The Role of Socio-Economic Projections in Supporting Just Urban Climate Change Adaptation

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Abstract

Urban climate change adaptation efforts have often been criticized for exacerbating the inequitable impacts of climate change by failing to address the social and economic consequences of adaptation. There is an urgent need to incorporate equity and justice concerns into adaptation planning; however, climate justice scholarship to date has been overwhelmingly theoretical and has failed to provide operational tools for supporting climate justice. Socio-economic projections could act as a promising tool to facilitate the consideration of justice in urban climate change adaptation planning. Therefore, this research investigates the question: how can socio-economic projections be utilized in urban climate change adaptation policy and planning to ensure climate justice? To answer this question, a systematic review of urban adaptation research utilizing socio-economic projections is conducted and urban adaptation policies from 18 global cities are analyzed. Grounded in a conceptual framework on urban climate justice, the research analyzes the evolution of research and policy applications of socio-economic projections and evaluates the potential for existing socio-economic scenario applications to promote climate justice. Results show that while socio-economic projections have not been explicitly linked to justice in the existing literature or policy, clear potentials exist for socio-economic projections to be used as a tool to promote distributive, procedural, and recognition and restorative justice. Consequently, a proposed framework is developed for the application of socio-economic projections to promote justice centered urban adaptation. Applying such a framework to urban adaptation planning and policy can help center justice concerns in larger strategic adaptation planning efforts and promote a new form of inclusive, data driven climate governance in cities.

Preface

This research was completed in collaboration with the Basque Centre for Climate Change (BC3) under the supervision of Marta Olazabal.

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Mia Prall

Executive Summary

The impacts of climate change are not felt equally and climate change policy and planning efforts have often exacerbated inequalities by failing to address the social and economic impacts of climate change and adaptation responses. In cities, the inequitable impacts of climate change are amplified due to the historic tendency for urban areas to be heightened sites of inequality and the more recent trend of cities as hubs of increased risk and vulnerability. These challenges indicate a clear need to consider equity and justice concerns in urban adaptation planning; however, there is currently a lack of operational tools for promoting climate justice. Scenario planning approaches could be a promising tool to promote a justice centered view of urban adaptation by providing a framework through which to cope with uncertainty, perform holistic analysis, and better anticipate the potential impacts of adaptation interventions, thus maximizing benefits and preventing maladaptation. In an urban context, it is especially critical that scenario planning approaches include analysis of projected future climate alongside future socio-economic projections in order to be able to cope with the wide range of changes cities are facing including climate change, economic crises, pandemics, and social and political polarization. Socio-economic projections may not immediately appear as an obvious avenue through which to ensure climate justice due to the tendency of projections to be perceived as top-down, technocratic tools. However, the application of socio-economic projections to justice-centered urban adaptation planning could illustrate the potential for socio-economic projections to combine diverse forms of scientific and local knowledge and support the adoption of new forms of inclusive data driven decision making. This study therefore examines how socio-economic projections can be utilized in urban climate change adaptation policy and planning to ensure climate justice.

This question is addressed through a two stage research approach that combines analysis of urban adaptation literature and policy. First, a systematic review of literature on socio-economic projections and urban adaptation is conducted to investigate how socio-economic projections can be used in urban climate change adaptation planning and to what extent socio-economic projections are useful as a tool for supporting climate justice. Second, 22 urban adaptation policies from 18 global cities are analyzed to understand how socio-economic projections are currently being considered in urban climate change adaptation policy and whether the inclusion of socio-economic projections in policy is motivated by climate justice concerns. These analyses are united by a common theoretical framework grounded in climate change adaptation policy and planning, socio-economic projections, and urban climate justice.

Results show that socio-economic projections are not widely applied in urban adaptation research or policy. None of the literature or policies reviewed consider socio-economic projections in relation to equity or justice, indicating that socio-economic projections are not yet acknowledged as a tool to promote justice. However, existing applications of socio-economic projections in urban adaptation literature and policy show potentials to ensure urban climate justice. Specifically, participatory approaches that co-create scenarios of potential socio-economic futures with local stakeholders appear to be promising for promoting equitable urban adaptation.

In order to ensure climate justice, co-created socio-economic scenarios should ensure broad and inclusive stakeholder participation at every stage of the scenario development and application process and should actively aim to integrate qualitative, quantitative, and spatial data gained from diverse forms of local and scientific knowledge. Local socio-economic scenarios should also maintain consistency with global scenarios and should always be used as a tool to facilitate robust decision making under uncertainty rather than as a means of reducing uncertainty. In order for socio-economic scenarios to truly facilitate just urban adaptation, scenario development and application approaches should be embedded into broader strategic planning processes and integrated into frameworks and guidelines already available to urban adaptation practitioners in order to accelerate the mainstreaming of future socio-economic data in adaptation decision making. The inclusive, participatory development of socio-economic scenarios has the potential to contribute to the emergence of a new form of inclusive, data driven governance wherein decision making is driven by diverse data and informed by a wide range of stakeholder voices.

Given the emerging nature of this research area, further research will be necessary to develop more nuanced approaches for integrating socio-economic scenario data into urban climate governance and to better understand the impact that using socio-economic scenarios can have on local climate justice outcomes. It will also be necessary to develop more detailed local socio-economic data and conduct empirical analysis of the impacts of socio-economic scenarios on justice in specific local contexts.

Table of Contents

1. Introduction **1**

2. Research Design **4**

3. Theoretical and Analytical Framework **6**

3.1 Climate change policy and planning **6**

3.1.1 Emergence of climate change policy and planning in cities 7

3.1.2 Urban climate change adaptation planning practice 9

3.2 Socio-economic projections **10**

3.2.1 Emergence and applications of socio-economic projections 10

3.2.2 Socio-economic projections in climate change research and practice 11

3.2.2.1 Global socio-economic projections *12*

3.2.2.2 Local socio-economic projections *14*

3.3 Conceptions of justice in urban climate change adaptation **15**

3.3.1 Urban and environmental justice 15

3.3.2 Climate justice and climate just cities 16

3.3.3 Just urban transitions and the right to the city 18

3.3.4 Framework for urban climate justice 19

4. Methodological Framework **20**

4.1 Theories of science **20**

4.2 Methods **20**

4.2.1 Systematic review methods 20

4.2.2 Policy analysis methods 24

5. Results **27**

5.1 Systematic review results **27**

5.1.1 Bibliometric analysis 27

5.1.2 Thematic analysis 31

5.1.2.1 Justifications for using socio-economic projections in urban climate change adaptation *32*

5.1.2.2 Types of socio-economic projections and methods for scenario development *33*

5.1.2.3 Use of socio-economic projections throughout the adaptation planning process *35*

5.1.2.4 Challenges and limitations of using socio-economic projections in urban adaptation planning *37*

5.1.2.5 Recommendations for use of socio-economic projections in urban adaptation planning *38*

5.1.2.6 Recommendations for use of socio-economic projections to support urban climate justice *39*

5.2 Policy analysis results **40**

5.2.1 Types of socio-economic projections and methods for scenario development 41

5.2.2 Use of socio-economic projections throughout the adaptation planning process 44

5.2.3 Consideration of justice in socio-economic projection applications 46

6. Discussion and Conclusions **48**

6.1 Systematic review discussion **48**

6.2 Policy analysis discussion **50**

6.3 Applications of socio-economic projections in research vs. policy **50**

6.4 Limitations **51**

6.5 Recommendations **52**

6.6 Further research **57**

References **59**

Appendix A **70**

Appendix B **80**

Appendix C **82**

Appendix D **87**

List of Figures

Figure 1: Overview of the Research Design 4

Figure 2: Overview of the Theoretical Framework 6

Figure 3: Climate Change Policy and Planning Across Spatial Scales 8

Figure 4: Publications on Socio-Economic Projections Over Time 10

Figure 5: Co-Occurrence of Keywords in Publications on Socio-Economic Projections 11

Figure 6: The SSP/RCP/SPA Matrix 13

Figure 7: Arnstein's Ladder of Citizen Participation in Planning 17

Figure 8: Urban Climate Justice Framework 19

Figure 9: Literature Search and Selection Process 22

Figure 10: Evolution of Publications on Socio-economic Projections and Urban Climate Change Adaptation 27

Figure 11: Disciplinary Origin of Publications 28

Figure 12: Climate Change Hazards and Impacts Studied in the Literature 29

Figure 13: Geographical Locations Studied in the Literature 29

Figure 14: Co-Occurrence of Keywords in Publications on Socio-Economic Projections in Urban Climate Change Adaptation 30

Figure 15: Co-Citation in Publications on Socio-Economic Projections in Urban Climate Change Adaptation 31

Figure 16: Potential for Socio-Economic Projections to Promote Urban Climate Justice 40

Figure 17: Potential for Policy Applications of Socio-Economic Projections to Promote Urban Climate Justice 47

List of Tables

Table 1: Stages of the Urban Climate Change Adaptation Planning Process 9

Table 2: Summary of the SSP Narratives 14

Table 3: Proposed Steps for Conducting a Systematic Review 21

Table 4: Urban Adaptation Related Policies Considering Socio-Economic Projections 25

Table 5: Literature Using Participatory Scenario Development 33

Table 6: Literature Using Modeling-Based Scenario Development 35

Table 7: Use of Socio-Economic Projections throughout the Adaptation Planning Process 36

Table 8: Policies Using Participatory Scenario Development 41

Table 9: Policies Using Modeling-Based Scenario Development 42

Table 10: Policies Using Existing Socio-Economic Projections 43

Table 11: Use of Socio-Economic Projections by Policies throughout the Adaptation Planning Process 44

Table 12: Framework for Justice-Centered Application of Socio-Economic Projections in Urban Climate Change Adaptation Planning and Policy 54

Table B1: Systematic Review Critical Appraisal 80

Table C1: Literature Using Participatory Scenario Development 82

Table C2: Literature Using Modeling-Based Scenario Development 83

Table C3: Use of Socio-Economic Projections throughout the Adaptation Planning Process 85

Table D1: Policies Using Participatory Scenario Development Approaches 87

Table D2: Policies Using Modeling-Based Scenario Development Approaches 88

Table D3: Policies Using Existing Socio-Economic Projections 89

Table D4: Use of Socio-Economic Projections by Policies throughout the Adaptation Planning Process 90

Table D5: Consideration of Equity or Justice by Policies 91

1. Introduction

While climate change is inherently a global challenge, the impacts of a changing climate are not felt equally across world regions, nations, cities, or communities. Climate change disproportionately impacts those who have contributed least to global greenhouse gas emissions and leaves marginalized and minority groups with low adaptive capacity highly exposed to climate hazards (Granberg & Glover, 2021; Hughes & Hoffmann, 2020; Shi, 2021; Shi et al., 2016).

Policy and planning efforts have often exacerbated the inequitable impacts of climate change by failing to address social and economic consequences of climatic changes, often leading to maladaptation (Hughes, 2020; Shi et al., 2016). Planning efforts that respond to climate change are deeply embedded in existing institutional and political landscapes and thus commonly operate from a place of power and privilege (Hughes, 2020; Jurjonas et al., 2020; Mohtat & Khirfan, 2021). Decision making on climate change adaptation is often biased towards interventions that promote economic development, protect valuable assets, increase property values, or otherwise benefit wealthy, white communities (Jurjonas et al., 2020; Mohtat & Khirfan, 2021; Shi, 2021). This can lead to a failure to address climate related challenges that disproportionately impact vulnerable groups such as heat, public health, and access to water and also means that marginalized groups are often excluded from the benefits of climate action and instead burdened with its costs (Mohtat & Khirfan, 2021; Shi, 2021). In some cases, climate action has even become a means of purposeful exclusion that powerful stakeholders can use to "target social rather than environmental threats" (Thomas & Warner, 2019, p.2).

At an urban scale, the impacts of both climate change and adaptation responses become spatially explicit leading to unique challenges for equity and justice in urban climate change adaptation planning. Cities have historically been sites of increased inequality and have more recently become hotspots of heightened risk and vulnerability in the face of climate change (Araos et al., 2016; Dodman et al., 2022). This collision of urban inequality and climate injustice leads to new drivers and stressors of inequity in cities and amplifies environmental risks and vulnerabilities faced by marginalized communities (Hughes & Hoffmann, 2020; Mohtat & Khirfan, 2021; Shi, 2021). Urban climate change adaptation efforts have often reinforced existing inequalities in cities through their tendency to selectively protect urban spaces and assets that are valued from an economic perspective (E. K. Chu & Cannon, 2021; Granberg & Glover, 2021; Steele et al., 2012).

The failure of urban adaptation to promote just urban transitions signals the urgent need to actively consider justice and equity implications in urban adaptation planning and policy making processes. It will be critical to advance creative, inclusive approaches to planning and governance that challenge drivers of systemic inequity in cities and enhance adaptive capacity for all urban dwellers (Granberg & Glover, 2021; Shi et al., 2016; Steele et al., 2012). However, climate justice scholarship to date has been primarily theoretical and has given limited attention to how to operationalize equity in climate change adaptation planning and policy making (Amorim-Maia et al., 2022; Hughes & Hoffmann, 2020).

Scenario planning approaches could provide one potential avenue through which to operationalize justice concerns in urban adaptation. Scenario planning is a powerful tool for coping with uncertainty (Butler et al., 2020) and could advance a holistic view of adaptation planning that may help to foresee the potential social and economic impacts of both climate change hazards and adaptation responses, thus enabling action that provides equitable outcomes for vulnerable groups and prevents maladaptation. Climate scenarios have become common best practice tools for adaptation planning due to their ability to facilitate decision making in the face of huge climate uncertainty (Dessai et al., 2005). However, while projecting potential climate futures has become standard practice, such projections are rarely accompanied by scenarios of future vulnerability (Jurgilevich et al., 2021). The resilience of our cities in coming decades will be shaped not only by climatic changes but also by socio-economic development trends that will reshape landscapes of urban risk and vulnerability (Birkmann et al., 2020; Jurgilevich et al., 2021; van Ruijven et al., 2014). Just as urban climates are rapidly changing, so too are urban populations, demographic compositions, economic growth trajectories, and social fabrics (Poot & Pawar, 2013). As urban climates and socio-economic development futures shift, cities are met with a range of other challenges including pandemics, economic crises, and social and political polarization. These challenges can be understood as 'compound urban crises' that call for integrated and interdisciplinary approaches to urban governance that have so far been severely lacking (Westman et al., 2022).

The joint analysis of projected socio-economic development patterns and climate futures could be one avenue through which to promote interdisciplinary approaches to the multiple crises our cities are expected to face. Such coupled analysis is critical in order to better understand social, environmental, and economic aspects of future vulnerability and be able to make informed adaptation decisions today that will ensure equitable outcomes for years to come (Meyer et al., 2019; Reimann, Vollstedt, et al., 2021).

Socio-economic projections could facilitate justice centered adaptation planning by illustrating potential development futures and helping decision makers to visualize who to plan for and how to promote solutions that not only cope with future climate uncertainty but also respond to the dynamic needs of urban communities under multiple potential socio-economic development pathways. While the exercise of projecting potential futures may traditionally be associated with top-down, technocratic, and overwhelmingly quantitative approaches to planning, the concept of socio-economic projections is in reality much broader. The application of socio-economic projections to urban adaptation governance could represent a unique opportunity to combine diverse forms of scientific and local knowledge and support the adoption of new forms of inclusive data driven decision making. It is widely acknowledged that evidence-based decision making is critical in advancing urban climate action; however, data driven urban governance has been criticized for its technocratic nature and tendency to favor external economic interests over local needs (Hughes, 2020). Attempts to counteract the overly technical nature of urban climate action have often employed participatory approaches to planning; however, successful integration of scientific and local or alternative knowledge systems in adaptation planning remains scarce (Olazabal et al., 2021). It is therefore pertinent to investigate whether inclusive applications of socio-economic projections could be used as a tool to bridge the gap between technical, scientific information and local knowledge to realize a new equitable form of data driven urban climate governance.

It is therefore interesting to explore whether socio-economic projections could act as a tool for the practical integration of scientific and local knowledge to advance just adaptation. To date, socio-economic projections have had very limited application in urban adaptation planning and policy making and the justice implications of using such projections as a planning tool are unexplored. Therefore, this research will seek to investigate the question: *how can socio-economic projections be utilized in urban climate change adaptation policy and planning to ensure climate justice?*

The following chapters present an overview of the research design used to answer this question (Chapter 2) before going on to outline the theoretical and analytical framework of the research (Chapter 3) and describe the methodological framework used in the analysis (Chapter 4). Next, the results are presented (Chapter 5) and finally key findings are discussed (Chapter 6).

2. Research Design

This chapter presents the overall structure of the research and visualizes how the unique aspects of the research design relate. Figure 1 below shows the structure of the research design.

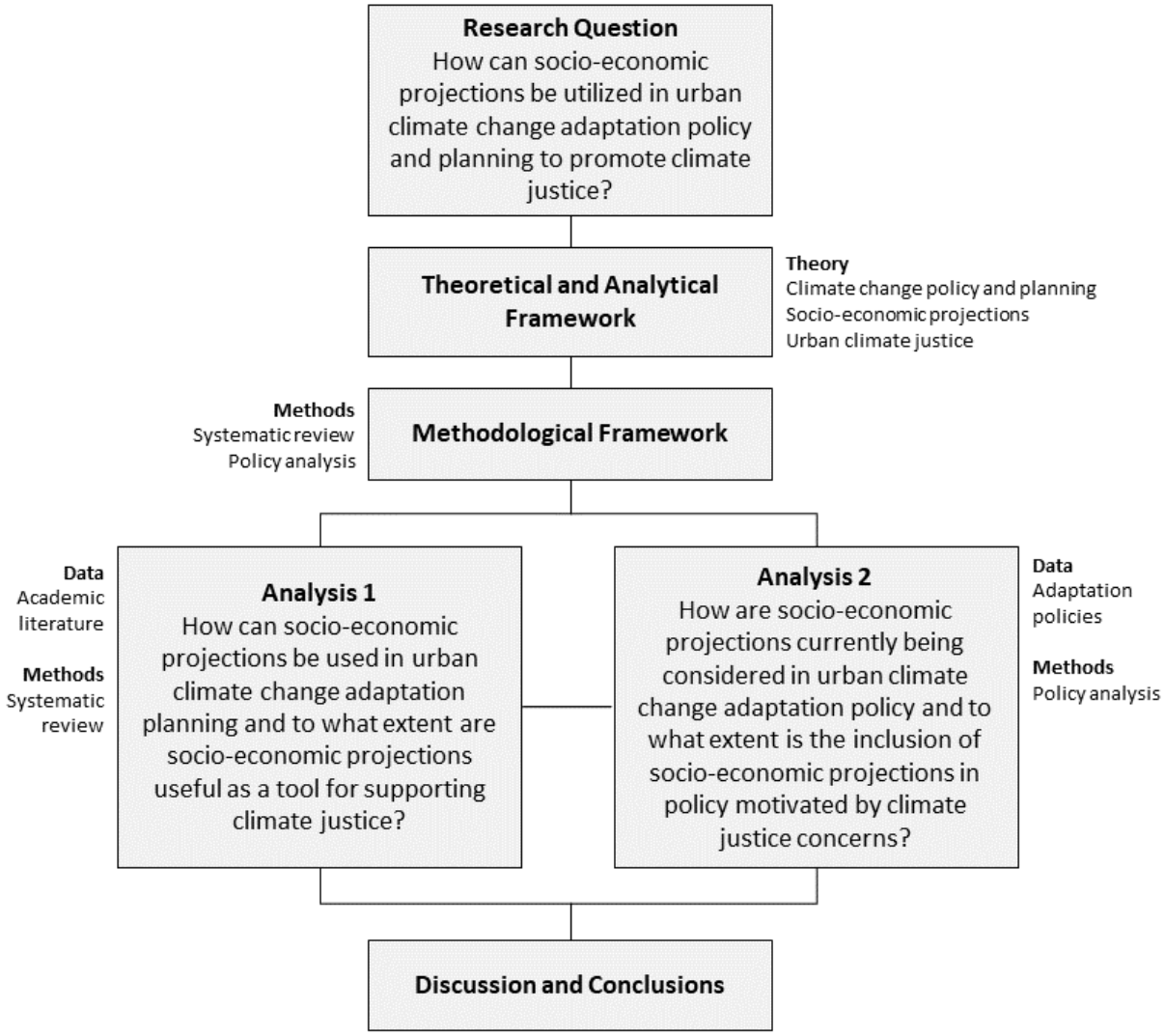

Figure 1: Overview of the Research Design

The study aims to answer the research question: *how can socio-economic projections be utilized in urban climate change adaptation policy and planning to ensure climate justice?* This will be done through two sub-analyses built on a common theoretical and analytical framework centered around climate change policy and planning, socio-economic projections, and urban climate justice and guided by a methodological framework utilizing systematic review and policy analysis.

The first analysis consists of a systematic review that aims to answer the question: *how can socio-economic projections be used in urban climate change adaptation planning and to what extent are socio-economic projections useful as a tool for supporting climate justice?* This analysis identifies literature on

the use of socio-economic projections in urban climate change adaptation planning through a systematic search and presents the results from this search in order to firstly investigate how socio-economic projections can be used for climate change adaptation planning in an urban context and secondly assess how socio-economic projections could theoretically support climate justice. The latter aspect of the analysis is completed through the application of results from the systematic review to the urban climate justice framework that guides the theoretical framing of the research.

The second analysis investigates 22 adaptation policies from 18 cities around the world to answer the question: *how are socio-economic projections currently being considered in urban climate change adaptation policy and to what extent is the inclusion of socio-economic projections in policy motivated by climate justice concerns?* This analysis builds on prior research (Olazabal, Ruiz De Gopegui et al., 2019) by investigating how each policy considers socio-economic projections and whether these projections are actively used as a tool to support climate justice.

These two sub-analyses invite questions of how climate justice can be supported through urban climate change adaptation planning and what role socio-economic projections have to play in the pursuit of building climate just cities.

3. Theoretical and Analytical Framework

This chapter presents the theoretical and analytical framework of the research which centers around three key concepts: climate change policy and planning, socio-economic projections, and urban climate justice. The connections between these concepts and their relation to the research question is illustrated in Figure 2 below.

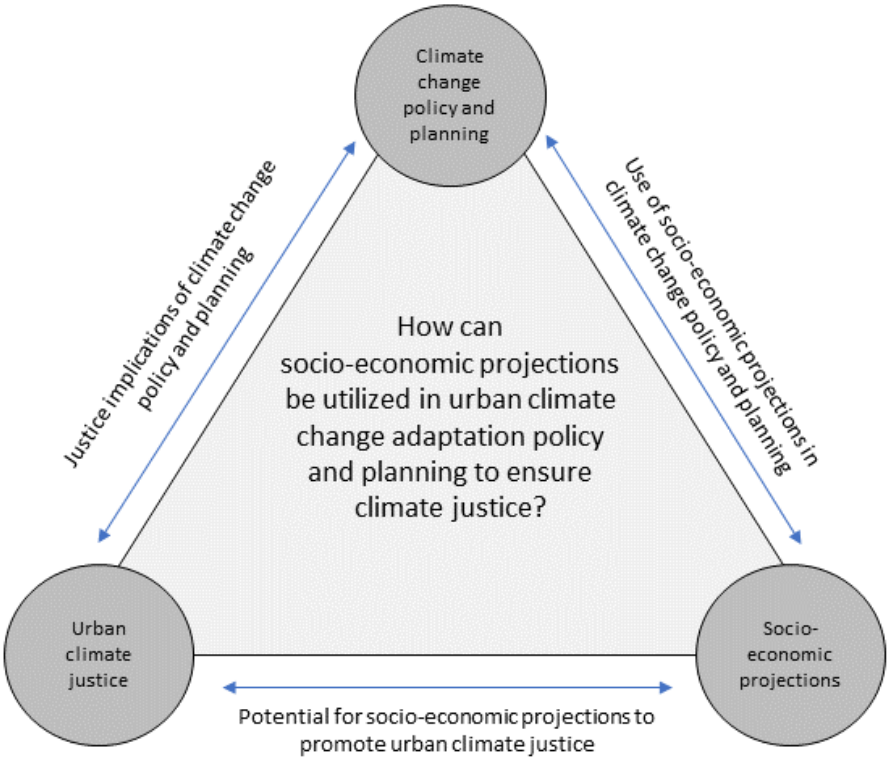

Figure 2: Overview of the Theoretical Framework

The following sections first provide an overview of climate change policy and planning. Second, socio-economic projections and their use in climate change research is discussed. Finally, conceptions of justice and equity in climate change and urban climate change adaptation are discussed and a framework for urban climate justice is developed.

