhar and Khirfan 2016; Hughes 2015; Lioubimtseva and da Cunha 2020). Discussed to some degree above in that uncertainty and the lack of reliable information about climate change and its projected impacts can impede climate adaptation efforts (Vogel et al. 2016), decision making inherently relies accurate and detailed information for the sake of informing choices among alternatives; the lack of adequate information about what climate impacts can be expected in a particular region necessarily hinders the ability to plan for the future. Similarly, one of the ways in which regional actors can increase support for climate adaptation efforts is by communicating the risks of inaction and emphasizing vulnerability (Vogel et al. 2016), which is indeed far more difficult without possession of said information to begin with.

Involving to some degree each of the aforementioned challenges to adaptation is the multi-scalar and cross-sectoral nature of climate change and its effects, and the degree to which this complicates adaptation responses in the context of the American system of governance. This has been cited as a primary challenge by all of the state-of-the-practice studies reviewed, as well as by the majority of the other papers referenced in this review (In particular: Adger et al. 2005; Barrett 2013; Bierbaum et al. 2013; Dhar and Khirfan 2016; Harris and Chu 2019; Patterson et al. 2019; Shi et al. 2016, 2020). Given that the social and ecological systems impacted by climate change (including ecosystems, transportation systems, watersheds, etc.) are not constrained by political boundaries, the fragmentation of governance and authority along municipal, regional, and state

lines, as well as between different departments and agencies with overlapping or competing authorities, is a critical barrier to building the resilience of said systems (Bierbaum et al. 2013).

One example of this is the scalar mismatch between the outputs of research on climate effects and adaptation, which has primarily been at the regional scale, and the authorities responsible for implementing the recommendations of said research, which are primarily at the local or municipal scale; this is further complicated by the reliance of municipal actors on higher levels of government for funding, regulatory authority, and institutional capacity (Dhar and Khirfan 2016). The lack of federal leadership, funding, and support discussed above (Shi et al. 2016, 2020) has led to a lack of coordination between municipalities and regions on adaptation activities, and a lack of standardized stakeholder involvement procedures has led to a lack of consistent coordination between individual governments and the private and voluntary sector actors within their territories. It has been established that higher levels of public participation and stakeholder involvement leads to better adaptation plans that are more likely to be implemented, and that are more likely to succeed at their goals once implemented (Berke and Stevens 2016; Lioubimtseva and da Cunha 2020), so it can be reasoned that this lack of coordination has impeded successful adaptation planning and implementation.

On the scale of a single municipality, Shi et al. (2016) find that the majority of cities have confined their adaptation efforts to their land use planning and environment departments, with very few engaging their water, wastewater, and waste management departments, and almost none engaging their departments of economic development or health. This lack of coordination and engagement across scales has implications for the ultimate success of any attempted adaptation effort, as lower degrees of coordination across sectors, scales, and the broader public are far more likely to result in maladaptive outcomes through the establishment of actions that succeed in their intended goals, but ultimately fail by exacerbating vulnerabilities across groups, space, and time (Barnett and O'Neill 2010). A lack of scalar and sectoral coordination directly leading to failures of adaptation efforts can be illustrated by the following example of a given municipality: even if said municipality has developed and implemented an adaptation plan through its planning and environment departments, other agencies will likely disregard the environmental, social, and climate effects of any given action taken solely by carrying out their mandates, as if there has not been a concerted effort to align procedures with the goals of the plan, adaptation goals are simply not part of the decision-making calculus (Adger et al. 2005).

It can be concluded from the literature that most existing responses to climate change have been reactive instead of anticipatory, often driven by a community's experience with extreme climate events (Adger et al. 2005; Vogel et al. 2016); are primarily concerned with emissions reductions, but are increasingly focusing on adaptation as a result of heightened awareness of vulnerabilities (Pizarro et al., 2006; Dhar and Khirfan, 2017); and have developed in the context of federal inaction over at least the last four presidential administrations, leading to a high degree of

fragmentation between levels of government and across jurisdictional boundaries (Shi and Moser 2021). Studies of the state-of-the-practice regarding climate adaptation efforts have revealed a number of common approaches across jurisdictions and scales, including moderately successful adaptation to specific climate threats (i.e. recurrent flooding due to sea level rise and increased precipitation, increased incidence of heat waves, droughts, etc.) that omit consideration of broader socioeconomic and climate vulnerabilities (Vogel et al. 2016); efforts to address the vulnerability of direct government assets (vehicle fleets, buildings, personnel, infrastructure, institutions) as a way to begin addressing adaptation needs within the context of their limited authority and resources (Hansen et al. 2013); efforts to make tangible reductions in vulnerability and increases in adaptive capacity, even if at a narrowly defined spatial and temporal scale (Vogel et al. 2016); and attempts to mainstream adaptation and make use of conventional policy tools to support the building of adaptive capacity through the course of normal government operations (Bierbaum et al. 2013; Vogel et al. 2016).

The improving but as yet still inadequate nature of climate adaptation efforts in the United States has led to the identification of a number of common challenges and barriers to adaptation, including a long-standing difficulty in conceptualizing how to comprehensively evaluate adaptation efforts (Shi and Moser 2021; Yohe et al. 2007), compounded by the long-term nature and recent emergence of adaptation as a field of study (Bierbaum et al. 2013); a lack of effective information gathering and dissemination to relevant actors in the form of climate change projections, best practices, and lessons learned (Bierbaum et al 2013; Lioubimtseva and da Cunha 2020); a lack of existing, concrete policy guidance on how to carry out adaptation efforts without exacerbating existing socioeconomic vulnerability (Shi et al. 2016), compounding a general lack of attention to equity, socioeconomic vulnerability, and the influence of non-climatic factors on vulnerability (Hughes 2015); a variable and sometimes difficult set of political circumstances surrounding adaptation efforts stemming from the politicization of climate change along partisan lines (Vogel et al. 2016); and the potential for the local emphasis of adaptation processes, combined with a lack of financial and technical support provision, to widen socio-spatial inequalities based on the differing capacities of cities to act (Shi et al. 2016).

All of the before-mentioned characteristics of and barriers to observed climate action are reflective of the difficulties posed by the multi-scalar and cross-sectoral nature of climate change and its effects, which complicates planning for adaptation within the context of the American system of distributed governance. Given that the coordination of actors across scales, sectors, and the public has been frequently cited as a primary mechanism for preventing maladaptive outcomes (Barnett and O'Neill 2010; Shi and Moser 2021; Lioubimtseva and da Cunha 2020), the fragmentation of governance across scalar, spatial, and institutional dimensions has been frequently cited as a barrier to more effective, more comprehensive, and more transformative climate adaptation (In particular: Adger et al. 2005; Barrett 2013; Bierbaum et al. 2013; Dhar and Khirfan 2016; Harris and Chu 2019; Patterson et al. 2019; Shi et al. 2016, 2020). It is around this central conflict between the

nature of climate change and the capacity for American governance to respond to it that the following section is oriented.

Metropolitan Planning Organizations (MPOs) and Climate Adaptation

In examining how to strengthen efforts to adapt to climate change within the context of existing networks of governance, it has been suggested that metropolitan planning organizations (MPOs) may represent an ideal type of institution to serve as part of a more highly coordinated response to climate change (Mason and Fragkias 2018). MPOs are regional planning bodies in urbanized areas of 50,000 people or more, mandated by federal law and required to carry out a "continuing, cooperative, and comprehensive" multimodal transportation effort including the development, management, and operation of transportation systems (23 U.S.C. 134, 2020). In urbanized areas with a population of 200,000 or more, the U.S. Secretary of Transportation designates a transportation management area (TMA), in which the area's MPO is granted additional powers and is subject to additional requirements under 23 U.S.C. 134 (2020). Unless stated otherwise, all references to MPOs in this thesis are part of a TMA. The boards governing MPOs must consist of elected officials from each of the constituent local governments, officials of public transportation agencies, and state officials. As part of the regional transportation process required of them, MPOs must develop long-range transportation plans (LRTPs) and transportation improvement plans (TIPs), and must coordinate transportation services and improvement projects throughout their jurisdictions. MPOs are also required by federal law to develop and abide by public participation plans, intended to ensure that all interested parties are able to participate in the development of plans and decisions made (23 U.S.C. 134, 2020). The most important features of MPOs for the purposes of this review are their role as regional forums for planning and cooperation between municipalities, and the link between their traditional planning work surrounding transportation and factors surrounding climate change, its causes, and the ways in which society must adapt to its effects.

The nature of MPOs as bodies that convene state and regional stakeholders, that exist in every urbanized area in the United States, and that assist with the coordination of public funding from all levels of government has led to hypotheses that this unique nexus could provide opportunities for overcoming the challenge of fragmented authority and limited cooperation regarding climate adaptation in the United States (Mason and Fragkias 2018; Beiler et al. 2016; Shi 2019). While the authority of MPOs has traditionally been limited to the coordination and disbursement of federal funds among local governments, Mason and Fragkias (2018) highlight the fact that MPOs in many regions have been granted additional authority over a variety of metropolitan scale issues and have continued to evolve in scope and purpose, creating the potential for regional-scale governance on climate issues to become part of their mandate.

Many of the barriers to adaptation discussed above, including the lack of institutional and fiscal capacity of most municipalities to plan and implement adaptation efforts, difficulties with vertical and horizontal coordination (between levels of government and other local governments), and

political constraints leading to a focus on single sources of vulnerability or precluding action at all, can theoretically be resolved through the involvement of a regional-scale institution with the power to convene stakeholders and with access to greater resources (Shi 2019). Separate from the potential to resolve existing challenges to adaptation, the IPCC (2013) has asserted that climate impacts, including higher temperatures, more frequent and more intense precipitation, sea level rise, and increases in extreme weather events will increasingly threaten existing multimodal transportation networks. Beiler et al. (2016) argue that regardless of political or institutional motivations surrounding climate adaptation, MPOs will have to take action to protect the transportation infrastructure that is core to their mandates from the impacts of climate change.

This attention on the need for MPOs to address climate change has led to a small but growing set of studies seeking to document and evaluate their progress towards climate change mitigation and adaptation efforts, and to identify potential challenges faced in doing so that may be overcome through further research (Beiler et al. 2016; Mason and Fragkias 2018; Shi 2019). Mason and Fragkias (2018) examined factors that affect the degree to which MPOs engage with climate change response efforts, and found that organizations with (1) a greater number of staff employed; (2) larger numbers of board members, reflecting a diverse set of constituencies and faced with a larger number of different climate risks; and (3) a higher belief among MPO board members and staff that climate change is both anthropogenic and a threat were significantly more likely to have begun taking action. They further found that both the degree of social vulnerability present in the MPO's jurisdiction and the area's partisan politics (as measured by Republican and Democrat vote share) had a negligible impact on an MPO's involvement in climate activity (Mason and Fragkias 2018).

Beiler et al. (2016) compared the adaptation efforts taken by Mid-Atlantic MPOs before and after Hurricane Sandy, and found that adaptation activities had increased, particularly as relates to rural conservation and floodplain designation for the purpose of reducing development of transportation facilities in sensitive areas, urban revitalization planning and funding, complete streets policies, and efforts to collaborate across horizontal and vertical scales. They also found that progress towards more comprehensive adaptation efforts, such as addressing sea level rise and conducting storm surge analyses, had not increased in activity, which they attributed to limited budgets and a lack of available resources and expertise (Beiler et al 2016).