3.1 Climate change policy and planning

The initial emergence of global climate policy through the 1997 Kyoto Protocol and subsequent policy efforts focused on mitigation, compelling nations to meet quantifiable greenhouse gas (GHG) emission reduction targets through neoclassical, market-based solutions (Meckling & Allan, 2020). In the past two decades, the scope of global climate action has expanded to include both mitigation (reducing GHG sources or increasing GHG sinks) (IPCC, 2014) and adaptation (adjusting to climate change impacts) (IPCC, 2022) and ideas surrounding climate action have broadened to encompass a much wider range of experimental and holistic policy alternatives (Meckling & Allan, 2020).

3.1.1 Emergence of climate change policy and planning in cities

As global discourse on climate change policy has evolved, the central role of local and urban climate action in mitigating and adapting to climate change has become widely acknowledged (Castán Broto, 2017). Early climate action in cities first emerged in the 1990s in a number of small and medium sized North American and European cities and initially mirrored global climate policy by concentrating mostly on mitigation (Bulkeley, 2010). In the early 2000s, a second wave of urban climate action emerged, characterized by greater geographic diversity, inclusion of more large cities, and increased involvement of a wider range of actors (Bulkeley, 2010). The 2009 Copenhagen Climate Change Conference (COP 15) is often cited as a key turning point for the popularization of climate policy in cities as the conference redefined the then top-down international climate action regime as more informal, decentralized, and polycentric, thus highlighting the possibilities for mitigation and adaptation action at a local and urban scale (Bäckstrand et al., 2017; Castán Broto, 2017; Castán Broto & Westman, 2020). The role of sub-national action in the international climate policy arena was solidified following the 2015 Paris Agreement which further emphasized the key role of local and urban action for mitigation and adaptation (Castán Broto & Westman, 2020). More recently, the urgency of climate action in cities has been highlighted by the rapidly urbanizing nature of the global population, the increase of extreme events in cities, and the unique position of urban areas as hubs of consumption and leading drivers of GHG emissions (Deetjen et al., 2018; Dhar & Khirfan, 2016; Madsen & Hansen, 2018).

As international climate action has failed to deliver on mitigation and cities have become key arenas for climate action, the role of spatial planning in mitigation and adaptation responses has been recognized (Jiang et al., 2017; Kauffman & Hill, 2021). The strategic and future-oriented nature of spatial planning has the potential to facilitate the reimagination of current unsustainable development trajectories and more explicitly investigate visions, goals, and competing or conflicting interests to imagine possible transitions to sustainable future pathways (Hrelja et al., 2015). Both mitigation and adaptation have spatial elements (Biesbroek et al., 2009) and spatial configuration, urban form, and land use have important impacts on climate at an urban scale (Hurlimann & March, 2012). For these reasons, spatial planning has been cited as a promising framework through which to integrate mitigation and adaptation action to achieve the broader goals of climate resilience and sustainable development (Albers & Deppisch, 2013; Biesbroek et al., 2009; Hurlimann & March, 2012).

While cities have become key actors in climate change policy, it is important to acknowledge that urban climate policy remains deeply embedded within a larger system of climate change planning and policy that takes place across multiple scales from global to local. The scales at which climate change policy operates today are illustrated in Figure 3 below.

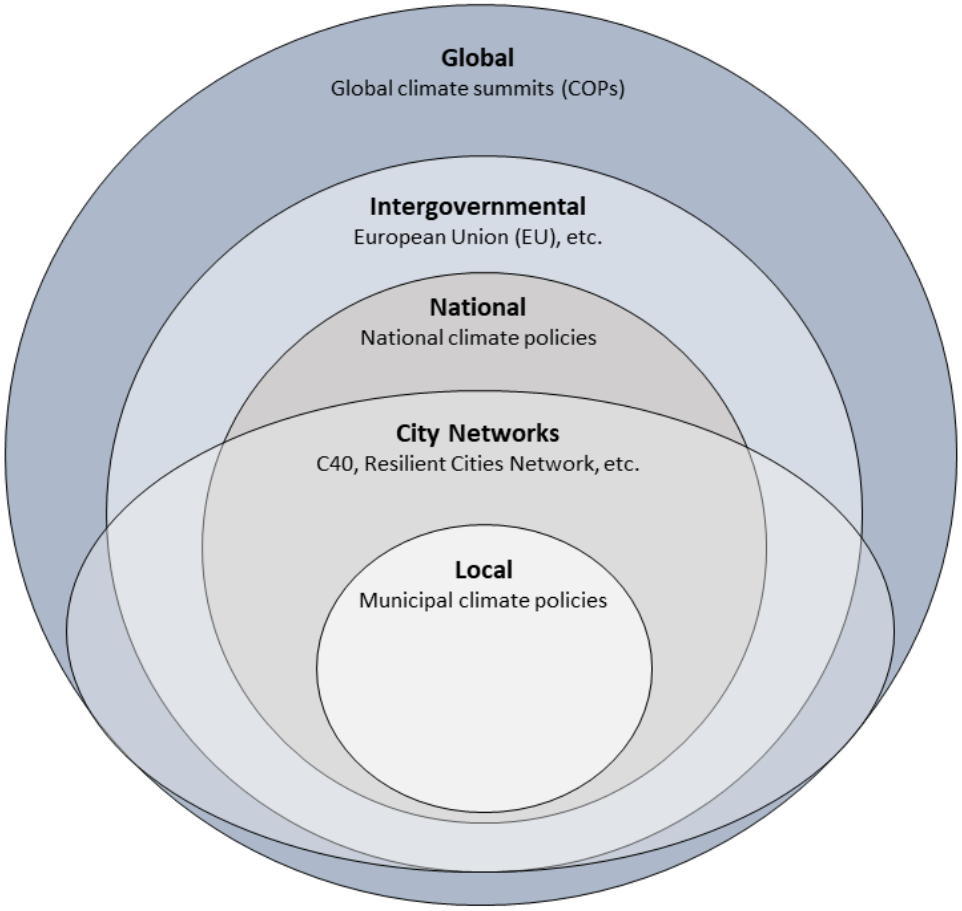

Figure 3: Climate Change Policy and Planning Across Spatial Scales

Despite the promising role of urban policy and spatial planning in combating climate change, challenges and gaps remain in urban climate action. Recent assessments of urban climate policy reveal that the majority of cities do not address mitigation and adaptation as strategic policy goals. Reckien et al. (2018) surveyed 885 European cities and found that 66% of cities have a mitigation plan, 26% have an adaptation plan, and only 17% plan for both adaptation and mitigation. Similarly, Araos et al. (2016) assess the governmental adaptation planning efforts of 401 urban areas globally and find that only 15% of cities with over 1 million inhabitants plan for adaptation.

The urban climate change action plans (CCAPs) and local climate plans (LCPs) that have been adopted demonstrate that large cities have made more progress on climate planning, the most ambitious urban climate planning has taken place in North America, Europe, and Oceania, and national regulations have a significant influence on the adoption of local climate policy (Araos et al., 2016; Grafakos et al., 2020; Reckien, Salvia, et al., 2018).

3.1.2 Urban climate change adaptation planning practice

Beyond urban climate policy, it is useful to understand how urban climate action is implemented in planning practice. As this research focuses specifically on adaptation, this section is limited to an overview of the urban climate change adaptation (CCA) planning process. Urban CCA focuses on planned adaptation which includes deliberate decision making intended to minimize risk and maximize opportunities of climate change (Araos et al., 2016; Füssel, 2007). Urban adaptation planning considers questions regarding future climate variability, the impact of future changes on current decision making, and the potential consequences of immediate or postponed action (Füssel, 2007).

In order to address such questions, the urban CCA planning process generally follows a number of sequential phases including risk assessment, identification and selection of adaptation options, implementation, and monitoring and evaluation (Climate ADAPT, n.d.). Table 1 below details the specific action that may be taken at each stage of the urban CCA planning process.

Table 1: Stages of the Urban Climate Change Adaptation Planning Process. Adapted from Climate ADAPT (n.d.) and New et al. (2022).

Planning Stage	Actions
Preparing the ground for adaptation	● Obtaining political support for adaptation ● Collecting initial information ● Setting up adaptation processes within and beyond the municipality ● Identifying and obtaining human and technical resources ● Identifying and obtaining financing and funding ● Identifying and engaging stakeholders ● Communicating adaptation
Assessing climate change risks and vulnerabilities	● Recognizing past and present climate impacts ● Understanding climate projections and future impacts ● Identifying vulnerable urban sectors ● Conducting risk and vulnerability assessments ● Understanding the role of surrounding areas in adaptation ● Identifying main adaptation concerns and defining objectives
Identifying adaptation options	● Creating a catalog of relevant adaptation options ● Finding examples of good adaptation practices
Assessing and selecting adaptation options	● Choosing an assessment framework for adaptation options ● Conducting a cost-benefit analysis of adaptation measures ● Prioritizing adaptation options
Implementing adaptation	● Designing an effective adaptation action plan ● Finding examples of adaptation action plans ● Mainstreaming adaptation in urban policies and plans ● Addressing climate change through adaptation and mitigation
Adaptation monitoring, evaluation and learning	● Developing the monitoring and evaluation approach ● Defining monitoring indicators ● Finding examples of adaptation monitoring indicators ● Using monitoring results to enhance the process of adaptation

3.2 Socio-economic projections

3.2.1 Emergence and applications of socio-economic projections

Socio-economic projections or scenarios have a wide range of definitions and applications but can broadly be understood as models of potential future development trends based on projected socio-economic variables such as population, demography, economic development, and land use. While some define socio-economic scenarios as combinations of quantitative and qualitative information that together characterize possible futures (Kriegler et al., 2012), this study takes a broader view of socio-economic projections or scenarios as qualitative, quantitative, or spatial projections of potential development futures and uses the terms 'projection' and 'scenario' interchangeably.

Socio-economic scenarios have been widely applied in a number of scientific disciplines over the past several decades. A search for scientific articles using socio-economic projections reveals over 5,000 publications on socio-economic projections indexed in Web of Science.[1] Socio-economic projections emerged as a research area in the 1990s and have steadily gained increased attention in the literature until today (see Figure 4 below).

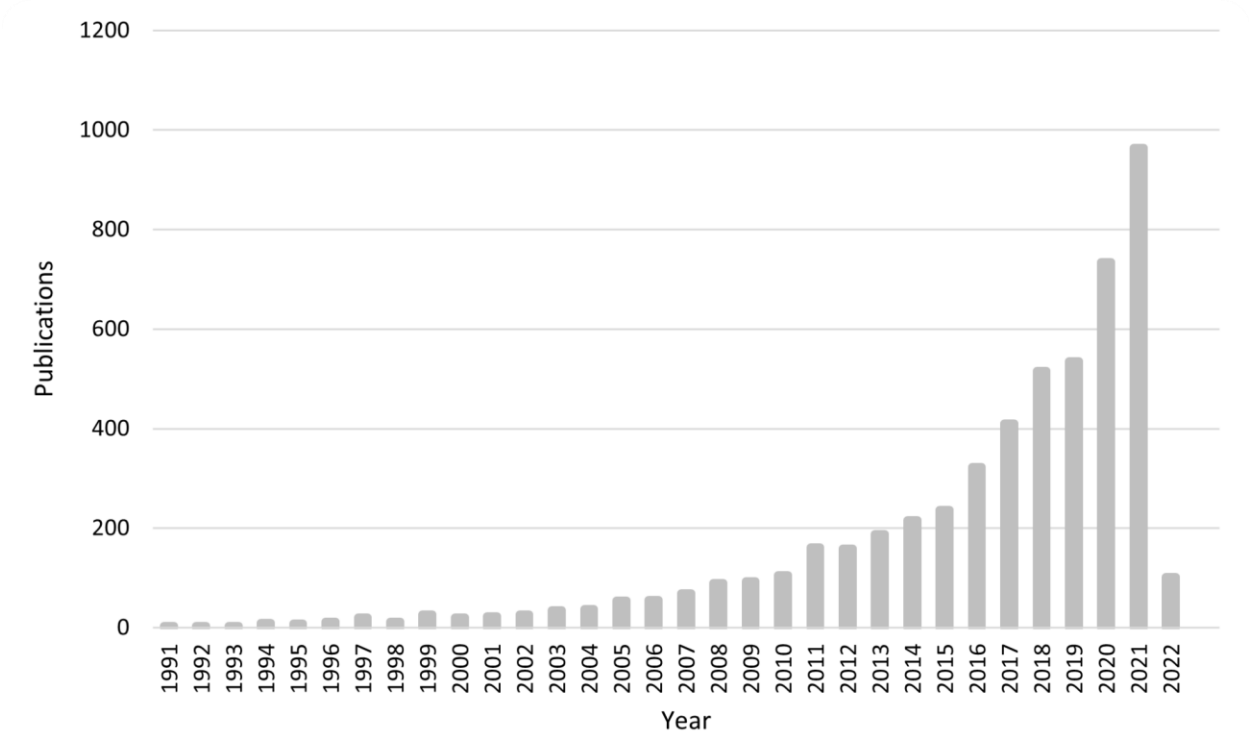

Figure 4: Publications on Socio-Economic Projections Over Time

Socio-economic projections have been applied in various fields over time, with environmental science, environmental studies, public health, and atmospheric sciences being the most common disciplines to

[1] Search conducted April 18th, 2022 using search string: ("socioeconomic" OR "socio-economic") AND ("projection" OR "scenario" OR "pathway"). Results limited to articles or review articles published in English.

utilize socio-economic projections. More broadly, research on socio-economic projections can be understood as belonging to four main clusters as seen in Figure 5 below.

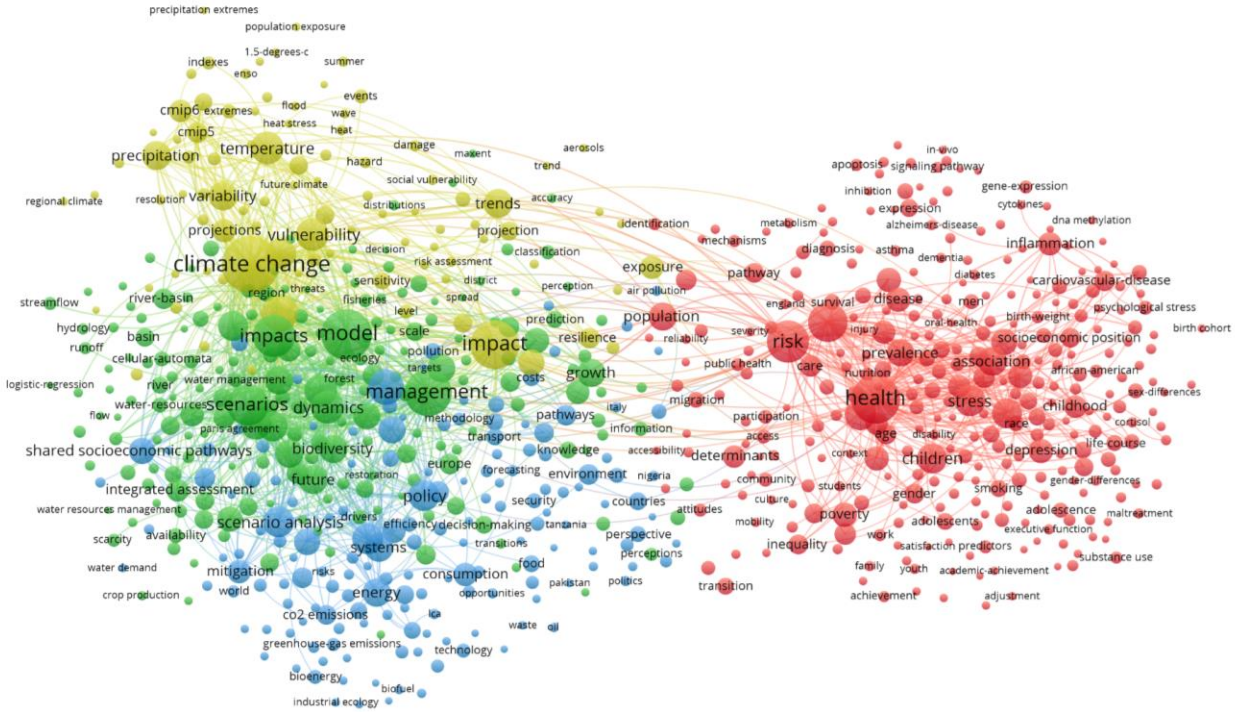

Figure 5: Co-Occurrence of Keywords in Publications on Socio-Economic Projections. Minimum number of occurrences of a keyword = 10. Node size corresponds to the number of occurrences of a keyword. Lines refer to connections between keywords. Distance between nodes corresponds to the tendency for keywords to be used together. Colors indicate the cluster to which an article belongs. Cluster 1 (red): health research. Cluster 2 (green): land use, ecology, biodiversity, and hydrology research. Cluster 3 (blue): climate policy, energy, emissions, and mitigation research. Cluster 4 (yellow): climate change impacts, adaptation, and vulnerability research. Illustration produced using VOSviewer software.

Figure 5 shows that socio-economic projections have primarily been applied in climate change and health research. Climate change research appears to use socio-economic projections in biodiversity and land use management research, climate policy and energy research, and impacts, adaptation, and vulnerability research. Health research appears to focus on risk, stress, and poverty in studies using socio-economic projections.

3.2.2 Socio-economic projections in climate change research and practice

Over the past few decades, scenario analysis has become a critical tool in climate change research and has been key to informing climate change adaptation and mitigation planning. Scenarios provide researchers and practitioners with the means to assess the long term impacts of planning and policy decisions taken today and help to envision multiple potential futures in the face of uncertainty (Riahi et al., 2017). Scenarios can be used for climate change risk and impact assessments and are useful for better understanding the impacts of climate change on both human and natural systems across a wide range of spatial and temporal scales (Riahi et al., 2017; van Ruijven et al., 2014).

While early climate change studies primarily used scenarios to explore physical systems and emissions projections, it has more recently been acknowledged that there is a need to integrate human dimensions of global change into climate change scenarios (Landreau et al., 2021; van Ruijven et al., 2014). Future risk will depend heavily on the evolution of social, economic, and technological systems in the face of a rapidly changing climate (van Ruijven et al., 2014). Socio-economic projections can help to better understand future exposure and vulnerability to climate change related hazards by providing scenarios of multiple potential futures based on indicators such as population, economic growth, and education levels (Landreau et al., 2021). In combination with emissions scenarios, socio-economic projections can help to identify suitable adaptation and mitigation alternatives that respond not only to physical climate futures but also to projected social and economic trends.

3.2.2.1 Global socio-economic projections

Several iterations of global socio-economic projections have been produced within the climate change research arena over the past several decades. The Special Report on Emissions Scenarios (SRES) published by the IPCC in 2000 contains early socio-economic projections in the form of the SRES scenarios consisting of four scenario families that incorporate assumptions about future socio-economic development trends in order to model potential emissions futures (Arnell et al., 2004).

In recent years, the SRES scenarios have become outdated due to major socio-economic development changes that have occurred over the beginning of the 21st century (Hausfather, 2018). In response, the shared socio-economic pathways (SSPs) were developed by an international team of researchers and initially published in 2016 (IIASA, 2018). These socio-economic scenarios are currently being used alongside radiative forcing scenarios (RCPs) in CMIP6 modeling efforts and inform the climate modeling to be presented in the IPCC's Sixth Assessment Report (AR6) (IIASA, 2018).

Together, the SSPs and RCPs form a new framework (see Figure 6 below) that utilizes a matrix architecture to facilitate integrated assessment of climate change impact and vulnerability as well as adaptation and mitigation pathways (IIASA, 2018; van Vuuren et al., 2014).

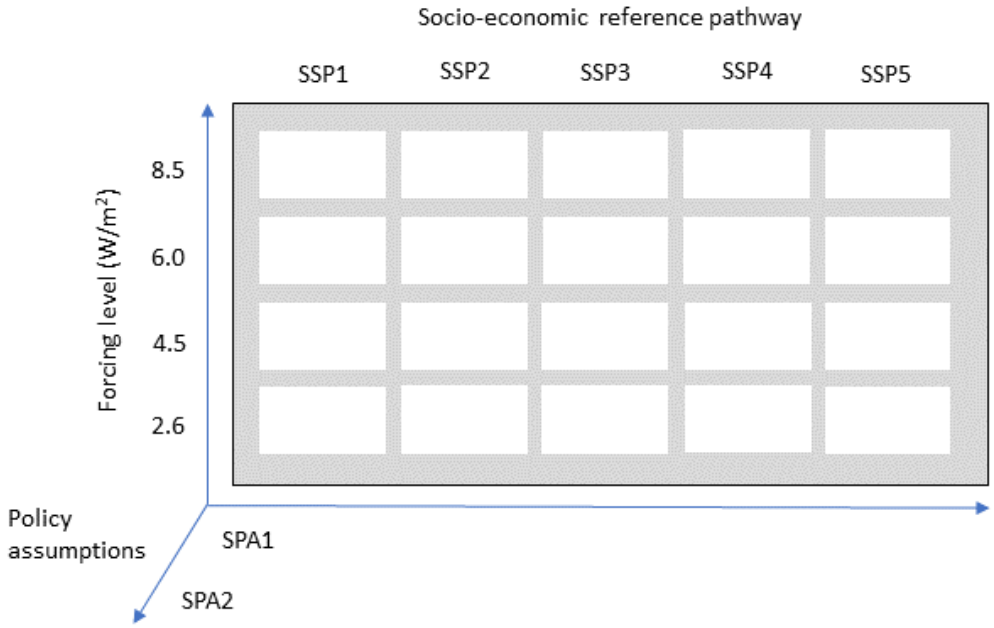

Figure 6: The SSP/RCP/SPA Matrix. Reproduced from van Vuuren et al. (2014)

In this matrix, radiative forcing (RCPs) occupies one axis while SSPs occupy another. The separation of radiative forcing scenarios and socio-economic scenarios differs from the previous SRES scenarios by allowing for the combination of potential socio-economic pathways with different forcing levels to form integrated future scenarios. As the SSPs do not consider future climate policy, shared policy assumptions (SPAs) can be added to the matrix as a third axis in order to predict climate futures under different socio-economic conditions and taking into account various future climate policy environments (van Vuuren et al., 2014).

Within this new framework for climate research, the SSPs describe narratives of very different future socio-economic development pathways for the 21st century based on future projected population, education, urbanization, and economic development (GDP) (Riahi et al., 2017). Five SSP narratives have been developed and are intended to showcase how future socio-economic developments might take shape in the absence of any new climate policy (Riahi et al., 2017).

The five SSP scenarios are presented both as qualitative narratives and quantitative model inputs. Narratives provide a description of potential socio-economic futures in terms of overarching societal trends and are useful in supporting quantitative model inputs as they demonstrate the major causal relationships assumed under each scenario and furthermore describe societal trends that are challenging to capture in numerical model inputs (Riahi et al., 2017). A summary of the SSP narratives is shown in Table 2 below.

Table 2: Summary of the SSP Narratives. Reproduced from Riahi et al. (2017).

SSP1	Sustainability - Taking the Green Road (Low challenges to mitigation and adaptation) *The world shifts gradually, but pervasively, toward a more sustainable path, emphasizing more inclusive development that respects perceived environmental boundaries. Management of the global commons slowly improves, educational and health investments accelerate the demographic transition, and the emphasis on economic growth shifts toward a broader emphasis on human well-being. Driven by an increasing commitment to achieving development goals, inequality is reduced both across and within countries. Consumption is oriented toward low material growth and lower resource and energy intensity.*
SSP2	Middle of the Road (Medium challenges to mitigation and adaptation) *The world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work toward but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Income inequality persists or improves only slowly and challenges to reducing vulnerability to societal and environmental changes remain.*
SSP3	Regional Rivalry - A Rocky Road (High challenges to mitigation and adaptation) *A resurgent nationalism, concerns about competitiveness and security, and regional conflicts push countries to increasingly focus on domestic or, at most, regional issues. Policies shift over time to become increasingly oriented toward national and regional security issues. Countries focus on achieving energy and food security goals within their own regions at the expense of broader-based development. Investments in education and technological development decline. Economic development is slow, consumption is material-intensive, and inequalities persist or worsen over time. Population growth is low in industrialized and high in developing countries. A low international priority for addressing environmental concerns leads to strong environmental degradation in some regions.*
SSP4	Inequality - A Road Divided (Low challenges to mitigation, high challenges to adaptation) *Highly unequal investments in human capital, combined with increasing disparities in economic opportunity and political power, lead to increasing inequalities and stratification both across and within countries. Over time, a gap widens between an internationally-connected society that contributes to knowledge- and capital-intensive sectors of the economy, and a fragmented collection of lower-income, poorly educated societies that work in a labor intensive, low-tech economy. Social cohesion degrades and conflict and unrest become increasingly common. Technology development is high in the high-tech economy and sectors. Environmental policies focus on local issues around middle and high income areas.*
SSP5	Fossil-fueled Development - Taking the Highway (High challenges to mitigation, low challenges to adaptation) *This world places increasing faith in competitive markets, innovation and participatory societies to produce rapid technological progress and development of human capital as the path to sustainable development. Global markets are increasingly integrated. There are also strong investments in health, education, and institutions to enhance human and social capital. At the same time, the push for economic and social development is coupled with the exploitation of abundant fossil fuel resources and the adoption of resource and energy intensive lifestyles around the world. All these factors lead to rapid growth of the global economy, while global population peaks and declines in the 21st century. Local environmental problems like air pollution are successfully managed. There is faith in the ability to effectively manage social and ecological systems, including by geo-engineering if necessary.*

Following the creation of these narratives, the SSPs have been quantified on a global, regional, and national scale (IIASA, 2018).

3.2.2.2 Local socio-economic projections

In addition to the global and national use of socio-economic projections based on SSPs, socio-economic scenario analysis is increasingly being used in country, city, or sector specific studies on climate change adaptation (van Ruijven et al., 2014). Scenarios used at these finer scales are either downscaled from

global projections such as the SSPs or are created through bottom-up approaches that focus on a specific local context (Birkmann et al., 2020, 2021; van Ruijven et al., 2014).

3.3 Conceptions of justice in urban climate change adaptation

Until recently, the challenge of climate change has been addressed primarily from a technical and scientific perspective (Granberg & Glover, 2021). However, it is increasingly being acknowledged that equity and justice are key considerations when planning for climate change due to the institutionalized reality of differential vulnerability to the impacts of the climate crisis (Granberg & Glover, 2021; Hughes, 2020; Thomas & Warner, 2019).

The question of equity first became relevant to the climate change debate when it was acknowledged that countries that have historically contributed the least to global greenhouse gas emissions are expected to be most severely impacted by climate change in the future (Reckien, Lwasa, et al., 2018). While the initial focus on equity surrounding climate change was on mitigation, it has been recognized that issues of justice are central to adaptation as well because it is on local scales where the unequal impacts of climate change will be felt and where differing adaptation needs will be present (Reckien, Lwasa, et al., 2018). Justice considerations are critical in relation to both adaptation and mitigation; however, this research is limited to a focus on justice in relation to adaptation. There is an urgent need to understand adaptation as a complex socio-political process embedded in questions of power rather than simply a technical fix or physical protection from the impacts of climate change (Gonda, 2019). Such an understanding of the inherent importance of equity and justice in adaptation planning is key to avoid maladaptation wherein interventions may benefit certain groups while disadvantaging those most vulnerable (Thomas & Warner, 2019).

The shift towards a justice centered view of climate change adaptation has been associated with a number of different theories and conceptual frameworks surrounding issues of equity. Urban justice and environmental justice can be understood as key founding concepts that have eventually led to the popularization of the term climate justice as well as the associated concepts of just urban transitions and the right to the city.

3.3.1 Urban and environmental justice

Cities and urban areas have historically been spaces of exacerbated inequity and social (Hughes & Hoffmann, 2020). Urban justice is a conceptual response to this trend that frames justice in the city in relation to equity, diversity, and democracy (Granberg & Glover, 2021; Steele et al., 2012). The concept of the just city has contemporary roots in the urbanization processes associated with the industrial revolution, however the central tenets of urban justice theory can be traced back further to the roots of various philosophical traditions (Granberg & Glover, 2021). Just city literature focuses primarily on social justice and does not generally include consideration of natural or non-human actors in urban environments (Steele et al., 2012).

The concept of environmental justice goes beyond the social justice sphere to incorporate socio-environmental challenges (Steele et al., 2012). Environmental justice seeks to shield all people from the impacts of environmental hazards and ensure healthy environments for all by addressing any issues that disproportionately expose vulnerable groups to environmental burdens (Hughes & Hoffmann, 2020; Reckien, Lwasa, et al., 2018). Environmental justice deals primarily with distributive justice as it centers around ensuring equitable allocations of resources and fair distribution of environmental burdens (Hughes, 2020; Hughes & Hoffmann, 2020). The concept of environmental justice gained popularity during the 1980s when community protests in the US brought attention to the inequitable environmental burdens being faced by minority communities (Hughes & Hoffmann, 2020). More recently, the notion of environmental justice has been expanded through the concept of ecological justice which focuses not only on healthy environments for humans but recognizes the rights of plants and animals to an urban existence free from harm (Steele et al., 2012).

3.3.2 Climate justice and climate just cities

The notion of climate justice is heavily influenced by environmental justice (Hughes & Hoffmann, 2020) and can be understood as a subset of environmental justice scholarship that deals specifically with environmental burdens associated with climate change. Climate justice theory centers around the acknowledgement that responsibility for climate change and vulnerability to its impacts are unequally distributed at a global scale (Bulkeley et al., 2013), but has also been used to understand more local questions of equity and justice in relation to climate change impacts (Hughes & Hoffmann, 2020; Rudge, 2021).

Climate justice measures equity along three dimensions: distributive justice, procedural justice, and recognition as justice (Hughes, 2020; Jurjonas et al., 2020; Swanson, 2021). Distributive justice focuses on physical distribution of resources and ensures that environmental burdens are experienced equally by all groups. Procedural justice ensures that vulnerable groups have a broad and meaningful voice in the entire adaptation process, from framing of problems to implementation of solutions. Finally, justice as recognition acknowledges the structural inequity present in society and aims to enact actions that reverse existing structural injustices by considering questions surrounding whose voices and needs are visible or invisible in decision making contexts (Hughes, 2020; Swanson, 2021).

On an urban scale, the climate just city perspective asks questions surrounding participation, social costs of adaptation, and the ability of groups within the city to influence policy and planning (Granberg & Glover, 2021). The climate just city concept criticizes the apolitical tendencies of adaptation scholarship and asserts that broad stakeholder collaboration and a shift away from short term, economic and technocratic planning and policy paradigms will be critical to realizing climate just cities (Granberg & Glover, 2021). Understanding climate justice in an urban context requires paying close attention to issues of recognition by investigating how climate change adaptation solutions interact with and impact existing structural inequity in the city (Hughes & Hoffmann, 2020).

Within the context of urban climate change adaptation, distributive justice, procedural justice, and justice as recognition take on more specific meanings than described above. Distributive justice relates to

securing equitable allocation of both the benefits and drawbacks of adaptation solutions for urban populations irrespective of their socio-economic status or adaptive capacity (Mohtat & Khirfan, 2021).

Achieving procedural justice requires the holistic consideration of the needs and priorities of different social groups in decision making processes surrounding adaptation planning (Mohtat & Khirfan, 2021). Arnstein's 'ladder of citizen participation' concept (Arnstein, 2019) provides a useful illustration of how procedural justice can take place in planning (see Figure 7 below).

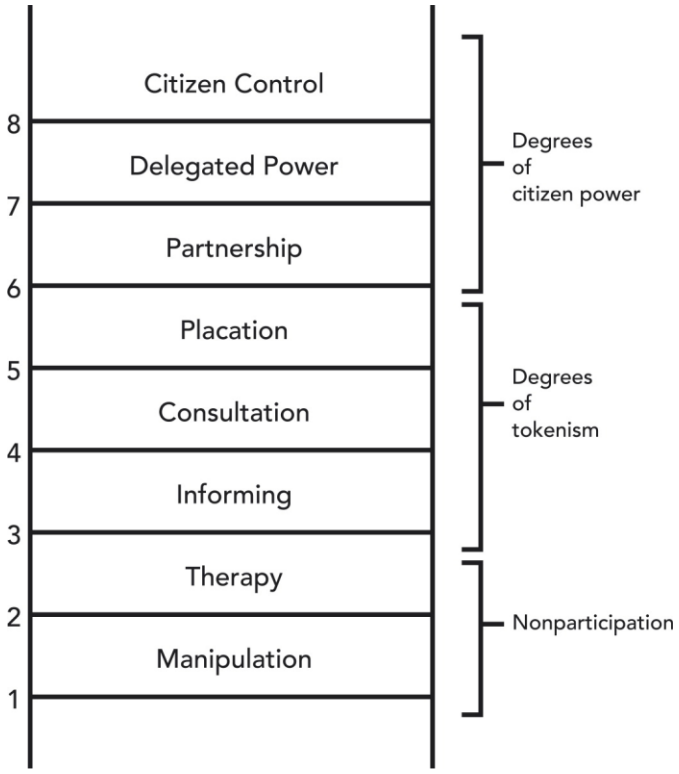

Figure 7: Arnstein's Ladder of Citizen Participation in Planning. Source: Arnstein (2019)

The lower rungs of the ladder represent non participatory planning processes that foster procedural injustice by viewing planning as a top-down activity to be imposed on citizens without their input or participation while the higher rungs represent a state in which citizens are deeply engaged in planning and hold the power to shape planning outcomes, thus promoting procedural justice (Arnstein, 2019).

Finally, ensuring recognitional justice requires identifying any historical processes that have led to locally specific narratives of inequity and developing adaptation responses that explicitly aim to eradicate such structural injustices within urban spaces (Mohtat & Khirfan, 2021). This includes the need to implement policies that not only ensure equality, but explicitly prioritize the needs of those most vulnerable (Bulkeley et al., 2013).

The issue of justice in urban climate change adaptation has recently been framed in terms of climate urbanism and just adaptation. Climate urbanism promotes cities as the most appropriate sites for responding to climate change but recognizes that urban climate action has potentially problematic impacts in terms of equity and justice given today's neoliberal environment (Long & Rice, 2018). Recent scholarship on climate urbanism has pointed to the structural injustice that is often embedded in urban climate action interventions and explored how urban responses to climate change reshape not only the urban environment but also urban life, potentially giving rise to increased inequalities in cities (Bulkeley, 2021; Castán Broto & Robin, 2020). Similarly, just adaptation research investigates how the implementation of adaptation policy impacts vulnerable groups (Malloy & Ashcraft, 2020). Just adaptation echoes the sentiments of distributive, procedural, and recognitional justice and emphasizes the importance of meaningful participation and full agency of vulnerable groups in decision making. Just adaptation also points to the importance of explicitly considering systemic injustice and its causes in adaptation policy making and further highlights the importance of evaluation of adaptation planning and policy in order to advance justice (Malloy & Ashcraft, 2020).

It has further been acknowledged within the context of feminist, post-colonial, and abolitionist scholarship that when working with the concept of urban climate justice in relation to adaptation, it is key to consider intersectionality, meaning that "climate justice is not just about the climate" (Ranganathan & Bratman, 2021, p.132). Discussions of climate justice need to be linked to other social, political, and economic challenges facing urban dwellers and the question of social justice should not be seen as an afterthought in climate action but rather as a key, integrated challenge (Ranganathan & Bratman, 2021; Westman & Castán Broto, 2021).

3.3.3 Just urban transitions and the right to the city

Within the context of urban climate change adaptation, the concepts of just urban transitions and the right to the city are also relevant for looking beyond static conceptions of justice to investigate how justice operates in relation to processes of change.

Notions of just transitions stem from the labor movement but have recently come to be associated with conversations surrounding environmental and climate justice (Heffron, 2021; Hughes & Hoffmann, 2020). Just transitions are defined as equitable transitions to sustainable, post-carbon societies (Hughes & Hoffmann, 2020). The concept of just transitions provides an important shift towards a dynamic and change-oriented conception of justice in urban adaptation processes (Hughes & Hoffmann, 2020). Just urban transition scholarship also makes an important addition to environmental and climate justice theory in that it focuses on restorative justice which centers around remedying environmental harm experienced by individuals or groups and bringing perpetrators of harm to justice (Hughes & Hoffmann, 2020).

This focus on change is closely echoed by the right to the city concept which argues for the collective right of urban communities to exercise power over processes of urbanization and urban change. This notion points out that individuals and groups should not only have the right to access existing urban spaces and services but should also be able to exercise their right to change the city according to their visions for the future (Granberg & Glover, 2021; Hughes & Hoffmann, 2020).

3.3.4 Framework for urban climate justice

Based on the theoretical underpinnings of justice and equity in the context of urban climate change adaptation described, the following conceptual framework is used to understand urban climate justice in this study (see Figure 8). This framework unites theory on urban and environmental justice, climate justice and climate just cities, climate urbanism, just adaptation, just urban transitions, and the right to the city to define urban climate justice in the context of adaptation planning and policy.

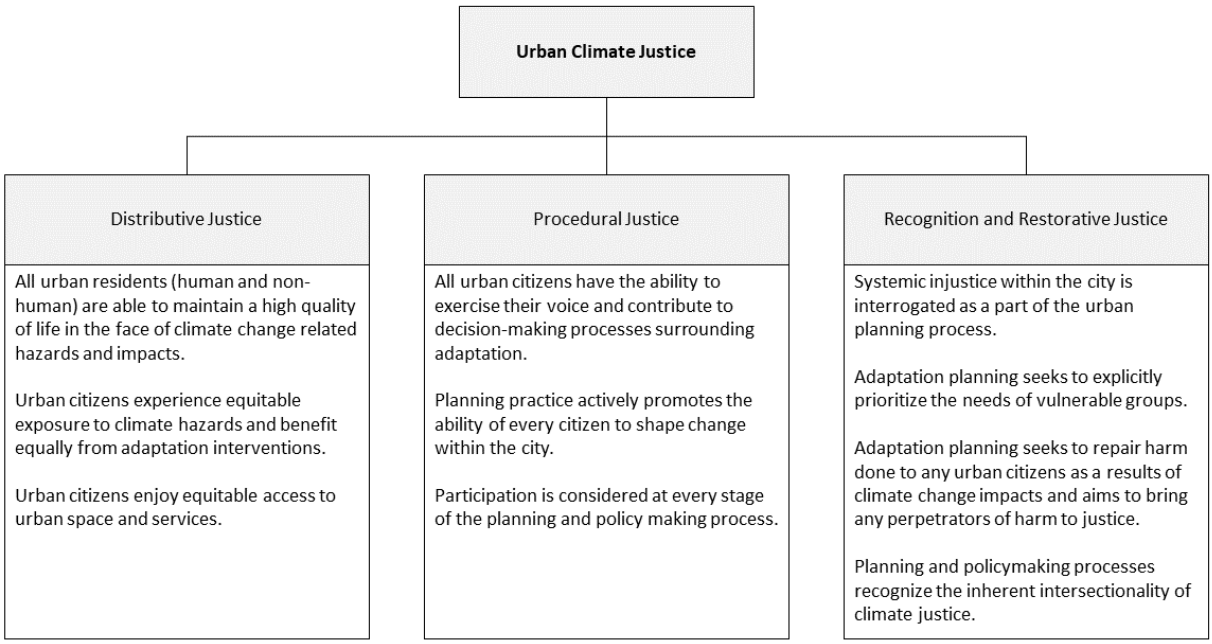

Figure 8: Urban Climate Justice Framework. Framework developed based on literature referenced in sections 3.3.1-3.3.3.

4. Methodological Framework

The following chapter describes the methodological framework of the research. First, the ontological and epistemological assumptions of the research are outlined. Second, the data collection and analysis methods used in the systematic review and policy analysis are described.

4.1 Theories of Science

An investigation of the intersection between urban climate change adaptation, socio-economic projections, and climate justice is inherently interdisciplinary and therefore draws on multiple ways of knowing and diverse ontological and epistemological perspectives. While socio-economic projections may often be viewed as a largely scientific, positivist domain; the hypothesis that such projections can be used as a tool to promote justice expands this narrow view of socio-economic projections. This research seeks to discover whether socio-economic scenarios can be redefined as tools to acknowledge diverse ways of knowing and understandings of the world, thus adopting a much more interpretivist worldview.

Therefore, this research is neither positivist nor interpretivist alone but instead sits somewhere along the spectrum between these two opposing paradigms. This approach shares similarities with much of modern planning research which does not subscribe to a single paradigm but instead seeks to merge scientific and value driven knowledge to answer complex and transdisciplinary research questions (Farthing, 2016).

4.2 Methods

This section describes the methods of data collection and analysis used in the research. First, the methods for conducting a systematic review are presented. Second, the methods of policy analysis are described.

4.2.1 Systematic review methods

A systematic review refers to a focused method of literature synthesis that utilizes rigorous, comprehensive, and transparent processes to ensure reproducibility and objectivity (Berrang-Ford et al., 2015; Grant & Booth, 2009; Haddaway et al., 2020). Systematic reviews attempt to avoid the potential for bias and inaccuracy that has often been associated with traditional literature review methods (Haddaway et al., 2020) and thus can be a useful approach for studying adaptation due to the widely recognized need to apply standardized and rigorous synthesis methods in adaptation research (Berrang-Ford et al., 2015).

Berrang-Ford et al. (2015) argue that systematic review approaches provide an opportunity to strengthen rigor and transparency in synthesis of adaptation research and propose a step by step process for conducting systematic reviews within the climate change adaptation field (see Table 3 below).

Table 3: Proposed Steps for Conducting a Systematic Review. Adapted from Berrang-Ford et al. (2015).

Define research question/aim	Explicit aims and objectives of review
	Clear description of theoretical or conceptual approach used to guide the review
Data source and document selection	Justification and description of literature source
	Articulation of search terms and/or detailed description of search process
	Description of criteria for inclusion/exclusion
	Documentation of literature included/excluded
Analysis and presentation of results	Description of methods for analysis
	Critical appraisal of information quality

This study takes inspiration from the methodology proposed by Berrang-Ford et al. (2015) to answer the question: *how can socio-economic projections be used in urban climate change adaptation planning and to what extent are socio-economic projections useful as a tool for supporting climate justice?* It is important to note that the systematic review conducted here is guided by the theoretical and analytical framework of the research described in Chapter 3 and is in particular framed by the urban climate justice framework presented in Section 3.3.4.

The literature search and selection process used in this review is visualized in Figure 9 below.

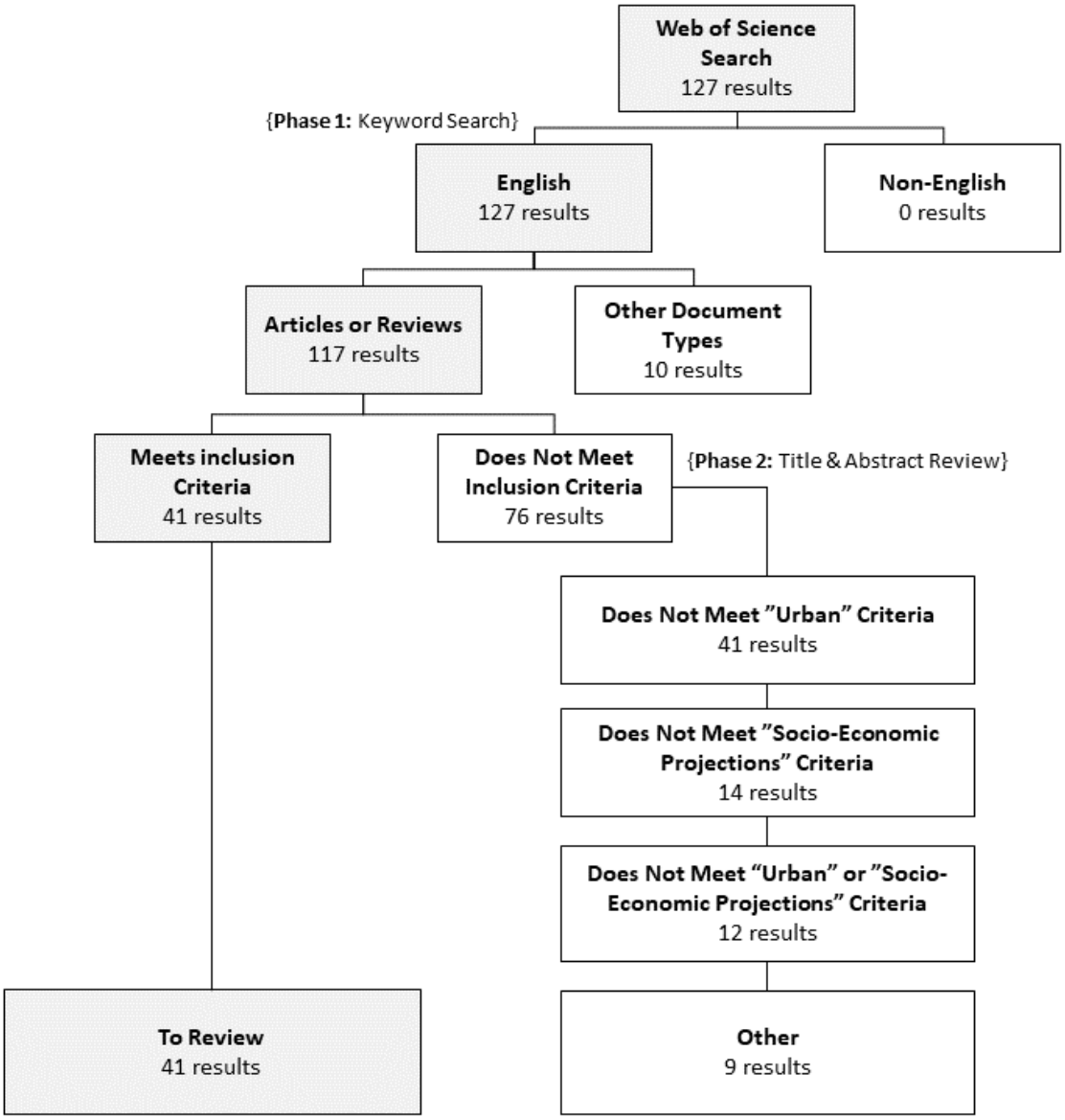

Figure 9: Literature Search and Selection Process

The literature search is conducted in the Web of Science Core Collection and is limited to results in English as well as to articles or reviews. All other document types are excluded from the analysis. No temporal range or geographical delimitation is specified in the search process.

Search terms are selected on the basis of the research objective. In this case, "urban", "climate change", "adaptation", "socio-economic projections", and "justice" are considered key terms. An iterative process is applied to test different search strings using these key terms as well as synonyms and related terms. During this process, it is found that including terms related to justice and equity in search strings produces irrelevant results due to the lack of literature currently linking justice issues to both urban climate change adaptation and socio-economic projections. Therefore, the choice is made to exclude justice from the final search string and instead analyze the selected literature through the lens of the urban climate justice

framework presented in Section 3.3.4 in order to assess the extent to which socio-economic projections can be used as a tool to support climate justice in urban adaptation planning. While refining the search string, searches including the term “assessment” as well as those including “social” and “economic” were tested with the intent of broadening the results; however, it was ultimately concluded that the inclusion of these terms led to a large number of irrelevant results and they were consequently excluded. In light of these considerations, the following final search string was developed:

> (urban* OR “cities” OR “city” OR “municipal”) AND climat* AND adapt* AND (“socioeconomic” OR “socio-economic”) AND (“projection” OR “scenario” OR “pathway”)

This search was conducted in the Web of Science Core Collection on February 28th, 2022 and produced 127 results. In the first stage of literature selection, results were filtered for inclusion based on language (English) and document type (article or review), thus limiting the material considered to 117 results. In the second stage of literature selection, results were selected for inclusion based on four inclusion criteria:

1. Article is urban scale or discusses urban issues
2. Article focuses on climate change
3. Article focuses on adaptation
4. Article discusses or applies socio-economic projections or scenarios

In order to identify results in line with these criteria, a review of article titles and abstracts was performed. Full text review was conducted when necessary. Following this review, 41 results were selected for inclusion while 76 results were excluded. The majority of excluded results failed to meet the inclusion criteria due to their lack of urban focus or failure to consider socio-economic projections. For a complete list of included and excluded literature, see Appendix A.

Prior to data analysis, a critical appraisal was conducted to assess study quality of the included publications. In this research, study quality is assumed to correlate with total citations and average citations with the assumption that more citations indicates higher impact and relevance thus translating to higher quality research. No studies were excluded from the systematic review based on the critical appraisal process, however the critical appraisal should be kept in mind when interpreting results. A complete ranking of publications based on total citations and average citations can be found in Appendix B.

Following the final literature selection and critical appraisal, results were analyzed using bibliometric analysis and thematic analysis. Bibliometric analysis is a rigorous method for tracking the evolution and emergence of research areas as well as identifying key connections within academic fields (Donthu et al., 2021). This study makes use of both performance analysis which constitutes a descriptive analysis of research contributions (i.e. date of publication, authors, disciplines) and science mapping which assesses relationships between publications on the basis of keyword co-occurrence or co-citation mapping among other methods (Donthu et al., 2021). Science mapping is conducted using VOSviewer software (VOSviewer, 2022).