Shi (2019) examined the regional adaptation efforts of Los Angeles, Boston, and Miami in order to critique the ability of regional planning to overcome the challenges present in local adaptation efforts. She found that regional efforts have been successful in reducing a number of said barriers, including a lack of information, staff capacity, and political leadership, and have helped more cities learn about their vulnerabilities, lobby for more resources from state and federal governments, and push for states to mandate local adaptation planning. Shi (2019) further found that regional efforts have been hindered by the weak nature of regional collaboratives as compared to local

governments and states, and that they have primarily advocated for resources, funding, and enabling legislation for localities, rather than for regional entities, reflecting their relative weakness in coordinating implementation across multiple jurisdictions. It is important to note that Shi's (2019) conclusions were focused on regional collaborative entities created for this purpose, rather than existing MPOs, but nonetheless provides insight on the processes and dynamics of coordinating adaptation efforts at the regional scale.

As the most recent of the reviewed studies, Shi's (2019) description of common challenges facing regional-scale adaptation to present are helpful in describing what needs to be improved moving forward: a narrow focus on physical assets, a lack of analysis on regional function and governance gaps, an inability to enforce integrated adaptation programs, a chronic lack of participation by socially vulnerable groups, a lack of mechanisms for reconciling regional and local priorities or to mediate disputes, and a lack of regional mechanisms to regionalize the financial impacts of development.

Review of the Literature - Summary

In summary, climate change is happening, and its impacts can be expected to intensify over at least the next fifty years, regardless of progress made on reducing global GHG emissions. Given the dismal progress made on emissions reductions to present, it is likely that climate impacts will continue to accelerate into the foreseeable future, necessitating actions be taken to help societies adapt to uncertain, dangerous, and unstable conditions (IPCC, 2021; Femia and Werrell, 2012). Climate adaptation was initially considered a taboo in academic and official circles due to the perception of threat to emissions reduction efforts, but Hurricane Katrina, Hurricane Sandy, and the Millennium Drought in the Western U.S. raised awareness of immediate climate impacts and existing vulnerabilities Following these extreme events, the number of academic studies on adaptation dramatically increased, as did the number of documented adaptation planning efforts in practice. Despite this increase, the number of studies and practical efforts focused on mitigation through the reduction of GHG emissions continue to far outpace those focused on adaptation (Dhar and Khirfan, 2017).

Increased attention on climate adaptation has led to the development of a number of concepts central to the emergent field of study. The most central of these concepts include those of vulnerability, resilience, risk, mainstreaming, and maladaptation (Tschakert et al. 2013; IPCC 2014; O'neill 2010; Adger et al. 2005; Schipper and Pelling, 2006). A number of theories of adaptation, rooted in a combination of the social and natural sciences, have proven influential to the discourse, among which those of ecosystem-based adaptation, community-based adaptation, and transformative adaptation were examined in this review. Held in common between all of these approaches is the essential importance of socioeconomic vulnerability to climate adaptation, as well as the need to address the root causes of said vulnerability in order to change a community's development trajectory towards one of justice and sustainability. (Doswald et. al., 2017; Ayers and Forsyth, 2009; Fedele et. al. 2019). Theories of planning have also proven to be instructive in

conceptualizing adaptation processes, as the disciplines are overlapping and involve many of the same issues; the theories of planning discussed in this review include Fainstein's Just City framework, Arnstein's Ladder of Citizen Participation, and an understanding of sustainability rooted in the Brundtland Commission's definition of sustainable development (Fainstein, 2010; Arnstein, 1969; Brundtland Commission, 1987). All of these theories stress the importance of addressing socioeconomic vulnerability and provide a moral orientation for climate adaptation efforts; however, as in planning practice, it has been found by scholars of adaptation that a perspective rooted in vulnerability reduction is more than a mere normative goal. Rather, by focusing on reducing socioeconomic, spatial, and temporal vulnerabilities, adaptation processes are more likely to succeed in the goal of reducing a community's overall exposure to climate impacts, and providing a long-term path towards resilient and sustainable economic, social, and physical development (Lisa 2007; Ayers and Forsyth 2009; Schipper et al. 2014; Shi and Moser 2021).

Given the increasing need to pursue adaptation planning efforts, several communities across the United States have engaged in processes designed to reduce their vulnerabilities and strengthen their adaptive capacity. The general assessment of the state of adaptation progress in the United States to present has been that efforts have been made, but more and better efforts are desperately needed. While adaptation efforts can and have been made at all scales of government, the abdication of responsibility on the part of the federal government over the last four presidential administrations has heightened the importance of local and regional efforts (Vogel et al. 2016; Bierbaum et al. 2013). The consensus of adaptation scholars is that documenting and evaluating adaptation efforts proves elusive, an observation consistent over the last twenty years. This can be attributed to the uneven distribution of adaptive capacity within and between societies, the relatively recent development of adaptation as a discipline combined with the long planning horizons of adaptation efforts, the degree to which success in mainstreaming has been achieved, and the fact that adaptation actions are not always explicit or even intentional (Yohe et. al., 2007; Shi and Moser 2021).

Key findings from this prior research include: most adaptation processes have been reactive rather than anticipatory; many begin by addressing the vulnerability of direct government assets as a way to foster community support for future adaptation measures; and that most policies implemented have been focused on creating tangible reductions in vulnerability to specific threats, often at the expense of broader and more comprehensive adaptation goals. These findings further suggest that there has been moderate success in mainstreaming climate concerns into existing policy domains in some states and localities across the U.S., but not all (Vogel et al., 2016; Bierbaum et al., 2013; Lioubimtseva and da Cunha, 2020).

Studies on the subject have also resulted in the identification of a number of common challenges and barriers to adaptation efforts, including the aforementioned difficulties in evaluating adaptation progress, a lack of effective information gathering and dissemination to relevant actors,

a lack of concrete policy guidance on how to carry out adaptation efforts without exacerbating existing socioeconomic vulnerabilities leading to a dramatic failure to include equity concerns across the board, as well as political difficulties rooted in a lack of community support and the partisan nature of climate change in public consciousness. Most of these factors are explained or exacerbated by the multi-scalar and cross-sectoral nature of climate change combined with the fragmented nature of governance in the United States. This is worsened by the aforementioned lack of federal leadership or investment in climate change programs, and has resulted in difficulties aligning actions among levels of government and sectors of society so as to prevent maladaptive outcomes (Vogel et al. 2016; Bierbaum et al. 2013; Shi and Moser, 2021).

In response to the degree to which the fragmentation of governance has hindered climate adaptation efforts in the U.S., some have hypothesized that metropolitan planning organizations (MPOs), regional bodies mandated by federal law involving representatives from state and local governments, public agencies, and other non-governmental actors, may provide an institutional context well suited to advancing climate adaptation goals on the regional scale (Mason and Fragkias, 2018). MPOs are present in every urbanized area of more than 50,000 people in the country, and primarily serve to coordinate transportation planning and investment between federal, state, and local governments. Some regions have empowered their MPOs to address other regional issues, which combined with the importance of transportation and land use planning to climate change issues lends credence to the idea that MPOs may be a prime venue for collective action.

There has been a small but growing interest in the planning and adaptation discourses around this idea, leading to evaluations of MPOs' progress on climate issues to date. These studies have found that while regional cooperation on climate adaptation issues has been effective in reducing some of the aforementioned barriers to adaptation, issues still remain in fully realizing the potential of regional action (Mason and Fragkias, 2018; Beiler et. al., 2016; Shi, 2019). Based on the existing assessments of regional adaptation progress to date, a number of factors influencing the likelihood of MPOs to engage in climate change planning and programming can be identified. These include organizational capacity, inclusion of diversity and equity, degree of regional coordination and integration, authority to act and implement adaptation plans across jurisdictional boundaries, leveraging existing skills and authority, and the availability of resources and tools. While not comprehensive, and to some degree overlapping, these factors include the lessons learned from existing adaptation efforts, while advancing the normative goals of adaptation discussed above (Beiler et. al., 2016; Shi, 2019).

Research Questions and Methodology

As discussed in the review of existing literature, the study of climate adaptation at the regional scale, and of the role of metropolitan planning organizations (MPOs) specifically, has emerged only relatively recently. Given that there is an ongoing need for research around the role, abilities,

and challenges of MPOs in regard to climate adaptation, this study aims to contribute to a relatively under-developed base of knowledge on the subject, specifically as relates to the mainstreaming of climate adaptation concerns into the practice of metropolitan transportation planning. Due to the local scale and context-specific nature of adaptation planning, this study is centered on the Commonwealth of Virginia, which faces a diversity of climate threats and features a wide variety of demographic conditions.

This study is oriented around three primary questions. The first of these questions, "***to what extent are MPOs in Virginia mainstreaming climate adaptation concerns into their regular transportation planning duties?***", is of central importance to any future adaptation efforts, as there have been no known attempts to evaluate the mainstreaming of climate adaptation among Virginia MPOs as of writing. Due to the lack of a universal definition of what climate adaptation efforts even consist of, as well as a lack of a universally accepted method for evaluating MPOs' (or other organizations') progress toward the nebulous goal of adaptation, a second question is thus considered: "***do the Virginia MPOs analyzed demonstrate a broad view of sustainability, or do they narrowly focus on a few particular aspects of sustainability?***" In addition to providing a secondary means of evaluating MPOs' recent planning efforts, considering the breadth of sustainability factors addressed by each of the plans analyzed is important in considering the degree to which MPOs' achievements on mainstreaming adaptation concerns per the first question are ultimately valid, as there exists the potential for ostensibly successful adaptation measures leading to maladaptive outcomes resulting from approaching adaptation needs from too narrow a perspective. The third of these questions, "***among the ecosystem-based, community-based, and transformative approaches to climate adaptation, which is most prominent among Virginia MPOs?***", is important insofar as characterizing the approaches to adaptation demonstrated by the studied MPOs can help researchers, officials, and other stakeholders to situate their understandings of these adaptation efforts within a more easily understandable conceptual framework.