In addition to bibliometric analysis, thematic analysis is conducted to identify key themes in the literature. Thematic analysis is a method of data synthesis that is helpful for identifying and reporting key patterns in qualitative data (Vaismoradi et al., 2013). The thematic analysis conducted here considers both manifest and latent content emerging from the literature, with a primary focus on latent content. Results from the literature are grouped into six themes: justifications for using socio-economic projections in urban climate change adaptation, types of socio-economic projections and methods for scenario development, use of socio-economic projections throughout the adaptation planning process, challenges and limitations of using socio-economic projections in urban adaptation planning, recommendations for future use of socio-economic projections in urban adaptation planning, and socio-economic projections as a tool to support urban climate justice.

4.2.2 Policy analysis methods

Following the systematic review of socio-economic projections in urban adaptation planning, policy analysis is conducted to investigate the question: *how are socio-economic projections currently being considered in urban climate change adaptation policy and to what extent is the inclusion of socio-economic projections in policy motivated by climate justice concerns?*

The policy analysis takes point of departure in an existing global assessment of adaptation related policies affecting the largest coastal port cities (> 1 million inhabitants) worldwide (Olazabal, Ruiz De Gopegui et al., 2019). Olazabal, Ruiz De Gopegui et al. (2019) analyze 226 adaptation related policies at the national, regional, metropolitan, and urban scale. As this research focuses exclusively on urban adaptation, only the 81 urban and metropolitan policies analyzed are considered here. Of the 81 urban and metropolitan policies reviewed, Olazabal, Ruiz De Gopegui et al. (2019) identify 22 policies from 18 cities that take into account or develop specific socio-economic projections. These policies are listed in Table 4 below.

Table 4: Urban Adaptation Related Policies Considering Socio-Economic Projections. Policies identified by Olazabal, Ruiz De Gopegui et al. (2019) as considering socio-economic projections.

Policy name	City	Country	Policy scale
Dakar Resilience Strategy	Dakar	Senegal	City
Rotterdam Climate Change Adaptation Strategy	Rotterdam	Netherlands	Metropolitan
The City of London Climate Change Adaptation Strategy	London	United Kingdom	City
Plano de Ação Vitória Sustentável	Grande Vitória	Brazil	City
Climate Change Adaptation Strategy for the City of Rio de Janeiro	Rio de Janeiro	Brazil	City
Plan Estratégico Distrital (PED)	Panama City	Panama	Metropolitan
Plan de Acción "Panamá Ciudad Sostenible"	Panama City	Panama	City
City of Virginia Beach Comprehensive Plan	Virginia Beach	United States of America	City
New Orleans Master Plan	New Orleans	United States of America	City
Resilient San Francisco	San Francisco	United States of America	City
Seattle Climate Preparedness Strategy	Seattle	United States of America	City
National Capital Region Climate Change Report	Washington DC	United States of America	Metropolitan
Growing Stronger: Toward a Climate Ready Philadelphia	Philadelphia	United States of America	City
OneNYC	New York City	United States of America	City
NYC Hazard Mitigation Plan	New York City	United States of America	City
The Fourth Regional Plan	New York City	United States of America	Metropolitan
City of Melbourne Climate Change Adaptation Strategy	Melbourne	Australia	Metropolitan
City of Melbourne Climate Change Adaptation Strategy REFRESH	Melbourne	Australia	Metropolitan
Surat Resilience Strategy	Surat	India	City
Davao City Climate Change Action Plan (LCCAP)	Davao	Philippines	City
100 Resilient: Resilient Bangkok Strategy	Bangkok	Thailand	Metropolitan
Auckland Plan 2050	Auckland	New Zealand	Metropolitan

An initial screening of these policies was conducted to determine the extent to which each policy considers socio-economic projections. The Rotterdam Climate Change Adaptation Strategy and the

Seattle Climate Preparedness Strategy do not provide sufficient explanation of their application of socio-economic projections and are therefore excluded from the analysis (City of Rotterdam, 2013; Seattle Office of Sustainability & Environment, 2017). Therefore, this research focuses on the remaining 20 policies affecting 16 global cities.

In order to assess how these policies consider socio-economic projections, each policy is categorized according to the type of scenario development method it uses, the stage of the adaptation planning process at which socio-economic projections are applied, and whether the policy considers equity or justice issues. Policies are categorized in this way to mirror the categorization of literature from the systematic review, thus enabling easy comparison between how socio-economic projections are being applied in academic literature and how they are currently used in adaptation policy.

In order to perform this categorization, a structured search protocol of policy documents is conducted. Each policy document is searched for keywords related to socio-economics, population, demography, projections, scenarios, and justice or equity concerns. The specific search terms used as well as the data collected from each policy are detailed in Annex A. For non-English policies, original policy texts are searched using equivalent search terms in the original policy language. Data collected from this keyword search is then translated and recorded in English as seen in Annex A.

5. Results

This chapter presents the results of the research. First, the results of the systematic review are discussed. Second, the results of the policy analysis are presented.

5.1 Systematic review results

This section provides an overview of the results of the systematic review conducted in response to the question: *how can socio-economic projections be used in urban climate change adaptation planning and to what extent are socio-economic projections useful as a tool for supporting climate justice?*

5.1.1. Bibliometric analysis

Research on socio-economic projections in urban climate change adaptation first emerged in 2011 and has gained popularity over the past decade as seen in Figure 10 below. 12 of the 41 publications reviewed were published in 2021, indicating a very recent popularization of the research area.

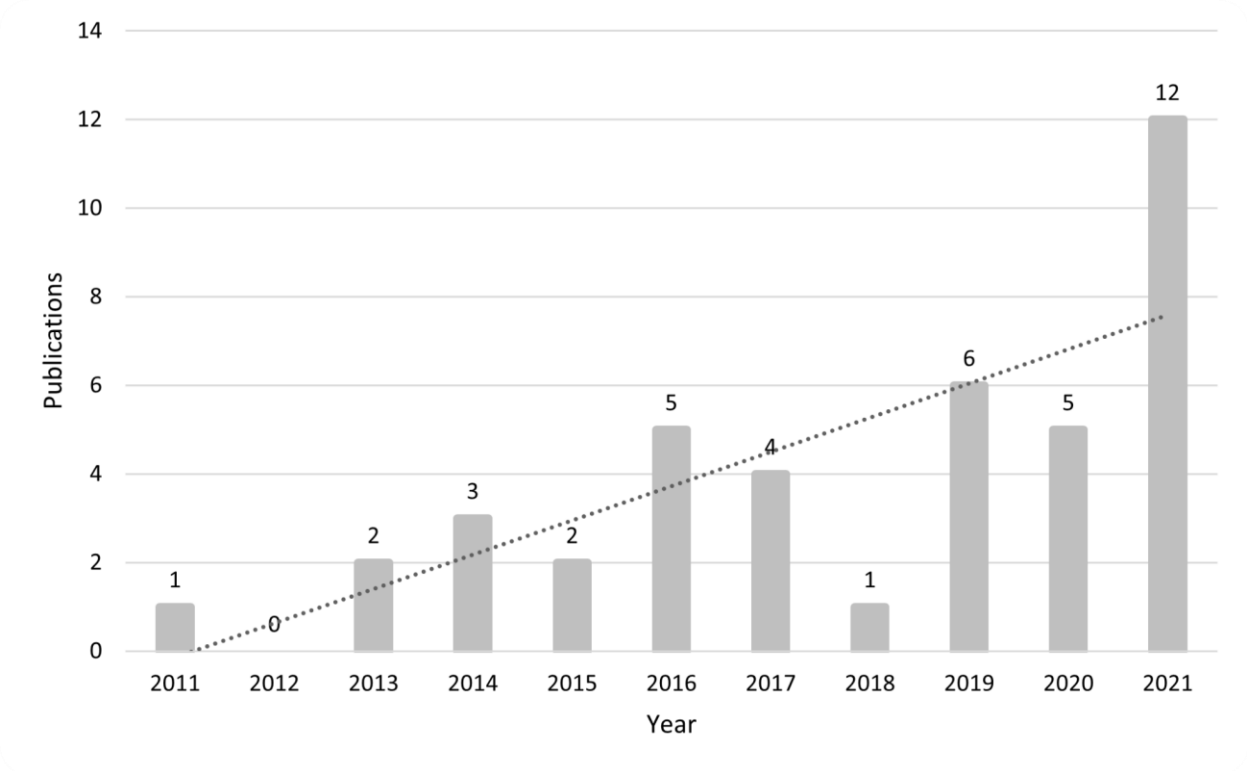

Figure 10: Evolution of Publications on Socio-Economic Projections and Urban Climate Change Adaptation

The majority of publications regarding socio-economic projections in urban climate change adaptation fall within the environmental sciences subject area according to Web of Science (WoS) categories. A large number of studies are also indexed as environmental studies, environmental engineering, and water resources. Figure 11 below shows the number of publications indexed in different WoS categories. Many publications are indexed under multiple subject areas. Therefore, Figure 11 shows the total number of

times each WoS category is indexed in the literature rather than the specific combined classification of each publication.

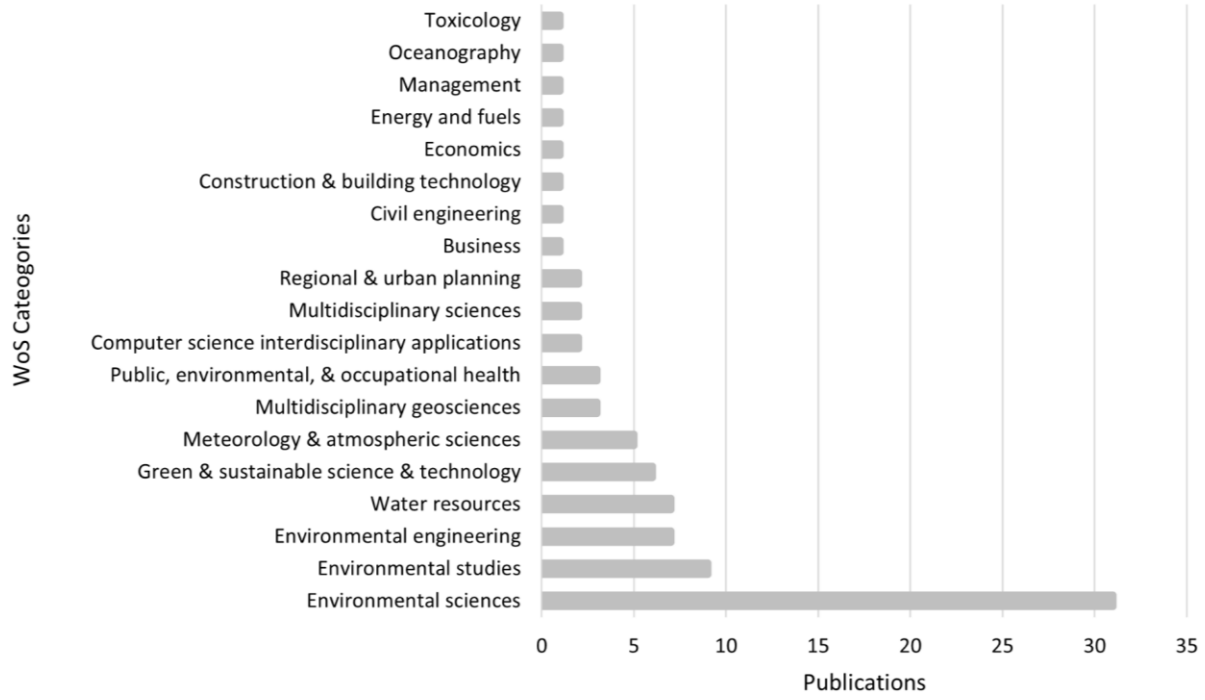

Figure 11: Disciplinary Origin of Publications. Web of Science Categories.

The publications on socio-economic projections in urban climate change adaptation focus on a number of different climate change hazards and impacts as shown in Figure 12 below. The majority of studies take a single hazard approach by focusing on heat, flooding, or urban water management. A small minority of studies take a multi-hazard approach or focus on a holistic analysis of future resilience in cities.

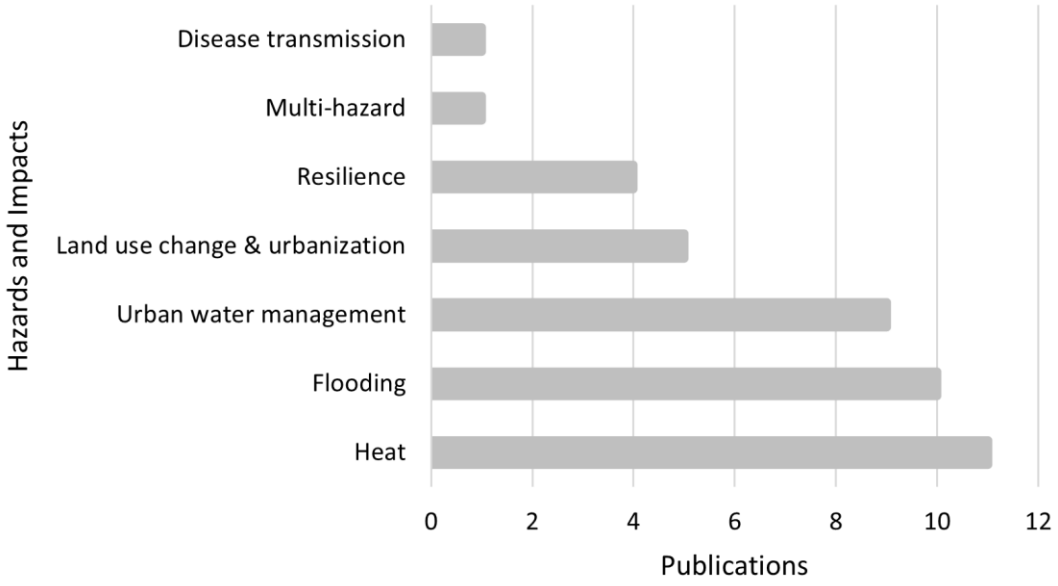

Figure 12: Climate Change Hazards and Impacts Studied in the Literature

The geographical coverage of the literature is primarily Asian and European, with a small number of studies conducting multi-region analysis. The specific geographic locations studied in the literature are shown in Figure 13 below.

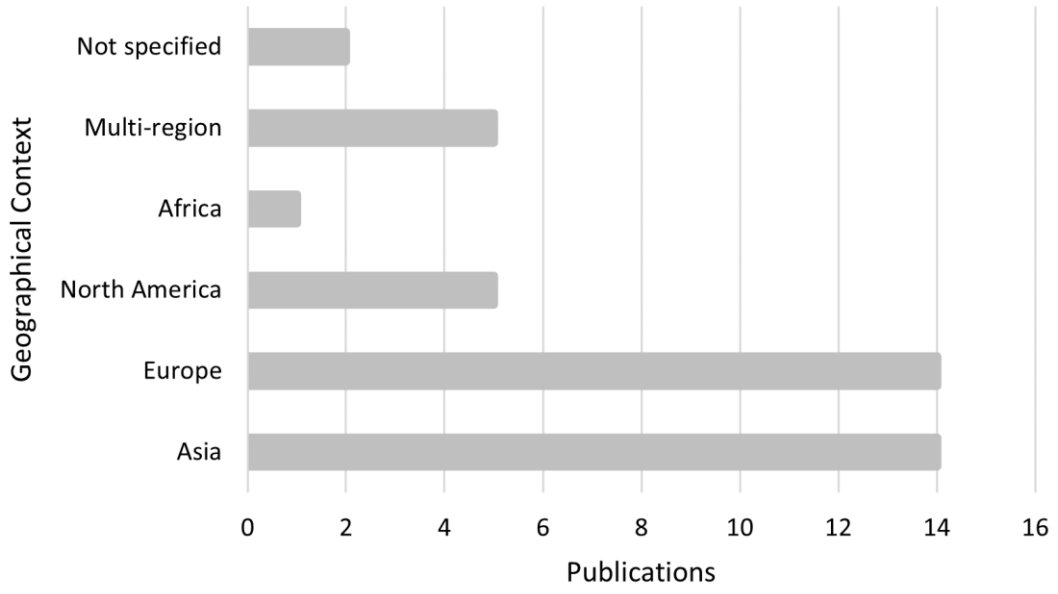

Figure 13: Geographical Locations Studied in the Literature

A co-occurrence analysis of keywords found in the literature on socio-economic projections in urban climate change adaptation planning provides further insight into the specific topics being addressed in

this research area. Figure 14 shows several clusters of keywords that appear in the literature. Cluster 1 (shown in red) focuses on climate change impacts, adaptive capacity and resilience while cluster 2 (shown in green) centers on adaptation in relation to heat stress and mortality. The third cluster (shown in blue) focuses on vulnerability, risk, uncertainty, and environmental change.

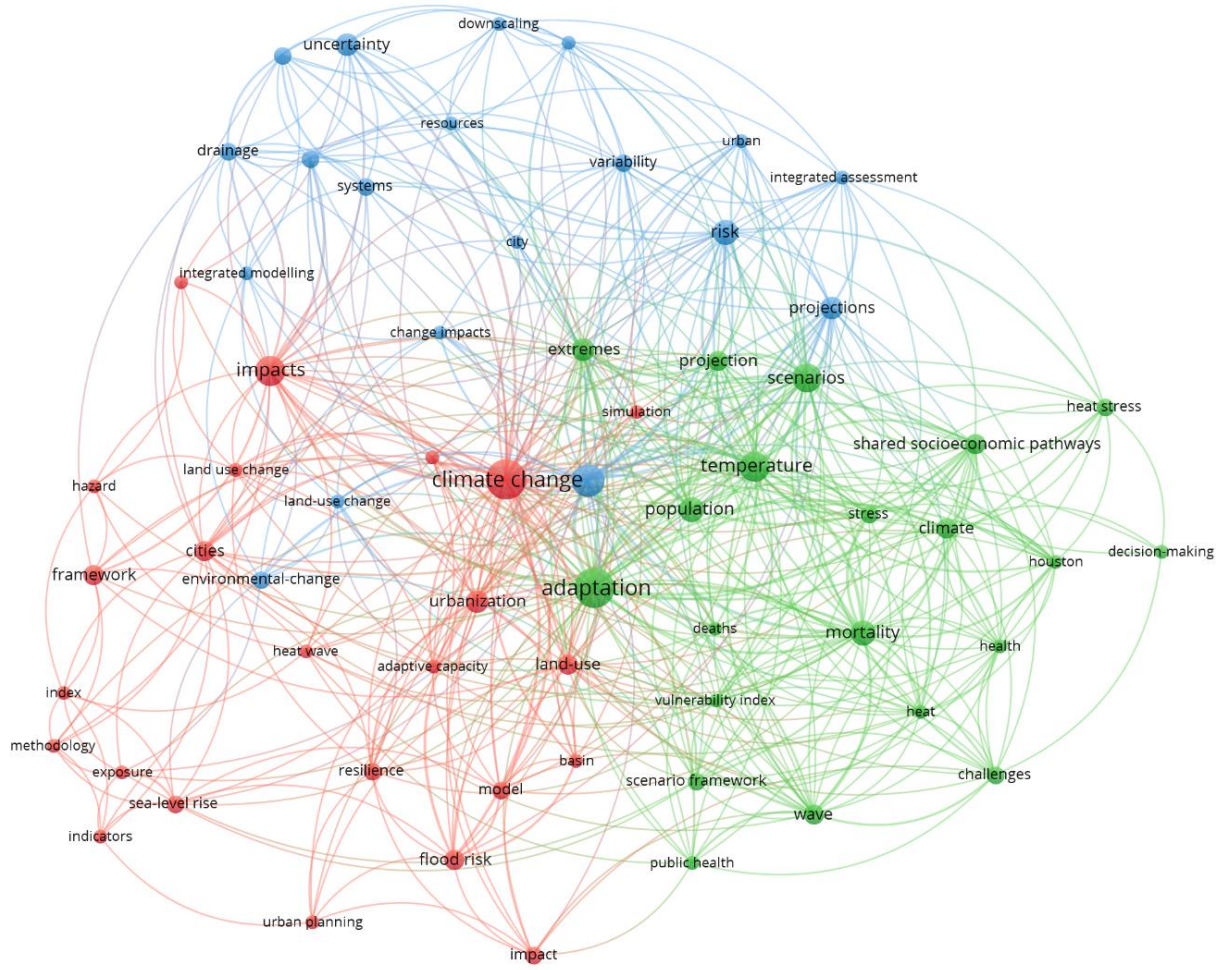

Figure 14: Co-Occurrence of Keywords in Publications on Socio-Economic Projections in Urban Climate Change Adaptation. Minimum number of occurrences of a keyword = 2. Node size corresponds to the number of occurrences of a keyword. Lines refer to connections between keywords. Distance between nodes corresponds to the tendency for keywords to be used together. Colors indicate the cluster to which an article belongs. Cluster 1 (red): climate change impacts, adaptive capacity, and resilience research. Cluster 2 (green): adaptation, temperature, heat stress, and mortality research. Cluster 3 (blue): vulnerability, risk, uncertainty, and environmental change research. Illustration produced using VOSviewer software.

In order to better understand the evolution of this research area, it is also interesting to conduct a co-citation analysis. Co-citation analysis maps shared references to show which articles are cited most often within a specific research area (Donthu et al., 2021; Meerow et al., 2016). Figure 15 below shows co-citation in publications on socio-economic projections in urban adaptation planning.

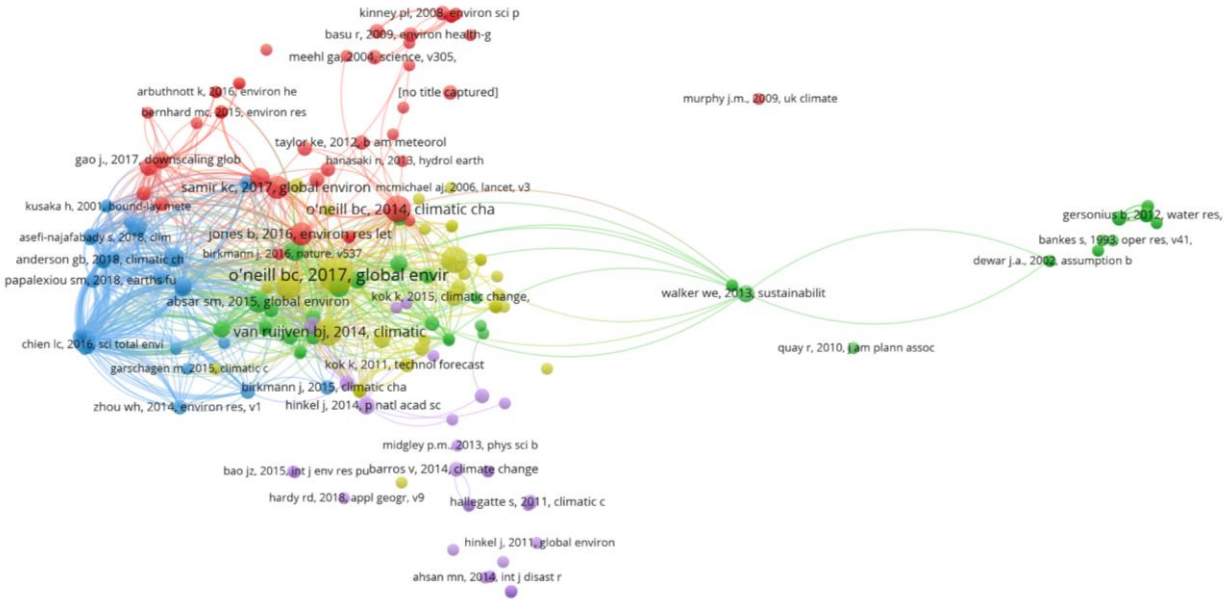

Figure 15: Co-Citation in Publications on Socio-Economic Projections in Urban Climate Change Adaptation. Minimum number of citations of a cited reference = 2. Node size corresponds to the number of citations. Lines refer to the existence of a citation in a given direction. Distance between nodes corresponds to the tendency for studies to be cited together in other literature. Colors indicate the cluster to which an article belongs. Topics associated with each cluster are not listed here, as the map simply intends to illustrate the most cited publications in the research area. Illustration produced using VOSviewer software.

Figure 15 shows that the most cited publication is O'Neill et al. (2017) (cited 16 times), a foundational paper explaining the SSP narratives and their development. Other influential publications include van Ruijven et al. (2014), Moss et al. (2010), and B. C. O'Neill et al. (2014) (cited 9-10 times respectively) which focus on how to use the SSPs in research on impacts, adaptation, and vulnerability as well as how to apply SSPs to specific adaptation and mitigation challenges. Also frequently cited are Samir & Lutz (2017) (cited 7 times) who develop demographic scenarios for 195 countries based on the SSP narratives and Jones & O'Neill (2016) (cited 7 times) who present a global set of spatial population scenarios consistent with the SSPs. The frequency of citations related to the SSPs demonstrates that the literature on socio-economic projections in urban adaptation planning draws heavily on these global scenarios to inform urban scenario applications.