Case Selection

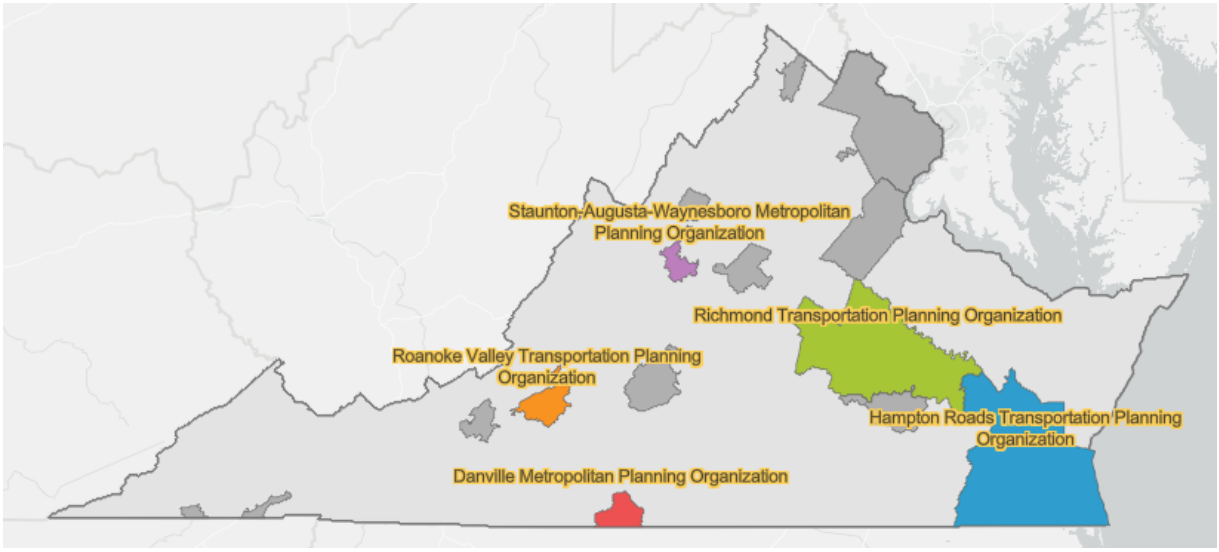
Five of Virginia's fourteen MPO regions were selected for analysis, as the goal of the study was to broadly investigate regional adaptation planning rather than to comprehensively document and evaluate all of the measures being taken across the state. Further, attempting to review and analyze all of the state's fourteen MPO regions would be impractical for the scope of a thesis project. As a result of these considerations, MPOs from five of Virginia's fourteen regions were selected as representing a broad cross-section of the state. The MPO regions selected for analysis in the study include Danville, Hampton Roads, Richmond, Roanoke, and Staunton. Characteristics of the selected MPO regions are listed in Table 1, and the geographic distribution of both the included regions and those not included are detailed in Figure 1 below. These five MPOs were selected for their nature as representative of the state's varying regions and the diversity of characteristics regarding population, economy, and vulnerability to climate change present between them. Despite being the most populous region of the state, the Northern Virginia region was not represented within the study due to its unique position as part of the Greater Washington, D.C. metropolitan

area and the resulting complexity of its governing institutions, including a greater degree of inter-state governance arrangements.

Table 1: Selected MPOs and Regional Characteristics

MPO Region	Geographic Region	Population (MSA, 2020)	Percent MSA Population Non-white (2019)	Median Household Income (2019)	Base Industries by Location Quotient (2019)
Danville	Southside Virginia	103,091	37.0%	$43,113	Manufacturing (2.2); Agriculture, forestry, fishing and hunting (1.6); Industries not classified (1.6)
Hampton Roads	Coastal Plain	1,799,674	41.4%	$68,454	Real estate and rental/leasing (1.4); Arts, entertainment, and recreation (1.3); Accomodation and food services (1.2)
Richmond	Central Virginia	1,314,434	40.1%	$71,223	Finance and Insurance (1.79); Utilities (1.8); Management of Companies and Enterprises (1.4)
Roanoke	Southwestern Virginia	315,251	20.3%	$57,642	Management of companies and enterprises (3.4); Healthcare and social assistance (1.2); Finance and insurance (1.2)
Staunton	Shenandoah Valley	125,433	11.0%	$58,116	Transportation and warehousing (2.0); Manufacturing (1.9); Retail trade (1.3)

Figure 1: Geographic distribution of selected MPOs' (highlighted) and excluded MPOs' (grayscale) constituent regions



Each of the selected MPOs' most recently adopted LRTPs were either published or amended within the two years prior to the spring of 2022, when this study was conducted, and remain current to date. The month and year of each plan's adoption or most recent amendment is detailed in table 2 below.

Table 2: Month and year of each analyzed plan's adoption or most recent amendment (by MPO region)

MPO Region	Hampton Roads	Richmond	Roanoke	Staunton	Danville
Month and Year Adopted or Amended	October 2020	October 2021	September 2021	December 2020	August 2020

All of the LRTPs analyzed were acquired through the websites of their respective MPO, and each remains publicly available through the internet.

Scoring

Prior research was instructive in constructing the method of analysis employed in this study. The content analysis employed in Mullin et al.'s (2020) evaluation of MPOs across three states as relates to planning for GHG emissions reductions coded for and focused on the goals and objectives portions of analyzed plans and sought to quantify the number of both implicit and explicit references to GHG reductions (or actions that would reduce GHG reductions). In addition to finding that most MPOs had not started planning to address climate change, Mullin et al.'s (2020) study found that MPOs that expressed greater commitments to addressing climate change had dedicated more funding towards projects that reduce emissions, emphasizing that broad policy language can allow MPOs to respond to state imposed goals or political pressure from local stakeholders without actually making solid commitments to implement said language through strategies or funding allocation (Mullin et al. 2020).

In Schrock et al.'s (2015) study assessing equity in climate and sustainability plans across 28 states, a content analysis methodology was employed to evaluate the extent to which equity had been incorporated into said plans, what kinds of cities and plans focused on equity, and whether there existed a trend towards a greater focus on equity in the context of sustainability planning. This analysis involved the creation of a qualitative coding scheme designed to assess whether and to what degree the cities sampled discussed equity in their plans, the criteria for which were divided along three types of equity. Schrock et al.'s (2015) methods in this study also involved the coding of relevant plan language as reflecting equity as a "problem, goal/objective, or an action", allowing the authors to assign each plan an overall score based on both the quantity and quality of its equity considerations in addition to identifying the degree to which each of the three types of equity is demonstrated (Schrock et al. 2015).

The development of both the content analysis methodology and the criteria by which each LRTP was scored were informed by the prior studies discussed above. The goals of this study include both quantifying the extent to which the selected Virginia MPOs are mainstreaming climate adaptation concerns and characterizing the conceptual approaches to adaptation and sustainability demonstrated in each MPO's LRTP, and so the methodology constructed to address these goals involves similar strategies as those demonstrated in the above referenced studies. The division of

analysis criteria into three conceptual categories is meant to facilitate the characterization of the mainstreaming efforts demonstrated by each MPO; the coding of plan language as being reflective of "vision, goals, or objectives", "existing or future conditions", "needs assessment", or "strategies" (with the latter two being weighted more heavily) is meant to address the higher value of action over more superficial rhetoric; and the ultimate calculation of an overall "adaptation score" for each plan is meant to provide an overview of both the quantity and quality of each of the plans' discussions of the subject at hand.

The specific procedure by which the content analysis was conducted involved the following: after each plan was acquired, each was read and analyzed according to the criteria as listed in Appendix I. Each time any of the criteria was found within the plan being scored, it was highlighted and coded according to which of the 27 criteria it represented, as well as whether the plan's language in said instance is reflective of "vision, goals, or objectives", "existing or future conditions", "needs assessment", or "strategies". These categories were developed for the following two reasons:

> (1) while all LRTPs are required to cover the same federally mandated issues, the organization and presentation of the information within them widely varies, necessitating standardization;
>
> (2) as discussed by Mullin et al. (2020), broad policy language can allow MPOs to respond to state requirements or community pressure without actually making implementation or funding commitments, necessitating a means by which more action-oriented language can be prioritized in the scoring of the plans.

In order to address these issues, the latter two categories of plan language ("needs assessment" and "strategies") are granted two points due to their action-orientation, while the former two categories ("vision, goals, and objectives" and "existing or future conditions") are granted a single point.

Upon the completion of scoring for each plan document, each document was then read and scored a second time, in an attempt to compensate for the effects of the analysis being conducted by a single individual. The points achieved on each criterion were then summed so as to result in an overall score for each plan both overall and for each of the three overarching categories of analysis criteria. This procedure is illustrated through the scoring sheets used for the analysis and score calculation included in Appendix II below, and the scores calculated are documented in tables 3-8 in the Findings section below. The scores calculated for each plan (overall and for each of the three adaptation approaches) are designed to shed light on not only whether each MPO has broadly mainstreamed climate adaptation concerns into their regular planning duties, but also whether any demonstrated mainstreaming efforts are illustrative of an ecosystem-based, community-based, or transformative approach to adaptation.

Using the completed scoring tables, a second set of scores was then calculated in an attempt to address the third of the study's orienting questions regarding the breadth of sustainability factors addressed by each plan. This second set of scores, detailed in table 4 and referred to as proportional scores, represents the number of criteria on which a given plan achieved at least one point, both out of each category and overall.
The study's implications for future research and policy development, as well as the areas in need of attention, support, or maintenance of efforts highlighted as a result, are detailed in the Discussion section below.

Research Findings

Introduction and Overview

The long-range transportation plans (LRTPs) of the Danville, Hampton Roads, Richmond, Roanoke, and Staunton MPOs were evaluated using a set of criteria developed based on three conceptual approaches to climate adaptation: ecosystem-based, community-based, and transformative.

Rather than in terms of a maximum-possible score, these results should be understood as indicators regarding which and to what extent the established criteria have been integrated into the region's long-term metropolitan planning processes, where each of the MPOs has succeeded in mainstreaming the aspects of sustainability important to adaptation, and where there may be room for improvement. Based on this understanding, the average scores achieved across plans analyzed can be considered indicative of not only which of the established sustainability factors the regions as a group have mainstreamed into their regular planning duties, but also the prioritization of each factor relative to one another. For example, a plan which achieved a (relative) high score on the community-based category and a (relative) low score on the ecosystem-based category has thus demonstrated more substantial integration of sustainability factors indicative of a community-based adaptation strategy while failing to integrate factors indicative of an ecosystem-based strategy.

Results

Detailed in table 3 below, Hampton Roads' plan achieved the highest overall adaptation score, followed by (in descending order) those of Richmond, Roanoke, Staunton, and Danville. Hampton Roads' and Richmond's plans achieved near-parity in overall scores, resulting in scores of 175 and 174, respectively; Roanoke's plan achieved the third-highest score of 129, and Staunton's achieved more than double the score of Danville's, at 93 and 39 respectively. The average score across all of the plans analyzed was 122, which in comparison to the plans themselves falls in between the score achieved by Roanoke's plan and that of Danville's plan. Despite the similarities of the highest-performing plans' scores to one another, their scores vary widely when considering the performance of each plan as relates to each of the three conceptual approaches to adaptation.

Table 3, Overall Scores by Category

MPO Region	Hampton Roads	Richmond	Roanoke	Staunton	Danville	Average
Ecosystem-based	64	45	43	27	7	**37.2**
Community-based	89	75	44	51	26	**57.0**
Transformative	22	54	42	15	6	**27.8**
Total	175	174	129	93	39	**122.0**

The Hampton Roads LRTP, which achieved the highest overall adaptation score, achieved the highest scores of the group on the ecosystem-based adaptation and community-based adaptation categories, while scoring third overall on the transformative adaptation category. Despite its slightly lower overall score, the Richmond region's LRTP was the only plan of those analyzed to achieve greater-than-average scores on all three categories, achieving the highest score of the group on transformative adaptation and second-highest on ecosystem-based and community-based adaptation. The third-highest scoring plan, that of the Roanoke region, achieved the second-highest score of the group on the transformative adaptation category, third-highest on the ecosystem-based adaptation category, and fourth-highest on the community-based adaptation category. The remaining two LRTPs, those of the Staunton and Danville regions, failed to achieve greater-than-average scores on criteria from any of the three categories; Staunton's plan achieved the third-highest score of the group on community-based adaptation and fourth-highest on the other two categories, and Danville's plan achieved the lowest scores of the group on all three categories.