5.1.2 Thematic analysis

This section presents the results of the thematic analysis. Results are grouped into six key themes: justifications for using socio-economic projections in urban climate change adaptation, types of socio-economic projections and methods of scenario development, use of socio-economic projections throughout the adaptation planning process, challenges and limitations of socio-economic projections, recommendations for further research on projections in urban adaptation planning, and socio-economic projections as a tool to promote urban climate justice.

5.1.2.1 Justifications for using socio-economic projections in urban climate change adaptation

It is widely regarded that despite future uncertainty, it is essential to make decisions on adaptation today. Scenario based approaches using socio-economic projections help to facilitate decision making on adaptation in the context of a highly uncertain future (Birkmann et al., 2020; Ciumasu, 2013; Huang et al., 2011; Reimann, Vollstedt, et al., 2021; Rohat et al., 2021; Rohat, Flacke, et al., 2019; Terama et al., 2019). Scenario analysis can help to illustrate potential alternative development pathways, visualize the long term impacts of planning decisions, aid in robust decision making, and promote strategic thinking in relation to urban adaptation planning and policy (Birkmann et al., 2020; Kamei et al., 2021; Rohat et al., 2021; Zhu et al., 2020).

The goal of scenario analysis is not to reduce future uncertainty but instead to better understand the range of possible futures in order to make informed decisions on urban adaptation today (Birkmann et al., 2021; Borris et al., 2016; Egger & Maurer, 2015; Huang et al., 2011). There is a growing consensus of the need for flexible, low regret adaptation options that meet current needs and can also succeed under a wide range of future climate and socio-economic development conditions (Casal-Campos et al., 2015; Li et al., 2017; Manocha & Babovic, 2017; Rohat et al., 2021).

It is especially critical to consider future socio-economic scenarios alongside climate projections to be able to better assess future vulnerability at an urban scale. So far, disaster risk reduction and urban climate change adaptation planning have disproportionately focused on future emissions projections and largely ignored future projections of vulnerability and adaptive capacity (Birkmann et al., 2020; Borris et al., 2016; Meyer et al., 2019; Parandvash & Chang, 2016; Peng & Li, 2021; Reimann, Vollstedt, et al., 2021). When socio-economic development pathways are considered in risk assessments, current socio-economic vulnerability data is often superimposed onto projections of future hazards to determine risk (Birkmann et al., 2020; Jurgilevich et al., 2021; Rohat, Wilhelmi, et al., 2019). Furthermore, the downscaling of climate projections to an urban scale is rarely accompanied by downscaling of future socio-economic data (Ciumasu, 2013).

The failure to consider socio-economic aspects in adaptation planning can lead to poor understanding of future socio-economic development and vulnerability, leading to inappropriate and ineffective adaptation interventions (Birkmann et al., 2020, 2021; Jurgilevich et al., 2021; Meyer et al., 2019; Xu et al., 2021). There is currently limited understanding of how socio-economic changes drive future climate vulnerability, particularly in relation to intersecting, indirect, and cascading effects of such change (Jurgilevich et al., 2021). It is especially critical to consider how future socio-economic development drives vulnerability in urban areas where socio-economic conditions are constantly and rapidly shifting (Rohat, Wilhelmi, et al., 2019). This points to an urgent need to utilize socio-economic scenarios at an urban scale in order to better assess local vulnerability to future climate change hazards and impacts (Birkmann et al., 2021).

The need to understand future socio-economic development scenarios is made even more urgent by recent findings that socio-economic development often has a significant impact on future climate change related risk. The impacts of climate change in the future will be driven not only by shifts in climate but

also by socio-economic development changes (Reimann, Jones, et al., 2021; Terama et al., 2019). This is true for a wide range of hazards including heat stress and coastal flood risk (Abadie, 2018; Birkmann et al., 2020; Borris et al., 2016; El-Fadel & Ghanimeh, 2013; Krummenauer et al., 2021; Park et al., 2021; Wolff et al., 2020). Some studies even find that future socio-economic variability contributes equally or more to future risk and impact than changes in climate. This has been found to be true for dangerous heat exposure, coastal risk, municipal water demand, and stormwater pollution (Borris et al., 2016; Parandvash & Chang, 2016; Parkinson et al., 2016; Rohat, Flacke, et al., 2019; Wolff et al., 2020). The importance of socio-economic development conditions in shaping future risk has important implications for adaptation planning and policy and points to the urgent need to explore different socio-economic scenarios in urban adaptation planning.

5.1.2.2 Types of socio-economic projections and methods for scenario development

Socio-economic scenario development and application generally follows two approaches: participatory scenario development or modeling-based scenario development.

Participatory scenario development

Participatory scenario development approaches are often undertaken in response to a lack of local data and are carried out with the intention of increasing the relevance of scenario development processes, promoting local ownership of adaptation solutions, and building trust among stakeholders (Birkmann et al., 2020; Li et al., 2017; Meyer et al., 2019; Rohat, Wilhelmi, et al., 2019). 13 of the studies analyzed use participatory scenario development approaches as shown in Table 5 below.

Table 5: Literature Using Participatory Scenario Development. Some literature uses multiple methods of scenario development and is therefore categorized more than once. See Appendix C for full categorization of literature.

Type	Methods (#)	Use of SSPs/SRES (#)	Scenario Output (#)	Sources (#)
Participatory scenario development	Stakeholder workshop (8)	Yes (5) No (3)	Qualitative (8) Quantitative (5) Spatial (2)	(8)
	Stakeholder consultation/questionnaire (6)	Yes (2) No (4)	Qualitative (2) Quantitative (4) Spatial (3)	(6)
	Participatory mapping (1)	Yes (0) No (1)	Qualitative (1) Quantitative (1) Spatial (1)	(1)

Stakeholder participation is embedded in socio-economic scenario development methodologies in different ways. Some approaches emphasize co-creation and co-production of knowledge and strive to include stakeholders throughout the entire process (Meyer et al., 2019; Reimann, Vollstedt, et al., 2021),

while others only use stakeholder feedback in the final stages of the scenario development process in order to get local feedback on scenario narratives already partially developed by researchers or better understand which socio-economic drivers are most important in the local area being studied (Ciumasu, 2013; Jurgilevich et al., 2021; Kamei et al., 2021; Rohat, Wilhelmi, et al., 2019). Most participatory approaches focus on including 'expert' stakeholders (Kamei et al., 2021; Meyer et al., 2019; Rohat, Wilhelmi, et al., 2019); however, some also strive to secure broader participation from local citizens (Reimann, Vollstedt, et al., 2021). Stakeholders are generally engaged through workshops, surveys, or questionnaires (Birkmann et al., 2020; Egger & Maurer, 2015; Jurgilevich et al., 2021; Kamei et al., 2021; Li et al., 2017; Meyer et al., 2019).

Scenario outputs from participatory scenario development approaches most often take the form of qualitative narratives describing potential futures (Birkmann et al., 2020, 2021; Ciumasu, 2013; Egger & Maurer, 2015; Jurgilevich et al., 2021; Kamei et al., 2021; Li et al., 2017; Meyer et al., 2019; Reimann, Vollstedt, et al., 2021; Wan et al., 2020). Some participatory approaches also use qualitative narratives as a starting point for creating quantified and spatialized socio-economic projections (Birkmann et al., 2020, 2021; Egger & Maurer, 2015; Hadipour et al., 2020; Jurgilevich et al., 2021; Li et al., 2017; Rohat, Wilhelmi, et al., 2019; Ronco et al., 2014; Wan et al., 2020). Li et al. (2017) directly use stakeholder workshops to create quantified socio-economic projections, while Jurgilevich et al. (2021) use participatory mapping to understand spatial patterns of risk under different future scenarios.

While a number of participatory scenario development approaches do not consider the SSPs (Birkmann et al., 2020; Ciumasu, 2013; Egger & Maurer, 2015; Hadipour et al., 2020; Jurgilevich et al., 2021; Ronco et al., 2014; Wan et al., 2020), some studies embed local scenarios in a global context by utilizing the SSPs as boundary conditions for local socio-economic narratives in an attempt to maintain local-global consistency and enable comparison across case studies (Birkmann et al., 2021; Kamei et al., 2021; Li et al., 2017; Meyer et al., 2019; Reimann, Vollstedt, et al., 2021; Rohat, Wilhelmi, et al., 2019).

Modeling-based scenario development

Modeling-based scenario development approaches generally take departure in downscaling of larger scale projections (Borris et al., 2016; K. Chen et al., 2017; Dubey et al., 2021; El-Fadel & Ghanimeh, 2013; Krummenauer et al., 2021; Park et al., 2021; Parkinson et al., 2016; Peng & Li, 2021; Rohat et al., 2021; Rohat, Flacke, et al., 2019; Terama et al., 2019; Wolff et al., 2020) or predictive modeling approaches that generate a wide range of possible future scenarios. Predictive modeling methodologies are diverse but include stochastic modeling (Abadie, 2018; Hemmati et al., 2021), gravity-based modeling (Reimann, Jones, et al., 2021), and CA-Markov modeling (X. Chen et al., 2021; Xu et al., 2021). Two studies take a slightly different approach by modeling adaptation pathways using mapping or pathway generation approaches (Manocha & Babovic, 2017; Urich & Rauch, 2014). A total of 27 studies use modeling-based approaches as shown in Table 6 below.

Table 6: Literature Using Modeling-Based Scenario Development. Some literature uses multiple methods of scenario development and is therefore categorized more than once. See Appendix C for full categorization of literature.

Type	Methods (#)	Use of SSPs/SRES (#)	Scenario Output (#)	Sources (#)
Modeling-based scenario development	Downscaling (12)	Yes (12) No (0)	Qualitative (1) Quantitative (12) Spatial (9)	(12)
	Predictive/ statistical modeling (13)	Yes (4) No (9)	Qualitative (0) Quantitative (13) Spatial (8)	(13)
	Adaptation pathway modeling (2)	Yes (0) No (2)	Qualitative (1) Quantitative (2) Spatial (1)	(2)

While some modeling-based approaches use SSPs (Borris et al., 2016; K. Chen et al., 2017; X. Chen et al., 2021; Dubey et al., 2021; Krummenauer et al., 2021; Park et al., 2021; Parkinson et al., 2016; Peng & Li, 2021; Reimann, Jones, et al., 2021; Rohat et al., 2021; Rohat, Flacke, et al., 2019; Terama et al., 2019; Wolff et al., 2020; Zhu et al., 2020), a number of studies do not consider SSPs in their scenario development approaches and instead rely on mathematical calculations of potential future scenarios (Abadie, 2018; Apreda et al., 2019; Banu et al., 2014; Casal-Campos et al., 2015; A. Chu et al., 2017; Hemmati et al., 2021; Manocha & Babovic, 2017; Parandvash & Chang, 2016; Sampson et al., 2016; Urich & Rauch, 2014; Xu et al., 2021). Scenario outputs from modeling-based approaches are mostly quantitative or spatial (Abadie, 2018; Apreda et al., 2019; Banu et al., 2014; Borris et al., 2016; Casal-Campos et al., 2015; K. Chen et al., 2017; X. Chen et al., 2021; A. Chu et al., 2017; Dubey et al., 2021; El-Fadel & Ghanimeh, 2013; Hemmati et al., 2021; Krummenauer et al., 2021; Manocha & Babovic, 2017; Parandvash & Chang, 2016; Park et al., 2021; Parkinson et al., 2016; Rohat, Flacke, et al., 2019; Sampson et al., 2016; Terama et al., 2019; Urich & Rauch, 2014; Wolff et al., 2020; Xu et al., 2021; Yan et al., 2016; Zhu et al., 2020), although some studies combine quantified or spatialized projections with qualitative narratives of potential futures (Borris et al., 2016; Manocha & Babovic, 2017).

5.1.2.3 Use of socio-economic projections throughout the adaptation planning process

Socio-economic projections have so far been applied at three key stages of the urban adaptation planning process: assessing climate change risks and vulnerabilities, identifying adaptation options, and assessing and selecting adaptation options (see Table 7 below).

Table 7: Use of Socio-Economic Projections throughout the Adaptation Planning Process. Some literature uses socio-economic projections at multiple stages of the planning process and is therefore categorized more than once. See Appendix C for full categorization of literature.

Planning Stage	Sources (#)
Preparing the ground for adaptation	(0)
Assessing climate change risks and vulnerabilities	(32)
Identifying adaptation options	(7)
Assessing and selecting adaptation options	(10)
Implementing adaptation	(0)
Adaptation monitoring, evaluation and learning	(0)

Table 7 shows that socio-economic projections are primarily used at the climate change risk and vulnerability assessment stage. At this planning stage, socio-economic scenarios can facilitate identification of local risks and assessment of future vulnerability at an urban scale (Birkmann et al., 2020, 2021; A. Chu et al., 2017; Meyer et al., 2019; Yan et al., 2016). Socio-economic projections can enhance a multifaceted understanding of risk and vulnerability in urban contexts by enabling dynamic analysis of human, economic, social, cultural and ecological systems across temporal and spatial scales (Ronco et al., 2014). A coupled approach to modeling future socio-economic and climate scenarios enables constant monitoring of risk and vulnerability in response to a wide range of potential changes (Apreda et al., 2019; Reimann, Vollstedt, et al., 2021).

During the risk assessment stage as well as in the process of identifying adaptation options, socio-economic projections can be used to visualize desirable futures and can also act as a decision support tool to guide strategic planning and policy making on adaptation. Participatory scenario building approaches can help stakeholders visualize both desirable and undesirable futures which can be useful in identifying adaptation objectives and can serve as a starting point for back casting possible pathways towards desired future visions (Birkmann et al., 2021; Ciumasu, 2013; Huang et al., 2011; Reimann, Vollstedt, et al., 2021). More generally, socio-economic projections can serve as a basis for high level planning and policy making by enabling decision makers to explore potential adaptation pathways (Birkmann et al., 2020; Huang et al., 2011; Li et al., 2017; Meyer et al., 2019; Peng & Li, 2021; Reimann, Vollstedt, et al., 2021; Rohat et al., 2021; Rohat, Wilhelmi, et al., 2019; Terama et al., 2019; Yan et al., 2016). Socio-economic scenarios can be used both to identify short term adaptation interventions and inform long term strategic planning (Sampson et al., 2016).

When identifying and selecting adaptation options, socio-economic projections can be used to develop robust, flexible, and low regret adaptation strategies that perform well under multiple futures (Jurgilevich et al., 2021; Manocha & Babovic, 2017; Rohat et al., 2021; Rohat, Wilhelmi, et al., 2019; Urich & Rauch, 2014). Scenario based modeling approaches can help to identify priority areas for adaptation interventions (Birkmann et al., 2021; K. Chen et al., 2017; Dubey et al., 2021; Manocha & Babovic, 2017;

Peng & Li, 2021; Wolff et al., 2020). Scenario approaches also enable performance assessment of climate adaptive design solutions under multiple future development and climate conditions (Apreda et al., 2019; Egger & Maurer, 2015; Hemmati et al., 2021; Jurgilevich et al., 2021; Manocha & Babovic, 2017; Sampson et al., 2016). Such performance assessment can provide a straightforward method for selecting adaptation options based on ranking of solutions according to their ability to reduce future risk and vulnerability under a wider range of potential development and climate pathways (Manocha & Babovic, 2017; Wan et al., 2020). This can contribute to an understanding of the costs and benefits of different adaptation solutions and can help to examine tradeoffs and prevent maladaptation (Hemmati et al., 2021; Jurgilevich et al., 2021).

5.1.2.4 Challenges and limitations of using socio-economic projections in urban adaptation planning

A number of challenges exist when utilizing socio-economic projections in urban adaptation planning. First, socio-economic projections are inherently uncertain (Ciumasu, 2013; Jurgilevich et al., 2021; Park et al., 2021; Rohat, Flacke, et al., 2019; Urich & Rauch, 2014) and the quality of scenario-based approaches depends closely on the assumptions used which often turn out to be unrealistic (Ciumasu, 2013; Urich & Rauch, 2014). Some argue that the irreducible uncertainty of socio-economic projections provides only a rough estimation of potential future development pathways and such scenarios are therefore a poor basis for decision making (Urich & Rauch, 2014). In an urban context, the inherent uncertainty of projections is exacerbated due to the complex nature of urban systems and the challenge of measuring intangible socio-economic indicators such as social capital and community networks (A. Chu et al., 2017).

Second, existing socio-economic projections such as the SSPs are not usable at an urban scale. The SSPs were conceptualized at a global scale and therefore lack the specificity necessary to understand spatial patterns of local socio-economic development and guide urban scale adaptation planning and policy making (Birkmann et al., 2021; Meyer et al., 2019; Reimann, Vollstedt, et al., 2021; Rohat, Wilhelmi, et al., 2019; Xu et al., 2021).

Third, downscaling global or national scenarios to an urban context proves challenging. There is a general lack of urban scale projections consistent with the SSPs (Rohat, Wilhelmi, et al., 2019) and those that do exist are based on global modeling approaches which are unable to accurately assess locally specific urban development trends (Birkmann et al., 2020, 2021). Studies using downscaled SSP scenarios therefore tend to underestimate the complexity of adaptation in urban contexts (Rohat et al., 2021).

Fourth, bottom-up and participatory scenario development approaches face their own set of challenges. These approaches can be time consuming and resource intensive and the lack of common methodology to bottom-up scenario development limits comparison across studies (Reimann, Vollstedt, et al., 2021). This challenge can be partially overcome by using global SSPs as boundary conditions for local scenario production, however this may also be detrimental as it can limit creativity and result in scenarios that too closely mirror global projections (Reimann, Vollstedt, et al., 2021). Furthermore, participatory scenario-building processes can be challenging as stakeholder contribution is directly dependent on their understanding of local climate, social context, and economy and stakeholders often find it challenging to envision alternative development futures (Meyer et al., 2019; Reimann, Vollstedt, et al., 2021).

Finally, local socio-economic data is often not available which makes urban scale scenario development difficult. The limited availability of local data often means that scenarios must be based on limited indicators and are therefore highly simplified depictions of future socio-economic development and vulnerability (Birkmann et al., 2020, 2021; Rohat, Flacke, et al., 2019; Wolff et al., 2020). There is also often a temporal mismatch in socio-economic and climate data, with local socio-economic data often only available on timescales inconsistent with global climate scenarios (Birkmann et al., 2020; Wolff et al., 2020). The potential of using socio-economic projections at an urban scale is especially limited in data poor study environments (Rohat, Flacke, et al., 2019).

5.1.2.5 Recommendations for use of socio-economic projections in urban adaptation planning

The literature offers the following recommendations and suggestions for further research in order to improve the usability of projections in urban climate change adaptation planning.

First, scenario approaches should more closely reflect locally specific trends. Further research should focus on developing modeling approaches and methodologies that are appropriate at an urban scale and consider the local spatial variability of development trends (Birkmann et al., 2020, 2021; Reimann, Vollstedt, et al., 2021; Rohat, Flacke, et al., 2019; Zhu et al., 2020). There is a need to develop case specific scenarios in every urban context in order to effectively capture locally specific development trends. It is not sufficient to simply downscale socio-economic data from a national or global scale (Birkmann et al., 2021; Egger & Maurer, 2015).

Second, future research should work towards including more detailed socio-economic data in scenario development approaches. Including a wide range of demographic indicators such as age, sex, poverty, income, race, and education alongside data on health, land use, and biodiversity can enhance the ability of scenario assessments to assess future vulnerability and adaptive capacity in complex urban systems (A. Chu et al., 2017; Peng & Li, 2021; Reimann, Jones, et al., 2021; Rohat, Wilhelmi, et al., 2019; Terama et al., 2019).

Third, despite the necessity of developing locally specific scenarios using urban scale data, it is still beneficial to maintain consistency of local projections with global SSPs. Utilizing the SSPs as boundary conditions for urban scenario development enables comparison between multiple urban scenario applications and facilitates an understanding of the interlinkages between local and global socio-economic development patterns (Park et al., 2021; Reimann, Vollstedt, et al., 2021; Rohat, Wilhelmi, et al., 2019). While ensuring local-global consistency is key, it may be necessary to develop a wider range of potential development pathways than those currently captured by the SSPs in order to visualize multiple potential avenues to sustainability beyond the globalized and growth centered scenarios put forth by the five existing SSP narratives (Kamei et al., 2021).

Fourth, to ensure the relevance of socio-economic projections for adaptation planning, future urban scenario applications should take a participatory approach by including stakeholders in the entire process. Local stakeholder input during scenario development is critical to ensure the relevance and credibility of

scenarios and promote local ownership (Li et al., 2017; Meyer et al., 2019; Reimann, Vollstedt, et al., 2021; Rohat et al., 2021; Rohat, Wilhelmi, et al., 2019). However, it is important to note that participatory scenario development approaches can be challenging. It is therefore key to utilize carefully designed methodologies that ensure stakeholders have sufficient time to familiarize themselves with scenario development, establish clear roles for stakeholders in the scenario creation process, and promote good communication between stakeholders and researchers (Li et al., 2017; Reimann, Vollstedt, et al., 2021).

Finally, future research should more explicitly explore how to best utilize socio-economic scenario information in urban adaptation planning and governance (Jurgilevich et al., 2021). Urban socio-economic projections could be used to further explore vulnerability dynamics, assess the costs and benefits of different adaptation options, identify tradeoffs between adaptation and mitigation, and investigate maladaptation in urban adaptation planning and policy making (Jurgilevich et al., 2021; Rohat et al., 2021; Rohat, Flacke, et al., 2019).

5.1.2.6 Recommendations for use of socio-economic projections to support urban climate justice

None of the literature reviewed on socio-economic projections and urban climate change adaptation planning explicitly mentions equity or justice in relation to socio-economic projections or scenarios. However, some studies do make reference to socio-economic projections as a tool to enhance understanding of future vulnerability and adaptive capacity (Birkmann et al., 2020, 2021; A. Chu et al., 2017; Ciumasu, 2013; Jurgilevich et al., 2021; Meyer et al., 2019; Peng & Li, 2021; Sampson et al., 2016), concepts that are arguably closely tied to justice. Despite the current lack of attention to the connection between socio-economic projections and urban climate justice, the literature illustrates that utilizing socio-economic scenarios in urban adaptation planning could have the potential to promote urban climate justice in several ways.

First, socio-economic projections could be used as a tool to ensure distributive justice in cities if socio-economic scenario analysis is used to select adaptation options that provide equitable access to urban space and services for all across multiple potential futures. Approaches that aim to develop adaptation pathways or select robust, no regret, and flexible solutions could be especially beneficial in promoting justice as these strategies could be regularly adjusted to improve justice outcomes in the future.

Second, participatory scenario development approaches could have the potential to strengthen procedural justice. Participatory approaches that embed stakeholder participation in the entire process of scenario design could be pursued to ensure that participation is present at every stage of the planning and decision making process. Furthermore, scenario development approaches that strive to ensure broad participation beyond traditional 'expert' stakeholder participation strategies could have the potential to elevate voices that are often not heard in the context of decision making on adaptation.

Third, recognition and restorative justice could be promoted through the use of socio-economic projections to aid in the selection of adaptation options that explicitly prioritize vulnerable groups. Socio-economic scenario analysis could also potentially help to better assess intersectionality of urban climate justice with other urban justice issues due to the ability of coupled socio-economic and climate projections

to integrate a wide range of indicators to form comprehensive analysis of future vulnerability. Therefore, socio-economic projections could help to facilitate the identification of drivers of injustice across spatial and temporal scales and between possible future scenarios.

The key opportunities for using socio-economic projections to promote urban climate justice can be summarized by applying approaches to socio-economic scenario development and application used in the literature to the urban climate justice framework presented in Section 3.3.4. These key potentials for existing socio-economic projection applications to promote justice are illustrated in Figure 16 below.