Across all of the plans analyzed, the category with the highest average score (57.0) was that of community-based adaptation, the category with the second-highest average score was ecosystem-based adaptation (37.2), and the category with the lowest average score was transformative adaptation (27.8).

When considering solely the proportion of all factors in a given category addressed by each plan, detailed in table 3 below, it becomes apparent that the means by which plans achieved their overall adaptation scores varied widely. Where some of the plans earned the majority of points achieved through their detailed handling of just a few of the factors in a given category, others earned their points through their broader but more general focus on a greater number of factors. This difference in approaches is most visible when comparing Hampton Roads' plan, which in this respect falls to third-highest scoring overall due to its somewhat singular focus on the physical impacts of climate change and its neglect of factors in the transformative adaptation category, and Richmond's plan, which addressed all of the factors in the community-based and transformative adaptation categories and addressed nine out of ten of the factors in the ecosystem-based category. In this

respect, Roanoke's plan rises to second-highest scoring overall primarily as a result of its addressing all of the factors in the transformative adaptation category, Staunton's plan becomes notable for its addressing more of the transformative adaptation factors than does Hampton Roads' plan, and Danville's plan remains the lowest scoring of the five analyzed both overall and in regard to each of the three adaptation approaches. This is illustrative of the complexity involved in attempting to construct an evaluation of climate adaptation progress in any plan to begin with, the further complexities introduced when attempting to evaluate multiple plans' adaptation progress for the sake of comparison with one another, and the importance of approaching any such effort from a holistic and context-sensitive perspective.

The difficulty in defining and evaluating adaptation implicit in these varying assessments of adaptation progress is underscored by a secondary set of scores from this study, based on the number of factors from each category addressed by each plan (rather than on the number of instances each factor is referenced) and designed to quantify the "breadth" of factors mainstreamed rather than the "depth" with which they are addressed.

Table 4, Overall scores by proportion of possible factors addressed. (1.0 = 9/9)

MPO Region	Hampton Roads	Richmond	Roanoke	Staunton	Danville	Average
Ecosystem-based	0.78	0.89	0.89	0.67	0.44	**0.73**
Community-based	1.00	1.00	0.56	0.44	0.44	**0.69**
Transformative	0.33	1.00	1.00	0.56	0.22	**0.62**
Total	2.11	2.89	2.44	1.67	1.11	**2.04**

In these terms focused on the breadth of factors addressed (as opposed to the depth of each plan's discussion of said factors), the average score across all of the plans analyzed is the greatest for the ecosystem-based category, which at 0.73 is significantly greater than those achieved on the community-based and transformative adaptation categories, at 0.69 and 0.62, respectively. This indicates that despite the level of detail provided regarding a smaller number of factors under the community-based adaptation category, which resulted in a greater average score for that category as a whole, the plans in general addressed a greater number of the factors under the ecosystem-based adaptation category.

Table 5: Comparison of overall versus proportional scores

LRTP	Overall "Depth" Score, (Rank)	Secondary "Breadth" Score, (Rank)

Hampton Roads	**175 (1)**	**2.11 (3)**
Richmond	**174 (2)**	**2.89 (1)**
Roanoke	**129 (3)**	**2.44 (2)**
Staunton	**93 (4)**	**1.11 (4)**
Danville	**39 (5)**	**2.04 (5)**

The differences between these two sets of scores is reflective of the subjective nature of any definition of "success" when evaluating plans for their integration of climate adaptation concerns. While Hampton Roads' LRTP achieves the highest score of the group in terms of its overall score, it falls to third-highest of the group when considering the number of overall factors addressed, and Richmond's plan rises to be the highest-scoring of the group by a wide margin. This is largely due to Hampton Roads' LRTP focusing extensively on ensuring that its transportation system can continue to function at its current level even as large areas of the region's land is inundated by rising seas. The result is a plan that is very focused on climate adaptation, but ultimately fails to address most of the factors contributing to social and economic vulnerability central to any truly robust adaptation program. Richmond's LRTP, in contrast, addresses all of the factors listed among the study's evaluation criteria and demonstrates a great deal of attention paid to these same social and economic vulnerabilities, while falling short by comparison when it comes to addressing the actual physical impacts of climate change projected to affect the region. These contrasting approaches raise questions about where the line is drawn in terms of having successfully demonstrated the mainstreaming of climate adaptation concerns.

Performance on Community-based Adaptation Factors

Of the nine factors included in the community-based adaptation category, four were addressed at least once by all of the plans analyzed, and only two of the five plans analyzed addressed all nine. Hampton Roads' plan achieved the highest score on this category, with a total of 89 points, followed by Richmond's, with 75 points, Staunton's, with 51 points, Roanoke's, with 44 points, and Danville's, with 26 points. These results are detailed in table 6 below and discussed in more detail in the following section.

Table 6: Scores per individual factor, community-based adaptation category

Code Number	Code Name/Label	Hampton Roads	Richmond	Roanoke	Staunton	Danville	Average
C1	**Mode-shift (social/economic)**	**23**	**21**	**25**	**25**	**15**	**21.8**

C2	Land use (social/economic)	11	4	8	1	1	5.0
C3	Local impact projection	20	5				12.5
C4	Coordination with localities	2	7				4.5
C5	Resilience - community	3	1	4			2.7
C6	Vulnerability assessment (social/economic)	9	11				10.0
C7	Barriers to inclusion	8	6				7.0
C8	Incorporation of public concerns	11	13	5	18	9	11.2
C9	Equity focus geographic strategy	2	7	2	7	1	3.8
Community-based Adaptation Score		89	75	44	51	26	57.0

None of the factors within the community-based adaptation category went completely unaddressed, with Hampton Roads' and Richmond's plans achieving at least one point for each. While points achieved by Richmond's plan were relatively evenly distributed among the factors in this category, with emphasis being placed on (C6) climate vulnerability assessments in the context of socioeconomic and community conditions, Hampton Roads' plan primarily emphasized (C3) identifying specific projected impacts of climate change at the local and regional levels. Roanoke's plan achieved the highest score on (C5) the inclusion of the concept of community resilience, despite its middling performance on community-based adaptation factors as a whole and its failure to address four of the nine factors within the category. Similarly, Staunton's plan achieved the highest score of the plans analyzed on factor C8, leading to its achievement of the third-highest score on community-based adaptation factors as a whole despite its failure to address five of the nine included. Danville's plan, the lowest-scoring of all plans analyzed, failed to address five of the nine factors in the category and achieved the majority of points awarded in its inclusion of factors C1 and C8.

Within the community-based adaptation category, all five plans performed the best on factor C1, which calls for the identification or discussion of the need to support the expansion of alternative modes of transportation, including transit, bicycle, and pedestrian travel, specifically in the context of social and economic factors. While the reasons for high performance on this metric vary, most of the plans achieved points for vision, goals, objectives, or identification of existing conditions

(rather than needs assessments or strategies) relating to shifting away from a status-quo, auto-dependent paradigm.

Beyond mode shift, all of the plans integrated to at least some degree factors within the community-based adaptation category relating to (C8) the identification of how information gained through public participation efforts is actually included in the plan, (C2) the identification of a need for intensification of land uses and the implementation of growth management strategies in the context of improving social or economic conditions in the region, and (C9) the inclusion of explicit provisions, strategies, or actions designed to redress existing forms of marginalization specific to geographic areas in their jurisdictions, in descending order by the frequency with which they are referenced. The frequency with which each of these factors is referenced in the plans varies widely, however, with different plans demonstrating greater integration of different factors. Richmond's plan emphasized factors C8 and C9 while emphasizing factor C2 to a lesser extent, while Hampton Roads' plan emphasized factors C2 and C8 while emphasizing factor C9 to a lesser extent.

While all of the plans scored at least one point for each of these four factors, the difference in scores achieved is indicative of some plans' deep integration of the relevant issues and some plans' rather cursory mention of the same issues. Given that these factors make up core components of transportation planning, it is unsurprising that these were the most consistently addressed.

It is notable that all of the plans analyzed discussed shifting to alternative modes of transportation in the context of social or economic factors more often than in the context of environmental impacts or climate change, despite environmental planning requirements imposed by the state and federal governments or an otherwise stated commitment to balancing infrastructure needs with the needs of the environment. The vast majority of references to this factor documented within the plans are in the context of economic factors specifically, often emphasizing the equity and accessibility benefits of alternative modes of transportation in terms of their impact on regions' economic development. Examples of this particular framing of the issue can be found within all five of the plans analyzed, illustrated by the excerpts below:

> *"An integrated public transit network will provide Hampton Roads with transportation choices, thereby ensuring greater mobility, economic development, environmental protection, energy independence, and quality of life"* (Hampton Roads LRTP, p.42)

> *"Transit demand is growing around the region. Access to jobs, meeting the mobility needs of the community and providing opportunities for residents are all needs to address."* (Richmond LRTP, p.19)

> *"When Transportation Demand Management shifts drivers from single-occupant to higher-occupancy transportation modes, not only do those drivers save money, what they save is more likely to stay in the local economy. For example, if we were able to get 10% of 10,000 daily commuters to shift mode, travelling at an average of 10 miles a day on a round trip commute, this change could bring approximately $400,000 a year back into the local economy based on a gallon of gas costing $3.00 a gallon."* (Roanoke LRTP, p.106)

> *"With lane miles going unused, the MPO could explore road projects that repurpose right-of-way for multi-use facilities, such as bike lanes, sidewalks or even transit lanes. These Road Diets could improve quality of life, stimulate reinvestment and serve the needs of those with limited mobility."* (Danville LRTP, p.35)

> *"As development continues in the designated growth areas of Fishersville, Stuarts Draft, Verona, Weyers Cave, and Staunton south and west, a minimum limited Sunday service may need to be introduced to connect people in Augusta County to jobs that have non-traditional working hours."* (Staunton LRTP, p.87)

While some plans' framing of this particular issue is rather limited to this economic development-centric perspective, most notably Danville's, most of the plans expand upon the benefits to social equity goals, support to upward mobility, and reductions in environmental impacts associated with shifts to more sustainable modes of transportation as well. As will be discussed in the following discussion of the plans' performance on factors within the ecosystem-based adaptation category, Roanoke's plan in particular emphasizes the environmental benefits of any potential mode shift away from private vehicles, achieving the highest score of all five plans for that particular factor.

That the community-based adaptation category as a whole received the highest score across all five plans can be primarily attributed to their performance on this singular factor, making up 25.8% of the Hampton Roads plan's points in the category, 28.0% of Richmond's, 56.8% of Roanoke's, 49.0% of Staunton's, and 57.7% of Danville's. Despite references to this factor being primarily superficial in nature, with the majority of points achieved in the goal-setting or existing conditions documentation portions of the plans, the sheer number of these references is demonstrative of the perceived importance of referencing this factor among MPO officials, stakeholders, and staff. Though the plans stopped far short of endorsing a fundamental shift away from the auto-oriented status quo, the growing importance of public transportation to vocal constituencies was plainly apparent.