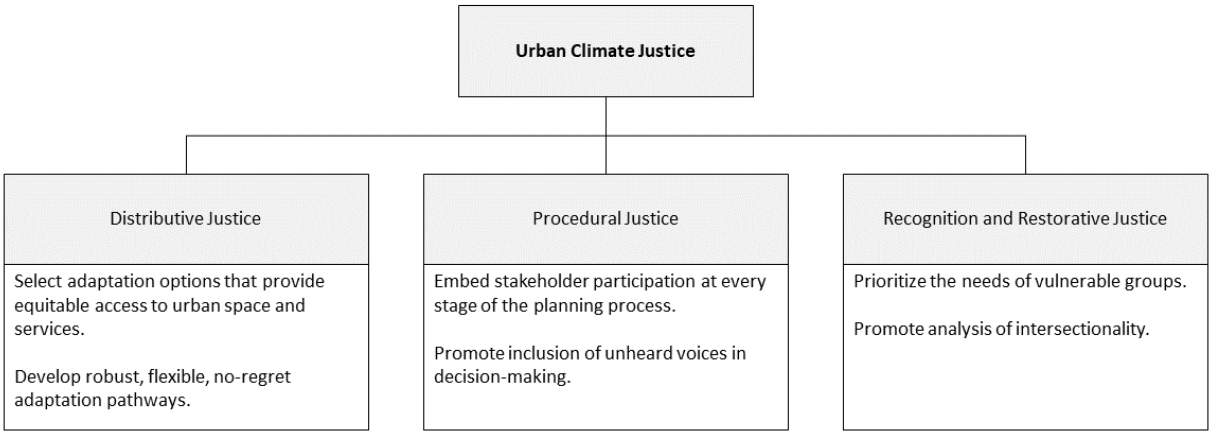

Figure 16: Potential for Socio-Economic Projections to Promote Urban Climate Justice

5.2 Policy analysis results

This section provides an overview of the results of the policy analysis performed in response to the question: *how are socio-economic projections currently being considered in urban climate change adaptation policy and to what extent is the inclusion of socio-economic projections in policy motivated by climate justice concerns?*

In order to answer this question, 20 urban and metropolitan adaptation related policies affecting 16 cities across the globe were analyzed (see Table 4 in Section 4.2.2). These policies were found to consider socio-economic projections by Olazabal, Ruiz De Gopegui et al. (2019); however, the specific ways in which socio-economic projections are applied in these policies and whether these applications are motivated by justice concerns has so far been unexplored.

Therefore, the following sections first explore the types of socio-economic projections and methods for scenario development used by these policies before investigating the stage of the adaptation planning process in which such projections are used and finally analyzing how justice is considered in socio-economic projection applications.

5.2.1 Types of socio-economic projections and methods for scenario development

The application of socio-economic projections and scenario development methodologies to adaptation policies is found to take three forms: participatory scenario development, modeling-based scenario development, and application of existing socio-economic projections to adaptation planning. 9 out of the 20 policies analyzed utilize existing socio-economic projections while 8 take a modeling-based approach to projection development and 3 use participatory scenario development methods.

Participatory scenario development

Participatory scenario development approaches utilize stakeholder workshops as well as stakeholder consultation and questionnaires to gain local input on future socio-economic development trends. Scenario outputs can be qualitative, quantitative, and spatial and none of the policies using participatory methods consider global socio-economic projections such as the SSPs or SRES scenarios. Three policies are found to use participatory methods to develop multiple potential future scenarios of socio-economic development as shown in Table 8 below.

Table 8: Policies Using Participatory Scenario Development. Some policies use multiple methods of scenario development and are therefore categorized more than once. See Appendix D for full categorization of policies.

Type	Methods (#)	Use of SSPs/SRES (#)	Scenario Output (#)	Policies (#)
Participatory scenario development	Stakeholder workshop (2)	Yes (0) No (2)	Qualitative (2) Quantitative (2) Spatial (2)	(2)
	Stakeholder consultation/questionnaire (2)	Yes (0) No (2)	Qualitative (2) Quantitative (1) Spatial (1)	(2)

Participatory scenario development takes two general forms in the policies studied. The Auckland Plan 2050 uses stakeholder consultation to build qualitative narratives of potential futures for the city of Auckland. In this approach, stakeholders provide input on how they view the future development of the city including assumptions about future urban land use patterns, food production and consumption, mobility systems, labor market trends, (in)equality, and coastal adaptation strategies. This future visioning exercise is used to develop both positive and negative scenarios for the future of Auckland. The participatory approach is also complemented by existing quantitative projections of future socio-economic trends based on historical data; however, the Auckland Plan 2050 explicitly recognizes the huge uncertainty associated with future socio-economic development and therefore aims to plan for multiple potential futures as informed by the participatory development of scenario narratives (Auckland Council, 2018).

The Plan Estratégico Distrital (PED) and Plano de Ação Vitória Sustentável take a slightly different approach by utilizing stakeholder workshops and consultation to inform the development of spatial urban growth scenarios. These policies take expert feedback into account in developing business as usual, intermediate, and optimal urban development scenarios (Alcaldía de Panama, 2019). The Plan Estratégico Distrital (PED) uses stakeholder workshops to validate challenges identified in each of these scenarios and also invites stakeholders to propose adaptation solutions to help inform the development of the optimal urban growth scenario for Panama City (Alcaldía de Panama, 2019). Similarly, the Plano de Ação Vitória Sustentável uses participatory workshops to guide the development of an intermediate urban growth scenario for Grande Vitoria. This scenario envisions how to plan for a sustainable future within current financial and administrative constraints, meaning that local stakeholder feedback is key in validating current challenges and envisioning a realistic intermediate scenario (Instituto Pólis, 2015). As both the Plan Estratégico Distrital (PED) and Plano de Ação Vitória Sustentável develop spatial urban growth scenarios, these policies combine a participatory scenario development approach with modeling-based scenario development using local historical socio-economic data to extrapolate future urban growth trends (Alcaldía de Panama, 2019; Instituto Pólis, 2015).

Modeling-based scenario development

Modeling-based approaches utilize either downscaling of global socio-economic scenarios or predictive modeling approaches using historical data to project potential future trends. Scenario outputs of modeling approaches are mostly quantitative but can also be spatialized or supported by qualitative narratives of future scenarios. 8 of the policies surveyed are found to use modeling-based approaches to scenario development as shown in Table 9 below.

Table 9: Policies Using Modeling-Based Scenario Development. See Appendix D for full categorization of policies.

Type	Methods (#)	Use of SSPs/SRES (#)	Scenario Output (#)	Policies (#)
Modeling-based scenario development	Downscaling (3)	Yes (3) No (0)	Qualitative (0) Quantitative (3) Spatial (0)	(3)
	Predictive/statistical modeling (5)	Yes (0) No (5)	Qualitative (1) Quantitative (5) Spatial (3)	(5)

A downscaling approach to socio-economic scenario development is used in three policies: the City of Melbourne Climate Change Adaptation Strategy, The City of London Climate Change Adaptation Strategy and Growing Stronger: Toward a Climate Ready Philadelphia. These policies all use downscaled SRES scenarios in their local climate change risk assessments. While the SRES scenarios include assumptions about future socio-economic development, these policies do not address future socio-economic trends extensively beyond their application of these scenarios (City of London, 2010; City of Melbourne, 2009;

Mayor's Office of Sustainability & ICF International, 2015). The City of Melbourne Climate Change Adaptation Strategy does incorporate existing local projections of socio-economic development to complement the downscaled SRES scenarios (City of Melbourne, 2009).

Predictive modeling approaches are used by five policies to extrapolate potential future socio-economic development trends on the basis of local historical data. The modeling approaches applied in these policies vary considerably in their complexity and methodological approach. The Davao City Climate Change Action Plan takes a simplistic approach by projecting future population growth based on the assumption that historical population growth trends will continue into the future. These projections are quantified on a city wide scale (City Government of Davao, 2014). The City of Virginia Beach Comprehensive Plan takes a slightly more complex approach by developing local population projections that consider low, medium, and high growth scenarios. The generation of these scenarios is also quantitative and considers historic data as well as planned urban growth (City of Virginia Beach, 2016). The Fourth Regional Plan, the Climate Change Adaptation Strategy for the City of Rio de Janeiro, and the Plan de Acción "Panamá Ciudad Sostenible'' go one step further by creating spatial growth scenarios. The Fourth Regional Plan uses land use data in combination with econometric modeling to extrapolate multiple urban growth scenarios and identify a best case scenario to aim for (Regional Plan Association, 2017). Similarly, the Climate Change Adaptation Strategy for the City of Rio de Janeiro considers land use data and demographic trends to create spatial socio-economic and land use scenarios for 2040 (Rio Prefeitura et al., 2016). The Plan de Acción "Panamá Ciudad Sostenible'' creates three potential future urban growth scenarios which are accompanied by qualitative narratives describing potential socio-economic futures (Alcaldía de Panama & BID, 2017).

Use of existing socio-economic projections

Policies that use existing socio-economic projections generally do not develop multiple potential socio-economic scenarios but instead use local, regional, or national projections to predict local socio-economic futures. These projections are presented as quantitative future trends. Nine of the policies analyzed use existing socio-economic projections as shown in Table 10 below.

Table 10: Policies Using Existing Socio-Economic Projections. See Appendix D for full categorization of policies.

Type	Methods (#)	Use of SSPs/SRES (#)	Scenario Output (#)	Policies (#)
Use of existing projections	Use of existing projections (9)	Yes (0)	Qualitative (0)	(9)
		No (9)	Quantitative (9)	
			Spatial (0)	

The majority of policies using existing projections primarily use projections of future population growth, with some policies also incorporating data on age, employment, urban densification, and daily users of the city (Bangkok Metropolitan Administration & 100 Resilient Cities, 2017; City and County of San Francisco, 2016; City of Melbourne, 2017; Metropolitan Washington Council of Governments, 2008; The

City of New York, 2014, 2015). Some policies also include projections of future energy or water demand based on expected future population growth (Bangkok Metropolitan Administration & 100 Resilient Cities, 2017; Metropolitan Washington Council of Governments, 2008; The City of New York, 2015; Ville de Dakar & 100 Resilient Cities, 2017).

While most policies do not consider multiple potential futures, the New Orleans Master Plan considers three scenarios of future population growth: low, moderate, and high. Exploring multiple projected futures is especially key in the New Orleans context because existing local socio-economic projections based on historic data are highly uncertain as Hurricane Katrina extensively changed the demographic composition of the New Orleans area when it devastated the city in 2005 (City of New Orleans, 2016).

5.2.2 Use of socio-economic projections throughout the adaptation planning process

The policies analyzed apply socio-economic projections at four stages of the adaptation planning process: assessing climate change risks and vulnerabilities, identifying adaptation options, assessing and selecting adaptation options, and monitoring and evaluating adaptation (see Table 11 below).

Table 11: Use of Socio-Economic Projections by Policies throughout the Adaptation Planning Process. Some policies use socio-economic projections at multiple stages of the planning process and are therefore categorized more than once. See Appendix D for full categorization of policies.

Planning Stage	Policies (#)
Preparing the ground for adaptation	(0)
Assessing climate change risks and vulnerabilities	(20)
Identifying adaptation options	(2)
Assessing and selecting adaptation options	(4)
Implementing adaptation	(0)
Adaptation monitoring, evaluation and learning	(1)

As shown in Table 11 above, all 20 of the policies assessed are found to use socio-economic projections in some capacity at the risk assessment stage. Some policies simply use future socio-economic data to frame the general development challenges that the future will bring in terms of trends such as population growth or aging (City and County of San Francisco, 2016; City of New Orleans, 2016; City of Virginia Beach, 2016).

However, some policies go further by integrating spatial information on future socio-economic trends into risk and vulnerability assessments in order to better understand future vulnerability to climate hazards. For example, the Climate Change Adaptation Strategy for the City of Rio de Janeiro uses socio-economic projections to conduct neighborhood scale analysis of future vulnerability and identifies areas where demographic trends such as aging may lead to an increased concentration of vulnerable population in the

future, thus increasing vulnerability to climate change related hazards such as heat, flooding, and landslides (Rio Prefeitura et al., 2016).

Similarly, OneNYC and the NYC Hazard Mitigation Plan discuss the challenge of population growth in relation to specific climate hazards such as heat and flooding (The City of New York, 2014, 2015). The Fourth Regional Plan quantifies the number of people that will be exposed to flooding in the future taking into account both climate and socio-economic projections (Regional Plan Association, 2017).

Two policies are found to consider socio-economic projections when identifying adaptation options: the Plan Estratégico Distrital (PED) and the Plano de Ação Vitória Sustentável. These policies use future socio-economic information to develop spatial urban growth scenarios. During the scenario development process, local stakeholders are asked to propose solutions to guide the development of optimal or intermediate growth scenarios. Therefore, these scenario development processes directly contribute to identifying potential adaptation solutions (Alcaldía de Panama, 2019; Instituto Pólis, 2015).

When assessing and selecting adaptation options, four policies consider socio-economic projections. The Plan Estratégico Distrital (PED) and the Plano de Ação Vitória Sustentável define adaptation solutions in their participatory scenario development processes based on local stakeholder input (Alcaldía de Panama, 2019; Instituto Pólis, 2015). The Plan de Acción "Panamá Ciudad Sostenible" uses socio-economic scenario information to prioritize adaptation options and conduct analysis of the costs of reaching different future scenarios compared to the costs of inaction (Alcaldía de Panama & BID, 2017).

The Auckland Plan 2050 also implicitly considers socio-economic trends in its selection of adaptation options by acknowledging the uncertainty of future development and accordingly choosing to pursue flexible green infrastructure solutions that can perform well in light of uncertain climate and socio-economic development futures (Auckland Council, 2018).

At the monitoring and evaluation stage, the City of Melbourne Climate Change Adaptation Strategy REFRESH utilizes socio-economic projections. This strategy incorporates updated socio-economic projections and is therefore able to evaluate the suitability of adaptation solutions proposed in the previous City of Melbourne Climate Change Adaptation Strategy given this new information (City of Melbourne, 2017).

It is also worth noting that some policies integrate socio-economic projections into their planning processes in regard to challenges not directly related to climate change adaptation. For example, the Virginia Beach Comprehensive Plan uses future socio-economic data to conduct a cost-benefit analysis of potential future transport planning schemes (City of Virginia Beach, 2016). The Dakar Resilience Strategy and the 100 Resilient: Resilient Bangkok strategy apply socio-economic projections to estimate future electricity demand, road use, and waste management needs (Bangkok Metropolitan Administration & 100 Resilient Cities, 2017; Ville de Dakar & 100 Resilient Cities, 2017).

Socio-economic projections can also be used in climate change mitigation planning. The National Capital Region Climate Change Report uses socio-economic projections to estimate future GHG emissions in a business as usual scenario and identify mitigative actions that could enable the city of Washington DC to meet local emissions reduction targets (Metropolitan Washington Council of Governments, 2008).

5.2.3 Consideration of climate justice in socio-economic projection applications

None of the policies analyzed mention equity or justice as motivation for using socio-economic projections or acknowledge the potential for socio-economic projections to support climate justice. However, 13 of the 20 policies analyzed mention equity or justice issues in general (see Appendix D). This signifies that justice is a consideration in urban adaptation policy and could signal a potential to introduce socio-economic projections as a tool to support the realization of existing equity goals within urban adaptation policies.

Furthermore, while none of the policies explicitly apply socio-economic projections to promote equity and justice, some aspects of the scenario development and application approaches found in the policies assessed could potentially contribute to supporting urban climate justice.

First, socio-economic projections could be used to promote distributive justice in adaptation policy if policies explicitly consider spatial patterns of future socio-economic vulnerability in their risk assessments. For example, neighborhood scale assessments of future vulnerability such as the one conducted in the Climate Change Adaptation Strategy for the City of Rio de Janeiro (Rio Prefeitura et al., 2016) could help to identify hotspots of vulnerability and climate injustice thus providing information necessary to implement adaptation interventions that benefit currently underserved and vulnerable populations or populations that are expected to become vulnerable in the future.

Second, participatory scenario development approaches such as the ones used in the Auckland Plan 2050, the Plan Estratégico Distrital (PED) and the Plano de Ação Vitória Sustentável could promote procedural justice by including diverse voices in adaptation planning. The approach used by the Auckland Plan 2050 (Auckland Council, 2018) promotes participation in the initial definition of future challenges and future visioning while the Plan Estratégico Distrital (PED) (Alcaldía de Panama, 2019) and the Plano de Ação Vitória Sustentável (Instituto Pólis, 2015) actively seek stakeholder input on specific adaptation solutions. Therefore, it could be useful to combine these approaches to ensure a participatory process that engages stakeholders throughout the entire adaptation planning process. Furthermore, the specific stakeholders that took part in the participatory processes carried out in Auckland, Panama City, and Grande Vitoria should be further investigated, as it is unclear from the policy documents which groups were consulted and who may have been excluded or overlooked in the process of participatory scenario development (Alcaldía de Panama, 2019; Auckland Council, 2018; Instituto Pólis, 2015).

While existing policy applications of socio-economic projections show promise for supporting distributive and procedural justice in cities, these approaches do not appear to take action that could actively promote recognition and restorative justice.

The key aspects of existing policy approaches that could serve as opportunities for supporting urban climate justice are summarized in Figure 17 below. Figure 17 applies socio-economic projection application approaches used in the policies analyzed to the urban climate justice framework presented in section 3.3.4 to illustrate how these approaches could support justice.

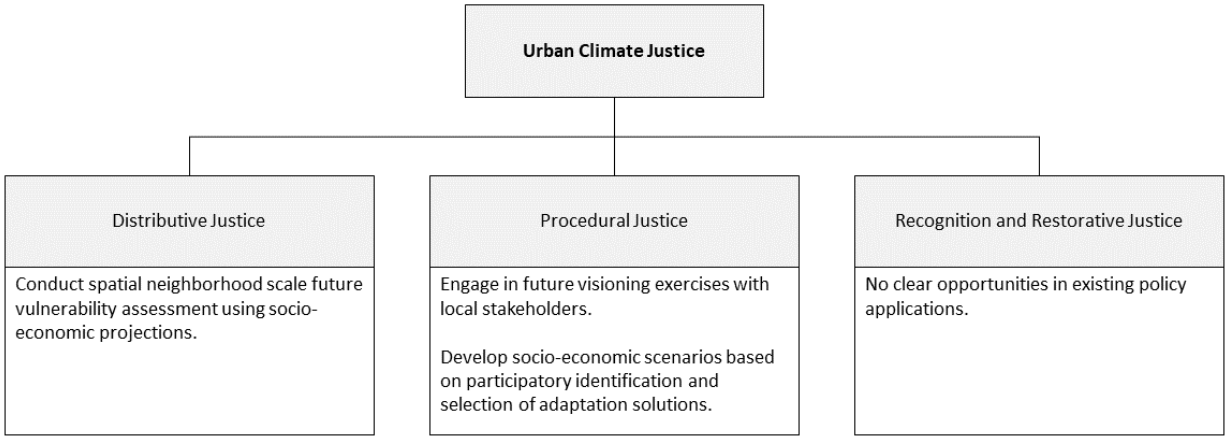

Figure 17: Potential for Policy Applications of Socio-Economic Projections to Promote Urban Climate Justice

6. Discussion and Conclusions

In order to understand how socio-economic projections can be utilized in urban climate change adaptation policy and planning to ensure climate justice, a systematic literature review and policy analysis have been conducted. The systematic review analyzed scientific literature that considers socio-economic projections in relation to urban climate change adaptation while the policy analysis studied adaptation policies that apply or develop socio-economic projections. The combined analysis of scientific literature and adaptation policies has enabled an understanding of how socio-economic projections are currently being used in both urban adaptation theory and practice and the identification of gaps and needs in science and policy. This coupled focus on projections in adaptation research and policy has also facilitated an understanding of the extent to which climate justice is actively being considered in socio-economic scenario analysis as well as potentials for socio-economic projections to promote climate justice through adaptation planning and policy making efforts.

This analysis raises questions about the usefulness and efficacy of current applications of socio-economic projections in urban adaptation research and policy and invites the question of how such projections should be used to best promote urban climate justice. The following sections will discuss the specific implications of the results of the systematic review and policy analysis before considering general limitations of the research approach and finally outlining recommendations for using socio-economic projections to promote justice as well as pointing to potential avenues for further research.

6.1 Systematic review discussion

Results of the systematic review show that the research area of socio-economic projections in urban climate change adaptation has emerged recently and remains relatively undeveloped. Only 41 articles on urban adaptation are found to consider socio-economic projections and no studies actively connect socio-economic projections to urban climate justice.

Socio-economic projections are developed either through participatory approaches that engage stakeholders through workshops, consultation, or participatory mapping or through modeling-based approaches that utilize downscaling or predictive and statistical modeling methods to create potential future scenarios. Modeling-based approaches are more widely adopted. The prominence of modeling-based approaches could be linked to the rise of neoliberal forms of climate urbanism wherein urban climate action primarily favors technocratic expertise and data (Robin & Castán Broto, 2021).

Socio-economic projections are rarely deeply embedded into planning approaches and are often only used at one stage of the planning process, with risk and vulnerability assessment being the most common phase during which to apply future socio-economic information. So far, urban adaptation research does not utilize socio-economic projections when preparing the ground for adaptation, implementing adaptation, or monitoring and evaluating adaptation interventions. This could be a missed opportunity especially in relation to monitoring and evaluation, as it is critical to track adaptation progress when working in highly complex urban systems (Ford & Berrang-Ford, 2016; Olazabal, Galarraga, et al., 2019; Otto et al., 2021) where socio-economic development trends are constantly shifting alongside local

adaptation needs (Westman et al., 2022). Integrated tracking of the environmental, social, and economic consequences of adaptation is one example of the forms of interdisciplinary urban governance that will be critical to enable effective responses to the 'compound urban crises' that our cities will face as urban climates and socio-economic development pathways shift into the future (Westman et al., 2022).

The limited application of socio-economic projections in urban adaptation research to date could be due to the challenges with developing and applying projections in cities due to the unsuitability of global socio-economic projections for use at an urban scale. Due to the local specificity of development trends, approaches that attempt to downscale the SSPs to a local scale risk overlooking local conditions that can impact the severity of risk and the potential for adaptation (Frame et al., 2018). Limited application of socio-economic projections in urban adaptation research could also stem from a lack of local data, difficulty measuring certain indicators of socio-economic development, and the challenges of producing local bottom-up scenarios.

Whatever the reason for the somewhat limited application of socio-economic projections to date, the literature (Birkmann et al., 2020; Ciumasu, 2013; Huang et al., 2011; Reimann, Vollstedt, et al., 2021; Rohat et al., 2021; Rohat, Flacke, et al., 2019; Terama et al., 2019) clearly points to the urgent need to better incorporate future socio-economic data into urban adaptation research due to the deep uncertainty of future climate and development trajectories and, perhaps more notably, due to the potential tendency for socio-economic changes to have a greater influence on future urban risk and vulnerability than climatic changes.

Furthermore, while no articles specifically discuss climate justice in relation to socio-economic projections, some approaches used in the literature do have the potential to promote justice and some studies actively aim to assess future vulnerability and adaptive capacity which are closely related to climate justice. For example, socio-economic scenario analysis could have the potential to promote all three dimensions of urban climate justice: distributive, procedural, and recognition and restorative justice. The literature demonstrates that socio-economic projections could be used to promote distributive justice by promoting adaptation options that provide equitable access to urban space and services and by using adaptation pathway approaches to identify robust and flexible solutions that can ensure justice in many potential futures. Procedural justice can be ensured in socio-economic scenario applications by using participatory socio-economic scenario development approaches that embed diverse participation across multiple planning stages and aim to give voice to marginalized groups. Recognition and restorative justice could be achieved through socio-economic scenario approaches that promote intersectionality by incorporating socio-economic data into risk and vulnerability assessments and adaptation solution selection. The presence of such opportunities for promoting justice even when studies do not actively seek to promote just adaptation indicate that socio-economic projections could be highly promising tools for ensuring climate justice if justice becomes a central driving factor of socio-economic scenario applications.

6.2 Policy analysis discussion

Results of the policy analysis show that the application of socio-economic projections to urban adaptation policy remains limited. Of the 81 urban and metropolitan policies impacting large coastal cities surveyed by Olazabal, Ruiz De Gopegui et al. (2019), only 22 policies from 18 cities are found to consider socio-economic projections. This means that approximately 27% of urban adaptation policies in large coastal cities currently consider socio-economic projections in some capacity.

The extent to which policies consider socio-economic projections also varies widely. While some policies use in depth participatory or modeling-based scenario development approaches to understand future socio-economic trends, many policies merely use existing projections of population to provide a general overview of future socio-economic challenges and do not consider multiple potential socio-economic futures. This failure to analyze multiple scenarios could be problematic due to the highly uncertain nature of both climate and socio-economic development trends in urban areas.

In adaptation policies, socio-economic projections are primarily used during risk assessment to frame potential future challenges or assess future changes in vulnerability due to socio-economic development trends. However, some policies also apply projections to identify adaptation options, assess and select adaptation solutions, or monitor and evaluate adaptation.

While socio-economic projections are not applied in any policies with the explicit purpose of promoting climate justice, many policies do mention equity or justice. This signifies that adaptation policies do often aim to promote equity and justice but that socio-economic projections are not yet commonly regarded as a tool through which to promote just urban adaptation. However, existing policy applications of socio-economic projections do demonstrate several potentials for promoting distributive and procedural justice. Adaptation policies could use socio-economic projections to promote distributive justice by conducting spatial assessments of future vulnerability taking into account potential development trends. This could help to identify future areas of high vulnerability and prevent injustice in terms of adaptation benefits and access to key urban services. Policy making can also use socio-economic projections to promote procedural justice by engaging in participatory future visioning exercises and actively consulting a diverse range of stakeholders when identifying and selecting adaptation options. While policy approaches show promise in terms of promoting distributive and procedural justice, there do not appear to be any apparent opportunities for promoting recognition and restorative justice in existing policy applications of socio-economic projections. However, there could be opportunities to expand existing policy applications to create opportunities for promoting recognition and restorative justice.