While Danville's plan achieved almost double the score of Roanoke's on factor C8, regarding the incorporation of public comments, the difference in approaches between the two plans to the subject is demonstrative of the fact that in conducting this kind of analysis, a better score does not necessarily indicate that one plan is normatively better than another. Despite the higher score of

Danville's plan on this particular factor, the language in the plan is far more general in nature, as indicated in the quote below:

> "*For 2045, the process included new approaches, such as public intercepts, comment postcards, and a MetroQuest survey. This public input played an important role in all aspects of the process, from validating the goals and performance measures to project selection.*" (Danville LRTP, p.13)

The language in the Danville plan also points to a public participation process that likely leaves much to be desired in terms of equity and inclusion, with the only analysis of public comments presented being oriented around the geographic location of respondents in relation to the location of proposed projects, as indicated here:

> "*Consultants developed heatmaps of public comments and overlaid those with projects to correlate public feedback with project selection*." (Danville LRTP, p.24)

The description of the Roanoke plan's public participation process, which appears to have been both more thorough in its efforts to include a broader diversity of stakeholders and is described as a much more central component of the plan's overall development, is excerpted below:

> "*The plan was guided by a steering committee made up of people representing local governments, non-profit organizations, health and business interests. An extensive public outreach process spanned three years and involved people throughout the multiple phases of the plan's development. Citizens were engaged via traditional public meetings, focus groups, online discussion forums, and public surveys administered online, on transit vehicles, and in person. In total, over 4,000 responses guided the region's vision for transit.*" (Roanoke LRTP, p.31)

Danville's plan very clearly earns a greater number of points through its greater number of references to the inclusion of public concerns on a conceptual level than does Roanoke's plan, despite the process it describes appearing to be of a lower quality and of a less inclusive nature than that conducted by the Roanoke MPO. This is indicative of the potential shortcomings of the study's methodology (as discussed at greater length in the Discussion section), and demonstrates the importance of analyzing the data collected from multiple perspectives as discussed above.

Performance on Ecosystem-based Adaptation Factors

Of the nine factors included in the ecosystem-based adaptation category, four were addressed at least once by all of the plans analyzed, ranging from singular instances to entire plan sections: (E1) identification or discussion of mode shift from private vehicles to active or sustainable modes of transportation in the context of reducing environmental impacts, (E3) discussion or acknowledgement of the tradeoffs involved in balancing infrastructural and economic needs with

protecting, conserving, or restoring the natural environment, (E4) inclusion of policies explicitly designed to rectify legacies of environmental injustice, and (E7) inclusion of some form of vulnerability assessment as relates to hazards that threaten existing or planned infrastructure or other aspects of the physical environment (as opposed to assessing the vulnerability of socioeconomic groups). These results are summarized in Table 7 below.

Table 7: Scores per individual factor, ecosystem-based adaptation category

Code Number	Code Name/Label	Hampton Roads	Richmond	Roanoke	Staunton	Danville	Average
E1	Mode-shift (Env.)	6	5	14	5	1	6.2
E2	Land use (Env.)	12	7	15	3		9.3
E3	Balancing infrastructure and environment	14	2	6	2	2	5.2
E4	Strategies to redress environmental injustice	3	6	1	6	2	3.6
E5	Resilience (Physical)	19	11	1			10.3
E6	Planning for ecosystem resilience	2	4	2	10		4.5
E7	Vulnerability assessment (infrastructure/built environment)	8	3	1	1	2	3.0
E8	Equitable TOD		7				7.0
E9	Jobs-housing balance			3			3.0
Ecosystem-based Adaptation Score		64	45	43	27	7	37.2

The vast majority of the points scored across plans on these four factors were as a result of state and federal environmental planning requirements, most notably those around air quality, water quality, and environmental justice. Illustrative of the differences in scores achieved on these factors between the plans is a comparison of the language in Richmond's plan addressing factor E4, and the language in Roanoke's plan addressing the same factor:

> *"The purpose of environmental justice is to avoid, minimize or mitigate disproportionately high and adverse human health or environmental effects on low income and minority populations; to ensure full and fair participation of low income and minority populations; and to prevent the denial of benefits to those same populations. Historically, minority and low-income populations have been*

> *identified as the largest disenfranchised group, both in terms of equal access to transportation supply and ability to influence change. Environmental justice seeks to ensure equal access to transportation systems and to the transportation planning process for everyone regardless of race, color, creed, or national origin. Limited English proficiency (LEP) populations are also included as part of the environmental justice analysis due to the rapidly rising numbers of this population in the Richmond Region."*
> Richmond LRTP, p. 13

> *"Environmental Justice (EJ) has a slightly misleading name. It is more of a social justice and fairness concept. It does have a connection to the physical environment through emphasizing that traditionally underrepresented communities, low-income and minority communities, should not be adversely affected by disproportionate exposure to pollution, or other adverse impacts, from transportation projects."*
> Roanoke LRTP, p. 43

While these two plans achieved nearly identical scores for the ecosystem-based adaptation category as a whole, and while both of their definitions of environmental justice can be considered correct, their approaches to the same issue are noticeably different. Both plans are addressing the issue of environmental justice, but Richmond's plan's definition is far more comprehensive, and demonstrates much more attention paid to how this particular issue is presented, resulting in Richmond's plan achieving a score of 6 on factor E4 and Roanoke's plan achieving a score of 1. This difference can likely be attributed to the fact that the Richmond region's population is much more diverse than the Roanoke region's, with more than 40% of the Richmond region's population identifying as non-white versus the Roanoke region's roughly 20%.

One of the most notable instances of this effect is the difference between the scores achieved on factor E3, which deals with the balancing of infrastructure needs and the needs of the environment; while most of the plans achieved between 2 and 6 points largely due to their inclusion of the air and water quality concerns that are standard for transportation plans, Hampton Roads' plan achieved a score of 14. This is due to Hampton Roads' unique position as a "frontline community" second only to New Orleans in its vulnerability to rising sea levels, floods, and other water-borne threats associated with climate change, requiring these environmental concerns to be a much more central consideration in the planning and construction of new transportation facilities. This difference is further borne out by the difference in scores between Hampton Roads' plan and those of Staunton and Danville on factor E5, which deals with environmental resilience. Where Hampton Roads' plan achieved a score of 19 on this particular metric, its highest in the category, Staunton and Danville's plans did not score a single point, again largely owing to the difference in each MPO's physical environments.

This is not to say that the difference in physical environments is the sole characteristic determining each MPO's performance on ecosystem-based factors, however, as each of the plans analyzed (except for Danville's) demonstrated meaningful integration of different factors within the category. While Hampton Roads' plan scored well above all of the others on factors related to preparing for the threat posed by rising seas, it failed to include more than cursory mentions of other factors, like addressing environmental justice. Richmond's plan was notable for its inclusion of (E5) resilience as relates to the physical built and natural environments; Roanoke's plan was notable for its score on factors relating to the intensification of land uses (E2) and mode shift to cleaner, more environmentally friendly modes of transportation (E1), and its status as the only plan to address the role of jobs-housing balance (E9); and Staunton's plan was notable for its inclusion of scoring metrics, guidelines, or other mechanisms to disincentivize infrastructure projects or real estate development in areas with greater vulnerabilities to natural hazards (E6).

Transformative Adaptation Factors

As demonstrated in table 8 below, Richmond's LRTP achieved the highest score of the group on the transformative adaptation category, with a total of 54 points, followed by Roanoke's, with 42 points, Hampton Roads', with 22 points, Staunton's, with 15 points, and Danville's, which achieved only 6 points. Of the five plans, only Richmond's and Roanoke's addressed all nine of the factors within the category, Staunton's addressed five, Hampton Roads' addressed three, and Danville's addressed only two.

Table 8: Scores per individual factor, transformative adaptation category

Code Number	Code Name/Label	Hampton Roads	Richmond	Roanoke	Staunton	Danville	Average
T1	VMT	9	8	4			7.0
T2	Root causes of inequities		2	3			2.5
T3	Solutions to root causes of inequities		6	5	3		4.7
T4	Opportunity in crisis		2	1			1.5
T5	Adapting to long-term trends		11	9	2	2	6.0
T6	Incentive structures		2	3			2.5

T7	**Collaboration across municipalities and sectors**	**10**	**16**	**6**	**3**	**4**	**7.8**
T8	**Leveraging federal resources**		**3**	**3**	**5**		**3.7**
T9	**Innovation**	**3**	**4**	**8**	**2**		**4.3**
Transformative Adaptation Score		**22**	**54**	**42**	**15**	**6**	**27.8**

Only one of the factors in the transformative adaptation category was addressed by all five plans, with each plan demonstrating to at least some degree collaboration across political boundaries and between sectors specifically as relates to equity, resilience, sustainability, or innovation topics (T7). Three of the five plans, Hampton Roads', Richmond's, and Danville's, achieved the highest scores on this factor out of the nine within the transformative adaptation category. This finding is notable in that most of the points achieved on this factor result from the plans' discussion of their respective MPOs' efforts to form committees, working groups, or other collaborative endeavors, many of which were brought about for the purpose of building knowledge and capacity on other factors for which they did not score points.

Despite only three of the plans achieving any points for their inclusion of vehicle miles traveled (VMT) as an evaluation metric for potential transportation investments (T1), the average score for this factor was the second-highest of the group. This indicates that while not all of the plans addressed this factor, those that did so to a meaningful degree. In terms of standard transportation planning practices, this particular metric is among the most important within the transformative adaptation category, as shifting from transportation planning and investment oriented around reducing congestion or travel times for private vehicles to reducing the cumulative distance driven by all members of a given community represents the kind of fundamental change implied by a transformative approach to systems of governance in the face of impending threats as severe as the climate crisis.

These two factors were the ones on which the Hampton Roads LRTP achieved the vast majority, about 86%, of the points earned for the transformative category as a whole, on which it dramatically underperformed relative to the ecosystem-based and community-based adaptation categories.

The relatively exceptional performance of Richmond's LRTP on factors within the transformative adaptation category are reflective of the plan's unique focus on social equity, which can be illustrated through the comparison of the plan's language relating to advancing solutions to the

root causes of long-standing inequities along the lines of race, class, and geography (T3) with the language of the Roanoke and Staunton plans, the only two of the other plans analyzed to achieve points for this particular factor. Where the latter two plans certainly earned the points they achieved on this factor through their acknowledgement of said inequities and their inclusion of strategies to prevent future transportation investments from exacerbating these inequities, Richmond's plan was unique in its focus on the processes through which such decisions are made (at both the local and national levels) and the need to prioritize marginalized communities in these processes, as opposed to merely ensuring that the negative externalities of these decisions do not disproportionately impact them.

> "*Past decisions both locally and nationally have impacted minority neighborhoods and caused hardship for segments of our population. It is readily recognized that plans and projects need to work especially hard to provide benefit to everyone — with a clear focus in the decision-making process on people who have been negatively impacted because of their race, age, income, or ability to access a car. ConnectRVA 2045 analyzes these impacts through data and factors those impacts as priority inputs into the final project rankings.*"
> Richmond LRTP, p. 3

> "*The EJ Framework will primarily identify red flags and screen out any potentially inappropriate projects from the long-range plan. Before projects are endorsed for federal funding programs, the TPO Policy Board can evaluate the projects again, in a more robust manner, and modify the scope of the project to address any additional EJ concerns that arise.*"
> Roanoke LRTP, p. 43

> "*A benefits and burdens analysis is a tool in the long-range transportation planning process that provides information on the social equity or environmental justice of a transportation investment plan or program. The analysis, which is applied to data on disadvantaged populations or groups, examines the potential for positive or negative impact (benefits and burdens) that a given transportation investment program could have on certain persons, demographic groups, or geographic locations.*"
> Staunton LRTP, p. 117

Roanoke's plan was notable in its achievement of the second-highest score of the group on the transformative adaptation category despite being third overall in terms of overall scores. The factors in the transformative adaptation category upon which it performed the best were identification of long-term trends regarding societal factors, development patterns, or travel behaviors and the inclusion of strategies to address them (T5), and discussion of policy experimentation, innovation, and the institutionalization of new and better methods in the future (T9). While all plans are forward-looking by their very nature as strategic documents, Roanoke's plan demonstrated a particular attention paid to the social, economic, and technological trends

(such as autonomous vehicles, micromobility, IoT, etc.,) poised to transform existing transportation networks over the coming decades. Its status as one of the two plans to achieve points for its implicit or explicit discussion of the incentive structures involved in the complex task of transportation and use planning was a direct result of this focus, illustrated in the following excerpt from page 35: "W*e are likely at a tipping point of technological and societal change that could profoundly impact future transportation demand, infrastructure, and services. The interplay between these demographic, cultural and technological trends are complex; so, there is no one simple answer for what the future holds*." While not explicitly oriented towards addressing the challenges posed by climate change, this unique approach to planning for the future in a rapidly changing world is demonstrative of the necessary big-picture perspective central to the transformative approach to climate adaptation.

Noteworthy for low scores achieved across all plans were factors regarding leveraging federal resources in service of equity, sustainability, or resilience goals (T8) and discussion of finding opportunities in the challenging circumstances presented by the overlapping crises of the contemporary moment (T4). Low performance on the first of these factors was surprising due MPOs by their nature as convening bodies across levels of government and the experience with leveraging federal resources that implies, and the low performance demonstrated on the latter factor was surprising due to all of the plans having made note of the Covid-19 pandemic and the difficulties presented in MPOs' planning duties as a result. Richmond's plan, while achieving only two points on the latter, was the only exception to this finding resulting from its discussion of the "zero-fare" transit policies introduced in response to the pandemic, as well as its emphasis on leveraging the out-migration from the nation's largest cities to support continued population growth in the region.

Discussion and Conclusions

The first question around which this study was oriented was: "*To what extent are selected Virginia MPOs mainstreaming climate adaptation concerns into their federally-mandated work products, specifically the long-range transportation plan*?" The study's findings indicate that the mainstreaming of factors relevant to climate adaptation into MPOs' regular transportation duties is occurring, but that said mainstreaming has been piecemeal in nature, and that the degree to which it has been demonstrated varies widely across regions of the state.

While Hampton Roads' LRTP achieved the highest score of the group, Richmond's LRTP addressed the greatest number of possible factors, leading to an inconclusive result regarding which of the two has mainstreamed climate adaptation concerns into their plans to a greater degree. This difference in approaches points to findings relevant to the second of the study's orienting questions, "*do the Virginia MPOs analyzed demonstrate a broad view of sustainability, or do they narrowly focus on a few particular aspects of sustainability*?" The evidence suggests that, across the group as a whole, the answer is that it varies, with Richmond's LRTP best demonstrating a

broad view of sustainability and Hampton Roads' LRTP best demonstrating a narrow (but intense) focus on just a few aspects of sustainability.

As relates to the third of the study's orienting questions, "*among the ecosystem-based, community-based, and transformative approaches to climate adaptation, which is most prominent among Virginia MPOs?*", the study's findings indicate that of the three adaptation approaches, the ecosystem-based and community-based approaches are most prominent, with the transformative approach being demonstrated to a significant degree only within two of the plans analyzed. Average overall scores were highest for community-based adaptation, second-highest for ecosystem-based adaptation, and lowest for transformative adaptation. This suggests that while MPOs across Virginia's regions are in fact mainstreaming adaptation concerns, the particular factors addressed are relatively limited to more immediate environmental and community needs as opposed to the kinds of big-picture, systemic shifts towards a more equitable, just, and sustainable set of baseline conditions associated with the transformative approach.

In a general sense, the study's overall findings reiterate the assessment of progress made towards climate adaptation in the United States made by Bierbaum et. al. in 2013: "*more than before, but less than needed."* Just as in 2013, when this assessment was made, few measures across Virginia have progressed past initial scoping stages, and even fewer have been implemented, despite the increasing urgency of the underlying issue such measures are meant to address.

The study's findings are also reiterative, however, of Vogel et. al.'s assessment from 2016, which found that the practice of adapting to climate variability and extreme events has been occurring for many years across a wide variety of communities, and that it is the formal practice of adaptation that remains in the early stages of development. Indeed, many of the factors included as part of the study's analysis are oriented around such non-explicit vulnerability reduction strategies, all of which ultimately shape a community's overall vulnerability in one way or another. The finding that each of the five studied MPOs has succeeded in mainstreaming at least some of the factors referenced among the study's criteria underscores the importance of considering the impact of a given measure on a community's vulnerability to climatic stressors, rather than their conformity to a pre-defined notion of what constitutes climate adaptation in the first place.

The following section explores the study's key findings and discusses their implications, including the plans' scores as relates to the three overarching categories, the particular factors they address or do not address, commonly identified barriers to adaptation, and MPOs' unique role in the American system of distributed governance.

Implications of Key Findings

In terms of the three overarching categories used in evaluating each MPO's long-range transportation plan (LRTP), all of the plans achieved the highest average scores on community-based adaptation, followed by ecosystem-based and transformative adaptation, respectively. These

scores indicate that on average, MPOs across Virginia's regions have prioritized sustainability factors regarding a general stewardship of the natural environment and the immediate needs of the communities they represent, as opposed to the kinds of systemic changes implicit in a transformative approach. This suggests that while Virginia MPOs recognize the increasing severity of the climate crisis, there is still much work to be done when it comes to the fundamental changes to planning and governance around transportation and land use issues that will ultimately be necessary to meet this generational challenge.

Of the individual factors referenced by the study's evaluation criteria, the highest scores were consistently achieved on those most directly related to MPOs' core transportation planning functions, as well as those directly implicated in preexisting state and federal requirements regarding environmental justice and public participation. Most notable among these was that regarding mode-shift from private vehicles to more sustainable forms of transportation in the context of social and economic concerns, on which all of the plans received the highest scores out of all 27 factors. This can primarily be attributed to MPOs' mandate to steward economic growth through their transportation planning duties, as well as the presence of constituencies interested in an expanded availability of transit services and safe active transportation infrastructure. This second influence emphasizes the importance of generating and disseminating knowledge on the subject, as the creation of active and vocal constituencies for issues relevant to adaptation is ultimately required for said issues to be addressed across the wide range of regions, organizations, and individual actors ultimately responsible for doing so.

Resulting from the variance between the plans' overall adaptation scores and their scores regarding the breadth of sustainability factors considered, the study and its findings ultimately raise questions regarding how to define "success" when evaluating climate adaptation measures. Richmond's plan emphasizes the social and economic equity concerns associated with planning for reductions in communities' overall vulnerability but fails to meaningfully address the physical impacts of climate change. Meanwhile, Hampton Roads' plan emphasizes the physical resilience of the existing transportation system in the face of severe climatic threats, but does so at the expense of likely exacerbating the vulnerabilities inherent in the status quo. Does Richmond's plan better represent success than does Hampton Roads' plan?

The existing literature is inconclusive on this subject, but as Schipper (2007, 7) points out in their exploration of the linkages between adaptation and development, mainstreaming cannot ultimately be effective if the existing development trajectories into which adaptation concerns are mainstreamed are inconsistent with the objectives of adaptation inasmuch as they explicitly contribute to vulnerability. These inconsistencies and the resulting perpetuation of vulnerability they produce are most often referred to as maladaptation, which has been defined as "action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on, or increases the vulnerability of other systems, sectors, or social groups" (Barnett and O'neill 2010,

211). Further, maladaptive efforts are defined as actions that, relative to alternatives, (1) result in increased GHG emissions over time; (2) disproportionately impact the most vulnerable; (3) have unreasonably high opportunity costs; (4) reduce the incentive for actors to adapt through reducing the rewards of adaptive behavior; or (5) reduce the options for adaptive activities available to future generations, often through the development of expensive infrastructure or institutional changes difficult to modify in the future (O'neill 2010). Given these definitions, it can be argued that Hampton Roads' plan is far more likely to result in maladaptive outcomes than is Richmond's, resulting from its clear objectives around perpetuating the status quo in the face of climatic disruptions. This characterization can be made even while Hampton Roads' plan certainly demonstrates substantial efforts made to increase the physical resilience of its built environment in response to specific, localized projections of climate impacts, which is definitely a form of adaptive activity. Rather than resolving these tensions, this study is in line with prior research efforts in that its findings serve to highlight yet another instance in which the difficulties involved in attempting to evaluate adaptation efforts result in more questions than answers.

The study and its results are further relevant in that it provides new evidence surrounding a number of commonly identified barriers to adaptation. The first of these barriers, articulated by Hughes (2015), is that most existing adaptation efforts have lacked attention to equity concerns, social vulnerability, and the influence of non-climatic issues on vulnerability. As discussed above, this barrier to adaptation was present across four of the five plans studied, and results in questions surrounding the ability of the adaptation scores as presented to adequately describe the ultimate success of the mainstreaming efforts they quantify. Additional barriers, identified by Shi (2019), include a narrow focus on physical assets, a chronic lack of participation by socially vulnerable groups, and a lack of analysis on regional function and governance gaps. The first of these barriers is certainly demonstrated by the Hampton Roads LRTP, and the second is unfortunately demonstrated to various degrees across all of the plans analyzed (and within planning practice more broadly). The third of these barriers, however, appears to have been overcome to at least some degree across the majority of the plans analyzed. As discussed in the Findings section, all of the plans achieved points for their demonstration of collaboration across political boundaries and between sectors, specifically as related to equity, resilience, sustainability, or innovation topics. Most of the points for this factor resulted from the plans' discussion of their respective MPOs' efforts to form committees, working groups, or other collaborative endeavors, many of which were brought about for the purpose of building knowledge and capacity on other factors for which they did not score points.

This finding is among the most important to result from the study, as it emphasizes the unique characteristic of MPOs as convening bodies. As discussed in the review of the literature, this unique characteristic of MPOs has resulted in hypotheses regarding their potential suitability as central bodies in future governance regimes and the opportunities this might present for overcoming the challenges to adaptation created by the system of distributed governance in the

U.S. (Mason and Fragkias 2018; Beiler et al. 2016; Shi 2019). While the study and its findings support the existence of said barriers, they also highlight a path towards resolving them; it appears that MPOs in Virginia are in the process of taking the first step on this path, demonstrated by the ways in which the plans pointed to collaborative efforts between and across sectors in service of strengthening future capacity to address issues central to adaptation. The ultimate success of these efforts, however, is likely contingent upon the ability of MPOs to then further facilitate the dissemination of knowledge gained as a result, as well as upon the degree to which these efforts are supported by higher levels of government and participated in by a widely representative group of stakeholders.