6.3 Applications of socio-economic projections in research vs. policy

Applications of socio-economic projections in both urban adaptation research and policy are still scarce. Including future socio-economic data in adaptation planning and policy making processes is not the norm and there does not appear to be standardized or widely adopted methodologies for applying socio-economic projections in urban adaptation research or policy. Furthermore, the potential for using socio-economic projections as a tool to support urban climate justice does not appear to be recognized in

research or policy as neither articles or policies explicitly connect socio-economic projections to justice or just adaptation.

The application of socio-economic projections differs slightly within research and policy. Scientific articles generally engage with more specific scenario development methods, using participatory or modeling-based scenario approaches to develop multiple potential future socio-economic scenarios. While some policies also use participatory methods or modeling-based approaches, many policies do not go so far and instead only use existing socio-economic data on future population or demographics. This indicates a need to bridge the gap between current understandings of socio-economic scenario applications in science vs. practice.

Both scientific articles and adaptation policies primarily use socio-economic projections at the risk and vulnerability assessment stage, with varying levels of application ranging from a broad framing of future challenges to in depth spatial analysis of future vulnerability at a neighborhood scale. Research and policy approaches also both apply projections when identifying and selecting adaptation solutions to a lesser extent. The literature on socio-economic projections does not apply projections during the monitoring and evaluation phase; however, one adaptation policy does use projections to monitor and evaluate adaptation decisions.

While neither research or policy applications explicitly aim to use socio-economic projections to promote urban climate justice, there are clear potentials for promoting justice through socio-economic scenario applications in both articles and policies. The literature demonstrates opportunities for using projections to promote justice across all three dimensions of urban climate justice while policy applications currently only show potentials for ensuring justice in relation to distributive and procedural justice.

While this initial comparison of socio-economic projections in literature vs. policy makes it appear that projections are currently being more deeply integrated in literature than policy, it is important to note that this could be due to the unique characteristics of academic articles compared to policy documents. Articles tend to provide a more comprehensive description of scenario development and application approaches than policy documents which could contribute to the perception that adaptation research currently applies socio-economic projections more than adaptation policy.

6.4 Limitations

It is important to note that a number of limitations may influence the validity and reliability of research findings. It is relevant to discuss several limitations of the systematic review and policy analysis methodologies as well as general limitations of the research approach.

The validity of the systematic review could be compromised by several methodological choices made. First, the systematic review is limited to articles indexed in Web of Science. It is possible that additional results may have been identified if additional databases were used during the search process. Second, the systematic review is limited to scientific articles. A wider search including gray literature could have

produced additional results. Third, the keyword search process used to select articles could limit relevance of findings. The research area of socio-economic projections in urban adaptation planning uses highly varied and ambiguous language meaning that it is possible that the keyword search conducted is not inclusive of language used by all researchers in this area. However, the final keyword search string was developed through an iterative search process that aimed to maximize keyword relevance and inclusivity as much as possible in order to ensure a holistic approach. Finally, the screening of literature for inclusion in the systematic review could contribute to low validity of findings as only one author completed this screening process. Ideally, this screening would have been conducted by two or more researchers independently to minimize implicit researcher bias or oversight; however, this was not possible within the scope of this research.

The methodological choices made during the policy analysis may also limit validity of findings. First, the policy analysis was based on previous work by Olazabal, Ruiz De Gopegui et al. (2019) which focused specifically on large coastal cities (> 1 million inhabitants). Therefore, the policies analyzed in this study are not representative of all urban areas meaning that results cannot be confidently generalized to all urban adaptation policies. Second, a predefined set of keywords was used to search policies for content related to socio-economic projections. The keywords searched could be an incomplete representation of terms used to discuss socio-economic projections meaning that validity of results may be compromised. Finally, several policies were not available in English meaning that analysis of these policies was based on translated texts which could limit the validity of the analysis.

The overall research approach may also be limited due to the challenge of applying the concept of urban climate justice to applications of socio-economic projections in urban adaptation literature and policy. There are currently no existing frameworks for understanding climate justice in relation to socio-economic scenario analysis meaning that this research takes an indirect, interpretative approach to analyzing the connection between socio-economic projections and urban climate justice. Specific definitions of each dimension of urban climate justice are constructed in an attempt to standardize the discussion of justice in relation to socio-economic scenario applications and link practical applications of socio-economic projections to current scientific debates on climate justice; however, results may still be somewhat skewed by implicit researcher bias.

6.5 Recommendations

While socio-economic projections have the potential to serve as a powerful tool for advancing urban climate justice, not all scenario development and application approaches are equally useful for ensuring just adaptation. In order for socio-economic projections to be a viable tool for promoting justice, it is critical that scenario development and application approaches actively merge technical and local knowledge to ensure that socio-economic projections do not simply become another top-down technocratic approach to urban climate governance that fails to address local needs and priorities. It is critical that broad and diverse stakeholder participation is integrated into every stage of the projection development and application process. It is also key to acknowledge the role of technical knowledge as socio-economic scenario approaches that only consider qualitative narratives of local socio-economic

futures based on citizen input will fall short in responding to the complex nature of urban change. It is therefore necessary that socio-economic projections integrate qualitative, quantitative, and spatial information gained from a wide range of sources including local citizens and expert stakeholders.

While local knowledge is critical in understanding urban development trends, it is also important to acknowledge the interconnectedness of local and global processes of change. It is essential to remember that socio-economic development trends and urban adaptation processes are situated in larger cross scale global landscapes of change meaning that it is key to integrate local socio-economic data with global projections such as the SSPs to ensure relevance and consistency across scales.

It should also be kept in mind that socio-economic projections are best used as a tool to make decisions under uncertainty rather than to predict likely futures. Socio-economic scenario applications should develop multiple future scenarios in recognition of the deep uncertainty associated with potential future development pathways and the potential shifts in local needs under different future conditions. Socio-economic projection applications that only model one possible future risk perpetuating ineffective adaptation, creating lock-in effects, and exacerbating injustice in tomorrow's cities.

In order to avoid maladaptation and promote just urban transitions, socio-economic projection applications should explicitly strive to ensure distributive, procedural, and recognition and restorative justice. Justice should be a key consideration when applying socio-economic projections at each stage of the urban adaptation planning process. Table 12 below provides a framework for using socio-economic projections in urban adaptation to promote justice, specifically outlining actions that decision makers can take at each stage of the planning process to ensure just application of socio-economic projections. The framework presented in Table 12 provides recommendations for actions to be taken at each of the six main stages of urban adaptation planning as defined by Climate ADAPT (n.d.) and New et al. (2022).

Table 12: Framework for Justice-Centered Application of Socio-Economic Projections in Urban Climate Change Adaptation Planning and Policy

Planning stage	Action	Justice element
Preparing the ground for adaptation	Conduct broad and inclusive stakeholder identification process	Procedural
	Identify relevant sources of local knowledge	Procedural
Assessing climate change risks and vulnerabilities	Consult stakeholders to identify future socio-economic development challenges and future needs	Procedural
	Develop scenario narratives of multiple potential desirable and undesirable socio-economic futures with stakeholders	Procedural
	Quantify and spatialize future scenarios with the help of local experts and embed scenarios within SSP narratives to enable spatial assessment of future risk and vulnerability at a neighborhood scale	Distributive Procedural
Identifying adaptation options	Consider stakeholder suggestions gained during participatory scenario development when identifying adaptation options	Procedural
	Identify potential solutions that provide benefits for all and explicitly prioritize the needs of vulnerable groups	Distributive Recognition and Restorative
Assessing and selecting adaptation options	Select flexible adaptation solutions that can perform well under multiple socio-economic futures	Distributive
	Select adaptation solutions that explicitly prioritize the needs of vulnerable and marginalized groups	Recognition and restorative
	Promote intersectionality by selecting multifunctional adaptation options that respond to climate justice challenges while also addressing other local drivers of injustice	Recognition and Restorative
Implementing adaptation	Embed socio-economic scenario data into all strategic planning and policy making efforts	Distributive Procedural Recognition and restorative
Adaptation monitoring, evaluation, and learning	Regularly update socio-economic scenarios based on new information and consult with stakeholders often to understand changing needs and assess effectiveness of adaptation solutions	Distributive Procedural

The framework presented in Table 12 aims to provide inspiration for planners and policy makers but does not intend to act as a one size fits all guide for applying socio-economic projections in support of urban climate justice. It is key to remember that each local context is unique and some actions may need to be amended to best respond to local needs or cope with context specific planning constraints.

It is also important to remember that socio-economic projections are only one tool within a larger set of planning mechanisms available to urban decision makers. While the application of socio-economic scenarios alone has the ability to promote justice outcomes, it is critical to embed justice within all actions taken during urban adaptation planning and policy making process in order to truly realize urban climate justice. Consequently, it will be critical for decision makers to strategically integrate socio-economic scenario information into all aspects of strategic planning. In order to enable practitioners to incorporate inclusive approaches to socio-economic scenario development into their everyday practices, it is useful to consider how the suggested actions presented in Table 12 could be integrated within existing climate action planning frameworks and guidelines available to city governments and stakeholders.

When preparing the ground for adaptation, identification of relevant stakeholders and sources of local knowledge could be facilitated through use of Climate ADAPT's Urban Adaptation Support Tool which provides guidance on the steps that should be taken at each stage of the adaptation planning process (Climate ADAPT, n.d.). The Urban Adaptation Support Tool proposes a method of stakeholder identification and analysis based on the RESIN approach which defines stakeholders according to their roles and responsibilities in relation to adaptation planning (Climate ADAPT, n.d.). While this approach does not explicitly consider justice, it could be adapted to consider equity concerns in the stakeholder identification process and ensure that marginalized voices and sources of informal local knowledge are explicitly targeted and prioritized.

The identification of relevant local data could further be supported through the use of a structured data collection protocol listing the recommended types of data that should be collected to support a justice-centered urban adaptation planning process with a strong focus on future socio-economic trends. This could be inspired by the data collection protocol for climate change adaptation planning in coastal towns and small cities developed by Lehmann et al. (2021). This data collection protocol provides a clear guide for climate change adaptation practitioners by naming key indicators to consider in relation to hazard, exposure, and vulnerability, suggesting potential data sources (such as local knowledge), and delineating the suggested temporal scales of each type of data (historic, current, future) (Lehmann et al., 2021). However, this typology only focuses on small coastal cities and while it includes future population data as one key indicator of exposure and vulnerability, it would be necessary to further develop the typology to be more inclusive of diverse city types and include additional socio-economic indicators beyond population. Specifically, an adapted data collection protocol aiming to support a data driven approach to just urban adaptation should include future demographic data as well as projected economic growth trends and any locally relevant data on expected migration or urbanization patterns. Here it is also important to note that future socio-economic data should consider multiple potential scenarios which should be developed in consultation with local stakeholders. The explicit integration of local knowledge and co-created socio-economic scenarios into urban adaptation planning can signal the beginning of a larger shift towards bottom-up and inclusive data driven governance. It is widely acknowledged that evidence-based decision making is critical in the highly complex and uncertain sphere of climate governance; however, approaches to data driven governance have often been guided by top-down, technocratic approaches (Hughes, 2020). The potential for co-creation of future socio-economic data demonstrates that data driven governance can also be bottom-up, inclusive, and justice centered.

During the risk and vulnerability assessment stage, it would be useful to integrate specific recommendations on participatory socio-economic scenario development into existing planning frameworks such as the C40 City Climate Change Action Planning Framework (C40 CCAPF). The C40 CCAPF is a practical guide for cities that aims to support urban policy makers in developing local climate action plans (C40 Cities, n.d.). The C40 CCAPF already points to the importance of considering socio-economic trends and emphasizes the urgency of implementing inclusive adaptation and mitigation actions (C40 Cities, n.d.). When identifying local challenges and opportunities, the C40 CCAPF suggests that cities should consider local social and economic trends within the broader framework of city priorities. This recommendation could easily be specified to include specific ways in which cities can develop and apply participatory socio-economic scenarios to assess future risk and vulnerability across potential development pathways. Including specific guidelines on the design of scenario development workshops and the translation of scenario narratives into quantitative and spatial maps of future vulnerability in a practical framework such as the C40 CCAPF that many city policy makers already look to for guidance on adaptation planning could help to bridge the gap between research and practice and accelerate the adoption of inclusive approaches to urban climate action by urban practitioners.

When identifying, assessing, selecting, and implementing adaptation options it could be useful to situate the analysis of future socio-economic trends within the larger strategic framework of adaptation pathway approaches or adaptive policymaking approaches. Adaptation pathways are emerging as a popular decision-centric approach to climate change adaptation planning. Adaptation pathways provide a structured approach to flexible decision making under uncertainty by defining sequences of actions that can be taken today and at various points in the future depending on future changes and knowledge development (Werners et al., 2021). Adaptation pathways are closely related to the concept of climate resilient development pathways which have recently been promoted by the IPCC as a promising means to operationalizing climate resilient development and a key guiding approach for climate policy (Schipper et al., 2022). Several studies analyzed in the systematic review utilize adaptation pathway approaches to test the effectiveness of adaptation strategies under different climate and socio-economic development futures (Manocha & Babovic, 2017; Urich & Rauch, 2014). Adaptive policymaking approaches share similarities with adaptation pathways as they aim to create robust plans under conditions of uncertainty but have been more broadly applied to strategic planning contexts beyond climate change adaptation (Walker et al., 2013). The concept of dynamic adaptive policy pathways (DAPP) combines adaptation pathways and adaptive policy making to form a structured approach to planning and policymaking under uncertainty that uses transient scenarios of potential futures to identify robust actions, develop potential pathways, and create dynamic adaptive plans (Haasnoot et al., 2013). DAPP could be a promising approach through which to mainstream the consideration of socio-economic scenario analysis in urban adaptation planning and policymaking. Applying future socio-economic data to a DAPP framework could further embed co-creation by going beyond future visioning with citizens to co-create concrete, step by step adaptation roadmaps with local stakeholders. This could help improve citizen understanding of the adaptation process and could also provide a useful framework for continued stakeholder consultation at every decision point along the adaptation pathway framework to ensure that planned adaptation actions are still functional in supporting equity and justice outcomes given potentially changed socio-economic

conditions. Embedding socio-economic scenario applications within high level and long-term DAPP approaches could increase ownership and further advance procedural justice in socio-economic projection applications. These potentials are in line with the assumption that climate resilient development pathway approaches can provide an inclusive framework through which to broaden the solution space of climate action and facilitate just system transitions (Schipper et al., 2022).

Finally, at the monitoring, evaluation, and learning stage it is again useful to consider how the regular update of scenario data and continued assessment of justice outcomes of adaptation can be integrated into existing monitoring and evaluation frameworks already being used by city stakeholders. The C40 Climate Action Planning Guide provides useful information for cities on monitoring and evaluation of adaptation that could be applied when assessing the justice implications of adaptation solutions (C40 Cities Climate Leadership Group & C40 Knowledge Hub, n.d.). The C40 guide emphasizes the importance of defining a governance structure for monitoring and evaluation systems and including a wide range of stakeholders in the process (C40 Cities Climate Leadership Group & C40 Knowledge Hub, n.d.). This type of participatory approach is essential when assessing justice outcomes and could be adapted to guide stakeholders in assessing and updating socio-economic scenario information and evaluating the justice outcomes of adaptation.

6.6 Further research

This research is an initial exploration of the use of socio-economic projections in urban adaptation planning and policy and their capacity to ensure climate justice. Further research will be necessary to develop more nuanced approaches for integrating socio-economic scenario data into urban climate governance and to better understand how such approaches impact justice outcomes. It will be key to develop more detailed local socio-economic data on a wide range of indicators. Further research should consider how to approach analysis of indicators such as social capital, isolation, and community networks that are key to understanding justice but can be difficult to measure and model within existing frameworks. Further research should also explore the local-global integration of socio-economic scenario data by potentially expanding the current range of SSPs or developing more detailed guidelines for using SSPs as boundary conditions in local socio-economic scenario applications.

Broader analysis of adaptation policies and their use of socio-economic projections will also be necessary. Many of the policies assessed in this research were published before the mainstreaming of SSPs in the IPCC reports, so it would be interesting to conduct a review of more recent policies to investigate whether the popularization of SSPs within the climate change research space has translated into an increased uptake of socio-economic scenario applications in adaptation policy.

More research is also needed to better understand how effective socio-economic scenario applications are at promoting justice in practice. This research has focused exclusively on the theoretical potential for socio-economic projections to ensure justice, but it will be necessary to conduct empirical research to better understand how socio-economic projections influence justice outcomes on the ground. A starting point for this research could be to conduct case study research in several of the cities found to integrate

socio-economic projections into their adaptation planning using participatory methods. Potential case studies could include Auckland, Panama City, and Grande Vitoria.

On a broader level, further research will be necessary to investigate how to best integrate the use of socio-economic projections within strategic planning and how to use socio-economic projections to promote new definitions of inclusive, justice-centered data driven governance in cities.

References

Abadie, L. M. (2018). Sea level damage risk with probabilistic weighting of IPCC scenarios: An application to major coastal cities. *Journal of Cleaner Production*, *175*, 582–598. https://doi.org/10.1016/J.JCLEPRO.2017.11.069

Albers, M., & Deppisch, S. (2013). Resilience in the Light of Climate Change: Useful Approach or Empty Phrase for Spatial Planning? *Http://Dx.Doi.Org/10.1080/09654313.2012.722961*, *21*(10), 1598–1610. https://doi.org/10.1080/09654313.2012.722961

Alcaldía de Panama. (2019). *Plan Estratégico Distrital (PED)*.

Alcaldía de Panama, & BID. (2017). *Plan de Acción "Panamá Ciudad Sostenible."*

Amorim-Maia, A. T., Anguelovski, I., Chu, E., & Connolly, J. (2022). Intersectional climate justice: A conceptual pathway for bridging adaptation planning, transformative action, and social equity. *Urban Climate*, *41*, 101053. https://doi.org/10.1016/J.UCLIM.2021.101053

Apreda, C., D'Ambrosio, V., & di Martino, F. (2019). A climate vulnerability and impact assessment model for complex urban systems. *Environmental Science & Policy*, *93*, 11–26. https://doi.org/10.1016/J.ENVSCI.2018.12.016

Araos, M., Berrang-Ford, L., Ford, J. D., Austin, S. E., Biesbroek, R., & Lesnikowski, A. (2016). Climate change adaptation planning in large cities: A systematic global assessment. *Environmental Science & Policy*, *66*, 375–382. https://doi.org/10.1016/J.ENVSCI.2016.06.009

Arnell, N. W., Livermore, M. J. L., Kovats, S., Levy, P. E., Nicholls, R., Parry, M. L., & Gaffin, S. R. (2004). Climate and socio-economic scenarios for global-scale climate change impacts assessments: characterising the SRES storylines. *Global Environmental Change*, *14*(1), 3–20. https://doi.org/10.1016/J.GLOENVCHA.2003.10.004

Arnstein, S. R. (2019). A Ladder of Citizen Participation. *Https://Doi-Org.Zorac.Aub.Aau.Dk/10.1080/01944363.2018.1559388*, *85*(1), 24–34. https://doi.org/10.1080/01944363.2018.1559388

Auckland Council. (2018). *Auckland Plan 2050*.

Bäckstrand, K., Kuyper, J. W., Linnér, B. O., & Lövbrand, E. (2017). Non-state actors in global climate governance: from Copenhagen to Paris and beyond. *Https://Doi.Org/10.1080/09644016.2017.1327485*, *26*(4), 561–579. https://doi.org/10.1080/09644016.2017.1327485

Bangkok Metropolitan Administration, & 100 Resilient Cities. (2017). *100 Resilient: Resilient Bangkok Strategy*.

Banu, S., Hu, W., Guo, Y., Hurst, C., & Tong, S. (2014). Projecting the impact of climate change on dengue transmission in Dhaka, Bangladesh. *Environment International*, *63*, 137–142. https://doi.org/10.1016/J.ENVINT.2013.11.002

Berrang-Ford, L., Pearce, T., & Ford, J. D. (2015). Systematic review approaches for climate change adaptation research. *Regional Environmental Change 2015 15:5*, *15*(5), 755–769. https://doi.org/10.1007/S10113-014-0708-7

Biesbroek, G. R., Swart, R. J., & van der Knaap, W. G. M. (2009). The mitigation–adaptation dichotomy and the role of spatial planning. *Habitat International*, *33*(3), 230–237. https://doi.org/10.1016/J.HABITATINT.2008.10.001

Birkmann, J., Sauter, H., Garschagen, M., Fleischhauer, M., Puntub, W., Klose, C., Burkhardt, A., Göttsche, F., Laranjeira, K., Müller, J., & Büter, B. (2021). New methods for local vulnerability scenarios to heat stress to inform urban planning—case study City of Ludwigsburg/Germany. *Climatic Change*, *165*(1–2), 1–20. https://doi.org/10.1007/S10584-021-03005-3/FIGURES/6

Birkmann, J., Sauter, H., Jamshed, A., Sorg, L., Fleischhauer, M., Sandholz, S., Wannewitz, M., Greiving, S., Bueter, B., Schneider, M., & Garschagen, M. (2020). Strengthening risk-informed decision-making: scenarios for human vulnerability and exposure to extreme events. *Disaster Prevention and Management: An International Journal*, *29*(5), 663–679. https://doi.org/10.1108/DPM-05-2020-0147/FULL/PDF

Borris, M., Leonhardt, G., Marsalek, J., Österlund, H., & Viklander, M. (2016). Source-Based Modeling Of Urban Stormwater Quality Response to the Selected Scenarios Combining Future Changes in Climate and Socio-Economic Factors. *Environmental Management*, *58*(2), 223–237. https://doi.org/10.1007/S00267-016-0705-3/TABLES/7

Bulkeley, H. (2010). Cities and the Governing of Climate Change. *Http://Dx.Doi.Org/10.1146/Annurev-Environ-072809-101747*, *35*, 229–253. https://doi.org/10.1146/ANNUREV-ENVIRON-072809-101747

Bulkeley, H. (2021). Climate changed urban futures: environmental politics in the anthropocene city. *Https://Doi.Org/10.1080/09644016.2021.1880713*, *30*(1–2), 266–284. https://doi.org/10.1080/09644016.2021.1880713

Bulkeley, H., Carmin, J. A., Castán Broto, V., Edwards, G. A. S., & Fuller, S. (2013). Climate justice and global cities: Mapping the emerging discourses. *Global Environmental Change*, *23*(5), 914–925. https://doi.org/10.1016/J.GLOENVCHA.2013.05.010

Butler, J. R. A., Bergseng, A. M., Bohensky, E., Pedde, S., Aitkenhead, M., & Hamden, R. (2020). Adapting scenarios for climate adaptation: Practitioners' perspectives on a popular planning method. *Environmental Science & Policy*, *104*, 13–19. https://doi.org/10.1016/J.ENVSCI.2019.10.014

C40 Cities. (n.d.). *Climate Action Planning Framework*. Retrieved May 10, 2022, from https://resourcecentre.c40.org/_app/breezy-summer-3041/preview/climate-action-planning-framework-home

C40 Cities Climate Leadership Group, & C40 Knowledge Hub. (n.d.). *How to set up monitoring, evaluation and reporting for your city's climate action plan*. Retrieved May 10, 2022, from https://www.c40knowledgehub.org/s/guide-navigation?language=en_US&guideArticleRecordId=a3s1Q000001iaiaQAA&guideRecordId=a3t1Q0000007lEWQAY

Casal-Campos, A., Fu, G., Butler, D., & Moore, A. (2015). An Integrated Environmental Assessment of Green and Gray Infrastructure Strategies for Robust Decision Making. *Environmental Science and Technology*, *49*(14), 8307–8314. https://doi.org/10.1021/ES506144F/SUPPL_FILE/ES506144F_SI_001.PDF

Castán Broto, V. (2017). Urban Governance and the Politics of Climate change. *World Development*, *93*, 1–15. https://doi.org/10.1016/J.WORLDDEV.2016.12.031

Castán Broto, V., & Robin, E. (2020). Climate urbanism as critical urban theory. *Https://Doi.Org/10.1080/02723638.2020.1850617*, *42*(6), 715–720. https://doi.org/10.1080/02723638.2020.1850617

Castán Broto, V., & Westman, L. K. (2020). Ten years after Copenhagen: Reimagining climate change governance in urban areas. *Wiley Interdisciplinary Reviews: Climate Change*, *11*(4), e643. https://doi.org/10.1002/WCC.643

Chen, K., Horton, R. M., Bader, D. A., Lesk, C., Jiang, L., Jones, B., Zhou, L., Chen, X., Bi, J., & Kinney, P. L. (2017). Impact of climate change on heat-related mortality in Jiangsu Province, China. *Environmental Pollution*, *224*, 317–325. https://doi.org/10.1016/J.ENVPOL.2017.02.011

Chen, X., Zhang, H., Chen, W., & Huang, G. (2021). Urbanization and climate change impacts on future flood risk in the Pearl River Delta under shared socioeconomic pathways. *Science of The Total Environment*, *762*, 143144. https://doi.org/10.1016/J.SCITOTENV.2020.143144

Chu, A., Lin, Y. C., & Chiueh, P. te. (2017). Incorporating the effect of urbanization in measuring climate adaptive capacity. *Land Use Policy*, *68*, 28–38. https://doi.org/10.1016/J.LANDUSEPOL.2017.07.019

Chu, E. K., & Cannon, C. E. (2021). Equity, inclusion, and justice as criteria for decision-making on climate adaptation in cities. *Current Opinion in Environmental Sustainability*, *51*, 85–94. https://doi.org/10.1016/J.COSUST.2021.02.009

City and County of San Francisco. (2016). *Resilient San Francisco*.