Limitations

Among potential shortcomings of the study's methodology is the ability of the overall scores as calculated to adequately capture "success" in mainstreaming climate adaptation concerns into MPOs' regular transportation duties. This is partly due to the lack of a clear definition of what such success would even look like, as discussed above; it is also due to the way in which the scores are derived. The methodology employed in this study awards points for the number of references to a given factor present with each plan, which does not always translate to a plan having more substantively addressed said factor. An example this shortcoming is discussed in the Findings section above; while Danville's plan included a greater number of references to environmental justice than Roanoke's plan did, the Roanoke plan's fewer references to the subject represented a far more substantive approach to the issue than did the Danville plan's many superficial references. Regardless, the methodology as designed resulted in Danville's plan achieving a higher score on criteria regarding environmental justice factors than did Roanoke's plan.

At scale, this could potentially result in the highest score being granted to a plan which, on closer examination, performs noticeably worse in terms of the spirit of the study but nonetheless technically outperforms another, substantially "better" plan. Similarly, future iterations of this study should include some mechanism for awarding partial points, as there were multiple instances where a given plan technically addressed a factor but in reality did not necessarily equal the other plans' instances of said factor that achieved the same number of points. A mechanism for including negative points could be introduced as well, which would account for plans' instances of explicitly planning for increased vehicle reliance and single-occupancy vehicle commutes, which obviously undermines climate goals through driving increases in vehicle-miles traveled (VMT) and GHG emissions.

Further limitations to the study and its findings include those inherent in attempting to define and quantify what constitutes success as relates to mainstreaming climate adaptation into transportation plans. Due to a lack of a scholarly consensus on the subject, however, this particular limitation was expected, with the study meant to contribute knowledge to the discipline on exactly this subject. Additionally, communities' likelihood to explicitly engage in climate change mitigation

or adaptation activities have historically been initiated in reaction to experiences with climate shocks in the form of highly impactful natural disasters, as discussed in the review of the literature. Given both the difficulty of quantifying a given community's experience with the impacts of climate change, and the increasing exposure of all Americans to climate risks as impacts rapidly intensify across the nation, this factor is not included in the study, but may have impacts on a given MPO's adaptation score.

The reliability of the study's findings is likely impacted through the reliance on a single coder, as the subjective nature of the criteria on which the plans were evaluated, along with the inherent biases present within every individual person, result in the fact that more reviewers will tend to lead to more reliable results. Attempts were made to account for this factor, however, through each of the plans being analyzed twice and data checked for agreement, and as such the data should be considered generally reliable for the study's purposes.

Conclusions

This study is unique among prior efforts at evaluating adaptation progress among MPOs in that the organizations selected are representative of a broader range of regions in terms of population and national significance, as well as in its attempt to evaluate progress in mainstreaming climate adaptation in terms of three separate but interrelated approaches to adaptation, and what that can communicate in terms of how specifically said mainstreaming is occurring. The results of the study are mostly consistent with prior studies, in that the evidence points to the existence of efforts to mainstream climate adaptation concerns within MPOs, but also in that the evidence suggests that these efforts are lacking in coordination and are limited by a number of common barriers.

Prior studies on the subject are also supported in that more evidence has been generated in support of the fact that adaptation is difficult to define, and that an authoritative method by which to evaluate adaptation efforts remains elusive. Common barriers to adaptation identified in the literature, such as a narrow focus on physical assets and a chronic lack of participation by socially vulnerable groups, demonstrably apply to adaptation efforts in Virginia. Among the study's most notable findings is that all of the plans achieved points for their demonstration of collaboration across political boundaries and between sectors specifically as relates to equity, resilience, sustainability, or innovation topics. Most of the points for this factor result from the plans' discussion of their respective MPOs' efforts to form committees, working groups, or other collaborative endeavors, many of which were brought about for the purpose of building knowledge and capacity on other factors for which they did not score points. This finding supports previous hypotheses around the potential for MPOs to serve as important institutions in future climate adaptation efforts in the United States due to their unique role as coordinating and convening bodies for stakeholders across sectors and levels of government.

Future research should be conducted specifically on this unique role of MPOs as convening bodies and a nexus for engagement among a diverse set of public, private, and voluntary sector

stakeholders, particularly as relates to how this role can be leveraged, expanded upon, and supported towards the ends of greater regional integration and cooperation in meeting increasingly urgent climate adaptation needs. Future research should also seek to better understand and define what constitutes activity demonstrative of mainstreaming climate adaptation, as well as analyze the relationships between a given MPO's adaptation score performance and more nuanced understandings of the existing conditions in its constituent community. In order to determine how this may impact relevant policymaking at the regional scale, perceptions of climate risk and previous exposure to climate-driven natural disasters should also be investigated, as should the motivations behind MPOs' decisions to mainstream climate adaptation concerns into their regular planning duties and the processes by which they do so.

Future iterations of this particular study should aim to evaluate plans' demonstrated progress in mainstreaming adaptation concerns, but through the lens of coping responses, incremental adaptation, and transformative adaptation as opposed to ecosystem-based, community-based, and transformative adaptation, so as to isolate the degree to which the transformative approach to adaptation is being demonstrated across Virginia's regions. Further beneficial would be for the transportation improvement program (TIP) associated with each plan to be evaluated for evidence of mainstreaming adaptation in order to support or refute the scores generated in the course of this study. Because the TIP details the funding decisions resulting from the LRTP process, an evaluation of this nature could potentially determine whether the scores calculated are predictive of stronger commitments to the factors discussed above as represented by where funds are ultimately directed.

As the threat posed by climate change to communities of all shapes and sizes continues to increase in severity and temporal proximity, decision makers at all levels of government, business leaders, and members of civil society should seek greater cooperation on addressing the profound vulnerabilities present within the built environment and the institutions we've constructed to maintain it. Illustrated by a growing body of evidence, meeting the generational challenge of adapting to climate change has the potential to resolve some of the longest-standing issues and most deeply entrenched inequities present within American society, but only if done so in an intentional and inclusive manner.

Appendix I: Content Analysis Scoring Criteria, Examples

Note: Example passages are labeled **(1)** or **(2)**. **(1)** describes a passage from the *Destination 2040 LRTP* of the Boston Region Metropolitan Planning Organization (2019). **(2)** describes a passage from the *Draft Regional Transportation Plan 2022 – 2050* of the Puget Sound Regional Council (2022).

Code Number	Code Name/Label	Definition	Example
E1	**Mode-shift (Env.)**	Identification or discussion of mode shift from private vehicles to active/sustainable transportation modes in the context of reducing environmental impacts, increasing sustainability, etc.	*Bicycle and pedestrian infrastructure improvements, locally developed transit services, and first-mile/last-mile connections can help to reduce VMT and reduce emissions through mode shift. (1)*
E2	**Land use (Env.)**	Identification or discussion of need for intensification of land uses (density), growth management strategies, or "smart growth" policies in the context of reducing environmental impacts, preserving natural/environmental resources, etc.	*To support smart growth development by making transportation investments that enable denser, smart growth development patterns that can support reduced GHG emissions (1)*
E3	**Balancing infrastructure and environment**	Discussion/acknowledgement of trade-offs involved in balancing infrastructure/economic needs with protection/conservation/restoration of local ecosystems/biodiversity, etc.	*With a goal to meet those needs in an equitable and environmentally responsible way while improving mobility, the RTP must be evaluated relative to outcomes related to people, climate, the environment, and mobility. (2)*
E4	**Strategies to redress environmental injustice**	Inclusion of policies explicitly provided to rectify legacies of environmental injustice	*Prioritize MPO investments that benefit equity populations* • Minimize potential harmful environmental, health, and safety effects of MPO-funded projects for all equity populations* • Promote investments that support transportation for all ages (age-friendly communities) • Promote investments that are accessible to all people regardless of ability (1)*
E5	**Resilience (Physical)**	Inclusion of resilience, either explicitly or implicitly, specifically in regard to the physical built and/or natural	*...this investment program was expanded in this LRTP to include additional funding for climate*

		environment (as opposed to human/social resilience).	*resilience improvements and... (1)*
E7	**Planning for ecosystem resilience**	Inclusion of scoring metrics, guidelines, or other mechanisms to disincentivize infrastructure projects or development in areas with greater vulnerability to natural hazards	*In this analysis, the total cost per index point was adjusted by the percentage, if any, of the project in a 100-year flood zone. This adjustment can improve a project's cost-effectiveness to reflect the fact that part of the project addresses two MPO objectives: system preservation and climate resiliency. (1)*
E6	**Vulnerability assessment (infrastructure /built environment)**	Inclusion of some form of vulnerability assessment (explicit or implicit) as relates to hazards that threaten existing/planned infrastructure and/or the specific threats that these hazards pose	*There are widespread consequences to these climate change impacts. Specific to the built environment and transportation network, potential effects include: • Accelerated deterioration of highways • Flooding of roadways and increased stormwater issues • Storm surge damage to docks and other facilities • More frequent landslides • Rail buckling from higher temperatures • Reduction in aircraft lift and efficiency due to higher temperatures • Reduced water levels affecting ships and barges (2)*
E8	**Equitable TOD**	Inclusion of equity-focused TOD planning/policy. TOD can be explicit (using TOD terminology) or implicit (planning or policy that implies a TOD-style approach).	*Building from the Growing Transit Communities Partnership in 2013, work has continued to advance transit-oriented development throughout the region, including a regional advisory committee housed at PSRC and recent work on a regional housing strategy. (2)*
E9	**Jobs-housing balance**	Demonstration of jobs-housing balance as included as a factor in transportation planning	*These efforts to focus growth, particularly around high-capacity transit, are key components of the Greenhouse Gas Strategy and support the reduction of emissions into the future. Further potential exists in continuing to work towards a greater jobs-housing balance throughout the*

			region, supported by policies in VISION 2050. (2)
C1	**Mode-shift (social/economic)**	Identification or discussion of mode shift from private vehicles to active/sustainable transportation modes in the context of improving accessibility/mobility/opportunity for marginalized groups, creating a more equitable transportation system, supporting upward mobility, etc.	*They will reduce delay and improve bus transit reliability. Expanded transportation options and better access to transit will improve mobility for all and encourage mode shift. (1)*
C2	**Land use (social/economic)**	Identification of need for intensification of land uses (density) and/or growth management strategies, social/economic justification	*Maintaining existing and creating new affordable housing near transit stations will be key to ensuring that transit-dependent populations will have easy access to the expanding transit network. (2)*
C3	**Local impact projection**	Identification of specific projected impacts of climate change at the local/regional level	*Climate change poses many challenges to the central Puget Sound region. According to the State of Knowledge: Climate Change in Puget Sound, published by the Climate Impacts Group at the University of Washington, the potential key impacts include51: • Increased temperatures • Variable precipitation • More frequent and intense rainfall • Sea level rise • Ocean acidification • Decreased snowpack and higher winter streamflow • Increased landslide risk and erosion • More frequent and intense flooding • Impacts to salmon and other species • Altered growing seasons (2)*
C4	**Coordination with localities**	Demonstration of coordination with localities on climate/sustainability/resilience efforts so as to maximize impact of planning and investment, strengthen communities' resilience	*Regional resilience policy: Advance the resilience of the transportation system by incorporating redundancies, preparing for disasters and other impacts, and coordinated planning for system recovery. (1)*

C5	**Resilience - community**	Inclusion of resilience, either explicitly or implicitly, specifically in regard to communities, individuals, or social groups (as opposed to natural/environmental/ecosystems resilience).	*Building resiliency into the region's transportation system includes a variety of different factors. Key among them are ensuring routes remain viable for delivery of food and medical services; ... and coordinated planning efforts such as emergency routing plans for critical systems closures. (2)*
C6	**Vulnerability asessment (social/economic)**	Identification of local vulnerabilities to projected impacts of climate change, specifically as relates to social/political/economic systems.	*The index considers expected annual loss, social vulnerability, and community resilience. Data are available at the countywide and census tract level. Census tract data allow for a neighborhood-level analysis of vulnerability. (2)*
C7	**Barriers to inclusion**	Identification of barriers to inclusion in regional planning process	*PSRC focused on an inclusive public engagement strategy to reduce barriers to participation. (2)*
C8	**Incorporation of public concerns**	Identification of how information gained through public participation efforts is included in the plan	*Key needs identified through these conversations include reduction in travel times – particularly transfer wait times, more transportation services at times when they are needed, more and better information about available services, and better access to health and wellness destinations including medical facilities, pharmacies, and grocery stores. (2)*
C9	**Equity focus geographic strategy**	Inclusion of explicit provisions/strategies/actions designed to redress above marginalization	*The program can provide funding for starting new, locally developed transit services that include transit vehicles and coordination of service to transportation equity populations in suburban areas. (1)*
T1	**VMT**	Discussion of shifting to and/or use of VMT as transportation system performance metrics or potential investment impact scoring methods	*A 19% reduction in VMT per capita and an additional 6.3 million hour of transit service as compared to 1990 levels. (Included among goals for transportation system conditions in 2050.) (2)*

T2	**Root causes of inequities**	Identification of the causes of inequities/challenges discussed in the plan; e.g. red-lining, urban renewal, etc.	*Inequitable planning policies and practices disproportionately limited access to opportunities and created undue burdens for many marginalized communities in the central Puget Sound region. As the region becomes increasingly diverse, providing equitable access to transportation, especially to historically marginalized and underserved communities, is critically important to the overall health of the region. (2)*
T3	**Solutions to root causes of inequities**	Inclusion of solutions (or partial solutions) to underlying causal issues identified above advanced to reverse long-standing trends	*Implement transportation programs and projects that provide access to opportunities while preventing or mitigating negative impacts to people of color, people with low incomes, and people with special transportation needs. • Ensure mobility choices for people with special transportation needs, including persons with disabilities, older adults, youth, and people with low incomes. (2)*
T4	**Opportunity in crisis**	Discussion/inclusion of policies or programming that demonstrates finding and taking advantage of opportunities in challenging circumstances/crises	*This challenge was an opportunity to deploy new techniques for engaging with PSRC members and communities, offering some real advantages through virtual engagement opportunities, which will be discussed further in this section. (2)*
T5	**Adapting to long-term trends**	Identification of societal factors/development patterns/travel behaviors that are irrevocably changing, inclusion of strategies to address them	*The COVID-19 pandemic changed overnight how residents live, work, and travel in the central Puget Sound region. The recovery has been slow and uneven. Questions remain about the future of commuting – and even the future of transportation. Will the region's central business districts recover? How many people will continue to work from home? Will people return to transit? (2)*

T6	**Incentive structures**	Discussion of planning/development incentive structures in any form specifically as relates to adaptation, sustainability, or equity	*The Building Green Cities guidebook provides information for jurisdictions on creating low-impact development incentive programs to encourage these development practices. VISION 2050 contains policies and actions that support these best practices. The Regional Transportation Plan supports this work by encouraging incorporation of these best practices into projects and programs. (2)*
T7	**Collaboration across municipalities and sectors**	Demonstration of collaboration between and across political boundaries and between government and private or non-profit sectors; specifically regarding sustainability/equity/resilience/innovation	*PSRC has also been increasing its understanding of the various approaches jurisdictions in the region use to improve their active transportation infrastructure. Currently, about half of jurisdictions in the region have adopted specific "Complete Streets" regulations. Although not every jurisdiction has adopted a Complete Streets code, many have adopted similar policies and regulations that do not explicitly use that terminology. On the planning side, every jurisdiction in the region includes policies and plans for improving active transportation infrastructure in their municipal and county comprehensive plans. (2)*
T8	**Leveraging federal resources**	Demonstration of efforts to leverage existing federal rules, requirements, programming, or funding in service of equity/sustainability/resilience goals specifically	*WSDOT developed the Travel Washington program, which uses the federal dollars to subsidize four intercity bus routes that fill gaps in the transportation network for rural and small urban areas. (2)*
T9	**Innovation**	Discussion of policy experimentation and/or institutionalization of new/better methods in the future	*As part of its ongoing work on a Regional Equity Strategy, PSRC is developing additional resources and tools, such as an equitable development toolkit and equitable engagement guidance, that should be used in project-level planning, environmental review, and in engaging*

			the public to better understand the needs of the region's residents. (2)

Appendix II: Completed Scoring Sheets

II.1: Overall Scores

Code Number	Code Name/Label	Definition	Hampton Roads	Richmond	Roanoke	Staunton	Danville	Average
E1	**Mode-shift (Env.)**	Identification or discussion of mode shift from private vehicles to active/sustainable transportation modes in the context of reducing environmental impacts, increasing sustainability, etc.	**6**	**5**	**14**	**5**	**1**	**6.2**
E2	**Land use (Env.)**	Identification or discussion of need for intensification of land uses (density), growth management strategies, or "smart growth" policies in the context of reducing environmental impacts, preserving natural/environmental resources, etc.	**12**	**7**	**15**	**3**		**9.25**
E3	**Balancing infrastructure and environment**	Discussion/acknowledgement of trade-offs involved in balancing infrastructure/economic needs with protection/conservation/restoration of local ecosystems/biodiversity, etc.	**14**	**2**	**6**	**2**	**2**	**5.2**
E4	**Strategies to redress environmental injustice**	Inclusion of policies explicitly provided to rectify legacies of environmental injustice	**3**	**6**	**1**	**6**	**2**	**3.6**
E5	**Resilience (Physical)**	Inclusion of resilience, either explicitly or implicitly,	**19**	**11**	**1**			**10.3333 3333**

		specifically in regard to the physical built and/or natural environment (as opposed to human/social resilience).						
E6	**Planning for ecosystem resilience**	Inclusion of scoring metrics, guidelines, or other mechanisms to disincentivize infrastructure projects or development in areas with greater vulnerability to natural hazards	**2**	**4**	**2**	**10**		**4.5**
E7	**Vulnerability assessment (infrastructure/built environment)**	Inclusion of some form of vulnerability assessment (explicit or implicit) as relates to hazards that threaten existing/planned infrastructure and/or the specific threats that these hazards pose	**8**	**3**	**1**	**1**	**2**	**3**
E8	**Equitable TOD**	Inclusion of equity-focused TOD planning/policy. TOD can be explicit (using TOD terminology) or implicit (planning or policy that implies a TOD-style approach).		**7**				**7**
E9	**Jobs-housing balance**	Demonstration of jobs-housing balance as included as a factor in transportation planning			**3**			**3**
C1	**Mode-shift (social/economic)**	Identification or discussion of mode shift from private vehicles to active/sustainable transportation modes in the context of improving accessibility/mobility/opportunity for marginalized groups, creating a more equitable transportation system, supporting upward mobility, etc.	**23**	**21**	**25**	**25**	**15**	**21.8**
C2	**Land use (social/economic)**	Identification of need for intensification of land uses (density) and/or growth management strategies,	**11**	**4**	**8**	**1**	**1**	**5**

		social/economic justification						
C3	**Local impact projection**	Identification of specific projected impacts of climate change at the local/regional level	**20**	**5**				**12.5**
C4	**Coordination with localities**	Demonstration of coordination with localities on climate/sustainability/resilience efforts so as to maximize impact of planning and investment, strengthen communities' resilience	**2**	**7**				**4.5**
C5	**Resilience - community**	Inclusion of resilience, either explicitly or implicitly, specifically in regard to communities, individuals, or social groups (as opposed to natural/environmental/ecosystems resilience).	**3**	**1**	**4**			**2.666666667**
C6	**Vulnerability asessment (social/economic)**	Identification of local vulnerabilities to projected impacts of climate change, specifically as relates to social/political/economic systems.	**9**	**11**				**10**
C7	**Barriers to inclusion**	Identification of barriers to inclusion in regional planning process	**8**	**6**				**7**
C8	**Incorporation of public concerns**	Identification of how information gained through public participation efforts is included in the plan	**11**	**13**	**5**	**18**	**9**	**11.2**
C9	**Equity focus geographic strategy**	Inclusion of explicit provisions/strategies/actions designed to redress geographically specific marginalization	**2**	**7**	**2**	**7**	**1**	**3.8**
T1	**VMT**	Discussion of shifting to and/or use of VMT as transportation system performance metrics or potential investment impact scoring methods	**9**	**8**	**4**			**7**

T2	**Root causes of inequities**	Identification of the causes of inequities/challenges discussed in the plan; e.g. red-lining, urban renewal, etc.		**2**	**3**			**2.5**
T3	**Solutions to root causes of inequities**	Inclusion of solutions (or partial solutions) to underlying causal issues identified above advanced to reverse long-standing trends		**6**	**5**	**3**		**4.666666667**
T4	**Opportunity in crisis**	Discussion/inclusion of policies or programming that demonstrates finding and taking advantage of opportunities in challenging circumstances/crises		**2**	**1**			**1.5**
T5	**Adapting to long-term trends**	Identification of societal factors/development patterns/travel behaviors that are irrevocably changing, inclusion of strategies to address them		**11**	**9**	**2**	**2**	**6**
T6	**Incentive structures**	Discussion of planning/development incentive structures in any form specifically as relates to adaptation, sustainability, or equity		**2**	**3**			**2.5**
T7	**Collaboration across municipalities and sectors**	Demonstration of collaboration between and across political boundaries and between government and private or non-profit sectors; specifically regarding sustainability/equity/resilience/innovation	**10**	**16**	**6**	**3**	**4**	**7.8**
T8	**Leveraging federal resources**	Demonstration of efforts to leverage existing federal rules, requirements, programming, or funding in service of equity/sustainability/resilience goals specifically		**3**	**3**	**5**		**3.666666667**
T9	**Innovation**	Discussion of policy experimentation and/or	**3**	**4**	**8**	**2**		**4.25**

		institutionalization of new/better methods in the future						
Ecosystem-based Adaptation Score			**64**	**45**	**43**	**27**	**7**	**37.2**
Community-based Adaptation Score			**89**	**75**	**44**	**51**	**26**	**57**
Transformative Adaptation Score			**22**	**54**	**42**	**15**	**6**	**27.8**
Total Weighted Score:			**175**	**174**	**129**	**93**	**39**	**122**

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