City Government of Davao. (2014). *Davao City Climate Change Action Plan (LCCAP)*.

City of London. (2010). *The City of London Climate Change Adaptation Strategy*.

City of Melbourne. (2009). *City of Melbourne Climate Change Adaptation Strategy*.

City of Melbourne. (2017). *City of Melbourne Climate Change Adaptation Strategy REFRESH*.

City of New Orleans. (2016). *New Orleans Master Plan*.

City of Rotterdam. (2013). *Rotterdam Climate Change Adaptation Strategy*.

City of Virginia Beach. (2016). *City of Virginia Beach Comprehensive Plan*.

Ciumasu, I. M. (2013). Dynamic decision trees for building resilience into future eco-cities. *Technological Forecasting and Social Change*, *80*(9), 1804–1814. https://doi.org/10.1016/J.TECHFORE.2012.12.010

Climate ADAPT. (n.d.). *Urban adaptation support tool*. Retrieved March 10, 2022, from https://climate-adapt.eea.europa.eu/knowledge/tools/urban-ast/step-0-0

Deetjen, T. A., Conger, J. P., Leibowicz, B. D., & Webber, M. E. (2018). Review of climate action plans in 29 major U.S. cities: Comparing current policies to research recommendations. *Sustainable Cities and Society*, *41*, 711–727. https://doi.org/10.1016/J.SCS.2018.06.023

Dessai, S., Lu, X., & Risbey, J. S. (2005). On the role of climate scenarios for adaptation planning. *Global Environmental Change*, *15*(2), 87–97. https://doi.org/10.1016/J.GLOENVCHA.2004.12.004

Dhar, T. K., & Khirfan, L. (2016). Climate change adaptation in the urban planning and design research: missing links and research agenda. *Https://Doi-Org.Zorac.Aub.Aau.Dk/10.1080/09640568.2016.1178107*, *60*(4), 602–627. https://doi.org/10.1080/09640568.2016.1178107

Dodman, D., B. Hayward, M. Pelling, V. Castan Broto, W. Chow, E. Chu, R. Dawson, L. Khirfan, T. McPhearson, A. Prakash, Y. Zheng, and G. Ziervogel, 2022: Cities, Settlements and Key Infrastructure. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., & Lim, W. M. (2021). How to conduct a bibliometric analysis: An overview and guidelines. *Journal of Business Research*, *133*, 285–296. https://doi.org/10.1016/J.JBUSRES.2021.04.070

Dubey, A. K., Lal, P., Kumar, P., Kumar, A., & Dvornikov, A. Y. (2021). Present and future projections of heatwave hazard-risk over India: A regional earth system model assessment. *Environmental Research*, *201*, 111573. https://doi.org/10.1016/J.ENVRES.2021.111573

Egger, C., & Maurer, M. (2015). Importance of anthropogenic climate impact, sampling error and urban development in sewer system design. *Water Research*, *73*, 78–97. https://doi.org/10.1016/J.WATRES.2014.12.050

El-Fadel, M., & Ghanimeh, S. (2013). Climate change and temperature rise in the Greater Beirut Area: Implications on heat-related premature mortality. *Regional Environmental Change*, *13*(5), 1059–1067. https://doi.org/10.1007/S10113-013-0415-9/TABLES/4

Farthing, S. M. (2016). *Research Design in Urban Planning: A Student's Guide*. Sage.

Ford, J. D., & Berrang-Ford, L. (2016). The 4Cs of adaptation tracking: consistency, comparability, comprehensiveness, coherency. *Mitigation and Adaptation Strategies for Global Change*, *21*(6), 839–859. https://doi.org/10.1007/S11027-014-9627-7/TABLES/4

Frame, B., Lawrence, J., Ausseil, A. G., Reisinger, A., & Daigneault, A. (2018). Adapting global shared socio-economic pathways for national and local scenarios. *Climate Risk Management*, *21*, 39–51. https://doi.org/10.1016/J.CRM.2018.05.001

Füssel, H. M. (2007). Adaptation planning for climate change: Concepts, assessment approaches, and key lessons. *Sustainability Science*, *2*(2), 265–275. https://doi.org/10.1007/S11625-007-0032-Y/FIGURES/3

Gonda, N. (2019). Re-politicizing the gender and climate change debate: The potential of feminist political ecology to engage with power in action in adaptation policies and projects in Nicaragua. *Geoforum*, *106*, 87–96. https://doi.org/10.1016/J.GEOFORUM.2019.07.020

Grafakos, S., Viero, G., Reckien, D., Trigg, K., Viguie, V., Sudmant, A., Graves, C., Foley, A., Heidrich, O., Mirailles, J. M., Carter, J., Chang, L. H., Nador, C., Liseri, M., Chelleri, L., Orru, H., Orru, K., Aelenei, R., Bilska, A., … Dawson, R. (2020). Integration of mitigation and adaptation in urban climate change action plans in Europe: A systematic assessment. *Renewable and Sustainable Energy Reviews*, *121*, 109623. https://doi.org/10.1016/J.RSER.2019.109623

Granberg, M., & Glover, L. (2021). The Climate Just City. *Sustainability 2021, Vol. 13, Page 1201*, *13*(3), 1201. https://doi.org/10.3390/SU13031201

Grant, M. J., & Booth, A. (2009). A typology of reviews: an analysis of 14 review types and associated methodologies. *Health Information & Libraries Journal*, *26*(2), 91–108. https://doi.org/10.1111/J.1471-1842.2009.00848.X

Haasnoot, M., Kwakkel, J. H., Walker, W. E., & ter Maat, J. (2013). Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world. *Global Environmental Change*, *23*(2), 485–498. https://doi.org/10.1016/J.GLOENVCHA.2012.12.006

Haddaway, N. R., Bethel, A., Dicks, L. v., Koricheva, J., Macura, B., Petrokofsky, G., Pullin, A. S., Savilaakso, S., & Stewart, G. B. (2020). Eight problems with literature reviews and how to fix them. *Nature Ecology & Evolution 2020 4:12*, *4*(12), 1582–1589. https://doi.org/10.1038/s41559-020-01295-x

Hadipour, V., Vafaie, F., & Kerle, N. (2020). An indicator-based approach to assess social vulnerability of coastal areas to sea-level rise and flooding: A case study of Bandar Abbas city, Iran. *Ocean & Coastal Management*, *188*, 105077. https://doi.org/10.1016/J.OCECOAMAN.2019.105077

Hausfather, Z. (2018). *Explainer: How 'Shared Socioeconomic Pathways' explore future climate change*. Carbon Brief. https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change

Heffron, R. J. (2021). What is the "Just Transition"? *Achieving a Just Transition to a Low-Carbon Economy*, 9–19. https://doi.org/10.1007/978-3-030-89460-3_2

Hemmati, M., Mahmoud, H. N., Ellingwood, B. R., & Crooks, A. T. (2021). Shaping urbanization to achieve communities resilient to floods. *Environmental Research Letters*, *16*(9), 094033. https://doi.org/10.1088/1748-9326/AC1E3C

Hrelja, R., Hjerpe, M., & Storbjörk, S. (2015). Creating Transformative Force? The Role of Spatial Planning in Climate Change Transitions Towards Sustainable Transportation. *Http://Dx.Doi.Org/10.1080/1523908X.2014.1003535*, *17*(5), 617–635. https://doi.org/10.1080/1523908X.2014.1003535

Huang, C., Barnett, A. G., Wang, X., Vaneckova, P., Fitzgerald, G., & Tong, S. (2011). Projecting Future heat-related mortality under climate change scenarios: A systematic review. *Environmental Health Perspectives*, *119*(12), 1681–1690. https://doi.org/10.1289/EHP.1103456

Hughes, S. (2020). Principles, drivers, and policy tools for just climate change adaptation in legacy cities. *Environmental Science & Policy*, *111*, 35–41. https://doi.org/10.1016/J.ENVSCI.2020.05.007

Hughes, S., & Hoffmann, M. (2020). Just urban transitions: Toward a research agenda. *Wiley Interdisciplinary Reviews: Climate Change*, *11*(3), e640. https://doi.org/10.1002/WCC.640

Hurlimann, A. C., & March, A. P. (2012). The role of spatial planning in adapting to climate change. *Wiley Interdisciplinary Reviews: Climate Change*, *3*(5), 477–488. https://doi.org/10.1002/WCC.183

IIASA. (2018, December). *SSP Database (Shared Socioeconomic Pathways) - Version 2.0*. https://secure.iiasa.ac.at/web-apps/ene/SspDb/dsd?Action=htmlpage&page=about

Instituto Pólis. (2015). *Plano de Ação Vitória Sustentável*.

IPCC. (2014). *Climate Change 2014 Mitigation of Climate Change - Summary for Policymakers*.

IPCC. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability*. https://www.ipcc.ch/report/ar6/wg2/

Jiang, Y., Hou, L., Shi, T., & Gui, Q. (2017). A Review of Urban Planning Research for Climate Change. *Sustainability 2017, Vol. 9, Page 2224*, *9*(12), 2224. https://doi.org/10.3390/SU9122224

Jones, B., & O'Neill, B. C. (2016). Spatially explicit global population scenarios consistent with the Shared Socioeconomic Pathways. *Environmental Research Letters*, *11*(8), 084003. https://doi.org/10.1088/1748-9326/11/8/084003

Jurgilevich, A., Räsänen, A., & Juhola, S. (2021). Assessing the dynamics of urban vulnerability to climate change: Case of Helsinki, Finland. *Environmental Science & Policy*, *125*, 32–43. https://doi.org/10.1016/J.ENVSCI.2021.08.002

Jurjonas, M., Seekamp, E., Rivers, L., & Cutts, B. (2020). Uncovering climate (in)justice with an adaptive capacity assessment: A multiple case study in rural coastal North Carolina. *Land Use Policy*, *94*, 104547. https://doi.org/10.1016/J.LANDUSEPOL.2020.104547

Kamei, M., Mastrucci, A., & van Ruijven, B. J. (2021). A Future Outlook of Narratives for the Built Environment in Japan. *Sustainability 2021, Vol. 13, Page 1653*, *13*(4), 1653. https://doi.org/10.3390/SU13041653

Kauffman, N., & Hill, K. (2021). Climate Change, Adaptation Planning and Institutional Integration: A Literature Review and Framework. *Sustainability 2021, Vol. 13, Page 10708*, *13*(19), 10708. https://doi.org/10.3390/SU131910708

Kriegler, E., O'Neill, B. C., Hallegatte, S., Kram, T., Lempert, R. J., Moss, R. H., & Wilbanks, T. (2012). The need for and use of socio-economic scenarios for climate change analysis: A new approach based on shared socio-economic pathways. *Global Environmental Change*, *22*(4), 807–822. https://doi.org/10.1016/J.GLOENVCHA.2012.05.005

Krummenauer, L., Costa, L., Prahl, B. F., & Kropp, J. P. (2021). Future heat adaptation and exposure among urban populations and why a prospering economy alone won't save us. *Scientific Reports 2021 11:1*, *11*(1), 1–14. https://doi.org/10.1038/S41598-021-99757-0

Landreau, A., Juhola, S., Jurgilevich, A., & Räsänen, A. (2021). Combining socio-economic and climate projections to assess heat risk. *Climatic Change*, *167*(1–2), 1–20. https://doi.org/10.1007/S10584-021-03148-3/FIGURES/5

Lehmann, M., Major, D. C., Fitton, J. M., Doust, K., & O'Donoghue, S. (2021). Towards a typology for coastal towns and small cities for climate change adaptation planning. *Ocean & Coastal Management*, *212*, 105784. https://doi.org/10.1016/J.OCECOAMAN.2021.105784

Li, S., Juhász-Horváth, L., Pedde, S., Pintér, L., Rounsevell, M. D. A., & Harrison, P. A. (2017). Integrated modelling of urban spatial development under uncertain climate futures: A case study in Hungary. *Environmental Modelling & Software*, *96*, 251–264. https://doi.org/10.1016/J.ENVSOFT.2017.07.005

Long, J., & Rice, J. L. (2018). From sustainable urbanism to climate urbanism: *Https://Doi.Org/10.1177/0042098018770846*, *56*(5), 992–1008. https://doi.org/10.1177/0042098018770846

Madsen, S. H. J., & Hansen, T. (2018). Cities and climate change – examining advantages and challenges of urban climate change experiments. *Https://Doi-Org.Zorac.Aub.Aau.Dk/10.1080/09654313.2017.1421907*, *27*(2), 282–299. https://doi.org/10.1080/09654313.2017.1421907

Malloy, J. T., & Ashcraft, C. M. (2020). A framework for implementing socially just climate adaptation. *Climatic Change*, *160*(1), 1–14. https://doi.org/10.1007/S10584-020-02705-6/TABLES/3

Manocha, N., & Babovic, V. (2017). Development and valuation of adaptation pathways for storm water management infrastructure. *Environmental Science & Policy*, *77*, 86–97. https://doi.org/10.1016/J.ENVSCI.2017.08.001

Mayor's Office of Sustainability, & ICF International. (2015). *Growing Stronger: Toward a Climate Ready Philadelphia*.

Meckling, J., & Allan, B. B. (2020). The evolution of ideas in global climate policy. *Nature Climate Change 2020 10:5*, *10*(5), 434–438. https://doi.org/10.1038/s41558-020-0739-7

Meerow, S., Newell, J. P., & Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning*, *147*, 38–49. https://doi.org/10.1016/J.LANDURBPLAN.2015.11.011

Metropolitan Washington Council of Governments. (2008). *National Capital Region Climate Change Report*.

Meyer, I., Hama, M., Jandl, R., Leitner, M., Keuschnig, M., Anders, I., Fritz, O., Berthold, H., & Eder, B. (2019). Co-creating a desirable and resilient future for Lienz, Austria—a local case study in socio-economic scenario development. *Regional Environmental Change*, *19*(4), 1059–1071. https://doi.org/10.1007/S10113-018-1439-Y/FIGURES/1

Mohtat, N., & Khirfan, L. (2021). The climate justice pillars vis-à-vis urban form adaptation to climate change: A review. *Urban Climate*, *39*, 100951. https://doi.org/10.1016/J.UCLIM.2021.100951

Moss, R. H., Edmonds, J. A., Hibbard, K. A., Manning, M. R., Rose, S. K., van Vuuren, D. P., Carter, T. R., Emori, S., Kainuma, M., Kram, T., Meehl, G. A., Mitchell, J. F. B., Nakicenovic, N., Riahi, K., Smith, S. J., Stouffer, R. J., Thomson, A. M., Weyant, J. P., & Wilbanks, T. J. (2010). The next generation of scenarios for climate change research and assessment. *Nature 2010 463:7282*, *463*(7282), 747–756. https://doi.org/10.1038/nature08823

New, M., D. Reckien, D. Viner, C. Adler, S.-M. Cheong, C. Conde, A. Constable, E. Coughlan de Perez, A. Lammel, R. Mechler, B. Orlove, and W. Solecki, 2022: Decision Making Options for Managing Risk. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

Olazabal, M., Chu, E., Castán Broto, V., & Patterson, J. (2021). Subaltern forms of knowledge are required to boost local adaptation. *One Earth*, *4*(6), 828–838. https://doi.org/10.1016/J.ONEEAR.2021.05.006

Olazabal, M., Galarraga, I., Ford, J., Sainz De Murieta, E., & Lesnikowski, A. (2019). Are local climate adaptation policies credible? A conceptual and operational assessment framework. *Https://Doi-Org.Zorac.Aub.Aau.Dk/10.1080/19463138.2019.1583234*, *11*(3), 277–296. https://doi.org/10.1080/19463138.2019.1583234

Olazabal, M., Ruiz De Gopegui, M., Tompkins, E. L., Venner, K., & Smith, R. (2019). A cross-scale worldwide analysis of coastal adaptation planning. *Environmental Research Letters*, *14*(12), 124056. https://doi.org/10.1088/1748-9326/AB5532

O'Neill, B. C., Kriegler, E., Riahi, K., Ebi, K. L., Hallegatte, S., Carter, T. R., Mathur, R., & van Vuuren, D. P. (2014). A new scenario framework for climate change research: The concept of shared

socioeconomic pathways. *Climatic Change*, *122*(3), 387–400. https://doi.org/10.1007/S10584-013-0905-2/TABLES/2

O'Neill, B., van Vuuren, D. P., Riahi, K., Calvin, K., Dellink, R., Emmerling, J., Fujimori, S., KC, S., & Kriegler, E. (2017). The Shared Socio-economic Pathways: Trajectories for human development and global environmental change. *Global Environmental Change*, *42*, 148–152. https://doi.org/10.1016/J.GLOENVCHA.2016.10.009

Otto, A., Göpfert, C., & Thieken, A. H. (2021). Are cities prepared for climate change? An analysis of adaptation readiness in 104 German cities. *Mitigation and Adaptation Strategies for Global Change*, *26*(8), 1–25. https://doi.org/10.1007/S11027-021-09971-4/FIGURES/6

Parandvash, G. H., & Chang, H. (2016). Analysis of long-term climate change on per capita water demand in urban versus suburban areas in the Portland metropolitan area, USA. *Journal of Hydrology*, *538*, 574–586. https://doi.org/10.1016/J.JHYDROL.2016.04.035

Park, C. Y., Thorne, J. H., Hashimoto, S., Lee, D. K., & Takahashi, K. (2021). Differing spatial patterns of the urban heat exposure of elderly populations in two megacities identifies alternate adaptation strategies. *Science of The Total Environment*, *781*, 146455. https://doi.org/10.1016/J.SCITOTENV.2021.146455

Parkinson, S. C., Johnson, N., Rao, N. D., Jones, B., van Vliet, M. T. H., Fricko, O., Djilali, N., Riahi, K., & Flörke, M. (2016). Climate and human development impacts on municipal water demand: A spatially-explicit global modeling framework. *Environmental Modelling & Software*, *85*, 266–278. https://doi.org/10.1016/J.ENVSOFT.2016.08.002

Peng, L., & Li, Z. (2021). Ensemble Flood Risk Assessment in the Yangtze River Economic Belt under CMIP6 SSP-RCP Scenarios. *Sustainability 2021, Vol. 13, Page 12097*, *13*(21), 12097. https://doi.org/10.3390/SU132112097

Poot, J., & Pawar, S. (2013). Is Demography Destiny? Urban Population Change and Economic Vitality of Future Cities. *Journal of Urban Management*, *2*(1), 5–23. https://doi.org/10.1016/S2226-5856(18)30062-1

Ranganathan, M., & Bratman, E. (2021). From Urban Resilience to Abolitionist Climate Justice in Washington, DC. *Antipode*, *53*(1), 115–137. https://doi.org/10.1111/ANTI.12555

Reckien, D., Lwasa, S., Satterthwaite, D., McEvoy, D., Creutzig, F., Montgomery, M., Schensul, D., Balk, D., & Khan, I. (2018). Equity, environmental justice, and urban climate change. In *Climate Change and Cities: Second Assessment Report of the Urban Climate Change Research Network* (pp. 173–224). Cambridge University Press.

Reckien, D., Salvia, M., Heidrich, O., Church, J. M., Pietrapertosa, F., de Gregorio-Hurtado, S., D'Alonzo, V., Foley, A., Simoes, S. G., Krkoška Lorencová, E., Orru, H., Orru, K., Wejs, A., Flacke, J., Olazabal, M., Geneletti, D., Feliu, E., Vasilie, S., Nador, C., … Dawson, R. (2018). How are cities planning to respond to climate change? Assessment of local climate plans from 885 cities in the EU-28. *Journal of Cleaner Production*, *191*, 207–219. https://doi.org/10.1016/J.JCLEPRO.2018.03.220

Regional Plan Association. (2017). *The Fourth Regional Plan*.

Reimann, L., Jones, B., Nikoletopoulos, T., & Vafeidis, A. T. (2021). Accounting for internal migration in spatial population projections—a gravity-based modeling approach using the Shared

Socioeconomic Pathways. *Environmental Research Letters*, *16*(7), 074025. https://doi.org/10.1088/1748-9326/AC0B66

Reimann, L., Vollstedt, B., Koerth, J., Tsakiris, M., Beer, M., & Vafeidis, A. T. (2021). Extending the Shared Socioeconomic Pathways (SSPs) to support local adaptation planning—A climate service for Flensburg, Germany. *Futures*, *127*, 102691. https://doi.org/10.1016/J.FUTURES.2020.102691

Riahi, K., van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., Fujimori, S., Bauer, N., Calvin, K., Dellink, R., Fricko, O., Lutz, W., Popp, A., Cuaresma, J. C., KC, S., Leimbach, M., Jiang, L., Kram, T., Rao, S., Emmerling, J., … Tavoni, M. (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. *Global Environmental Change*, *42*, 153–168. https://doi.org/10.1016/J.GLOENVCHA.2016.05.009

Rio Prefeitura, Centro Clima, & Coppe UFRJ. (2016). *Climate Change Adaptation Strategy for the City of Rio de Janeiro*.

Robin, E., & Castán Broto, V. (2021). TOWARDS A POSTCOLONIAL PERSPECTIVE ON CLIMATE URBANISM. *International Journal of Urban and Regional Research*, *45*(5), 869–878. https://doi.org/10.1111/1468-2427.12981

Rohat, G., Flacke, J., Dosio, A., Dao, H., & van Maarseveen, M. (2019). Projections of Human Exposure to Dangerous Heat in African Cities Under Multiple Socioeconomic and Climate Scenarios. *Earth's Future*, *7*(5), 528–546. https://doi.org/10.1029/2018EF001020

Rohat, G., Wilhelmi, O., Flacke, J., Monaghan, A., Gao, J., Dao, H., & van Maarseveen, M. (2019). Characterizing the role of socioeconomic pathways in shaping future urban heat-related challenges. *Science of The Total Environment*, *695*, 133941. https://doi.org/10.1016/J.SCITOTENV.2019.133941

Rohat, G., Wilhelmi, O., Flacke, J., Monaghan, A., Gao, J., van Maarseveen, M., & Dao, H. (2021). Assessing urban heat-related adaptation strategies under multiple futures for a major U.S. city. *Climatic Change*, *164*(3–4), 1–20. https://doi.org/10.1007/S10584-021-02990-9/FIGURES/6

Ronco, P., Gallina, V., Torresan, S., Zabeo, A., Semenzin, E., Critto, A., & Marcomini, A. (2014). The KULTURisk Regional Risk Assessment methodology for water-related natural hazards - Part 1: Physical-environmental assessment. *Hydrology and Earth System Sciences*, *18*(12), 5399–5414. https://doi.org/10.5194/HESS-18-5399-2014

Rudge, K. (2021). Participatory climate adaptation planning in New York City: Analyzing the role of community-based organizations. *Urban Climate*, *40*, 101018. https://doi.org/10.1016/J.UCLIM.2021.101018

Samir, K., & Lutz, W. (2017). The human core of the shared socioeconomic pathways: Population scenarios by age, sex and level of education for all countries to 2100. *Global Environmental Change*, *42*, 181–192. https://doi.org/10.1016/J.GLOENVCHA.2014.06.004

Sampson, D. A., Quay, R., & White, D. D. (2016). Anticipatory modeling for water supply sustainability in Phoenix, Arizona. *Environmental Science & Policy*, *55*(P1), 36–46. https://doi.org/10.1016/J.ENVSCI.2015.08.014

Schipper, E.L.F., A. Revi, B.L. Preston, E.R. Carr, S.H. Eriksen, L.R. Fernandez-Carril, B. Glavovic, N.J.M. Hilmi, D. Ley, R. Mukerji, M.S. Muylaert de Araujo, R. Perez, S.K. Rose, and P.K. Singh, 2022:

Climate Resilient Development Pathways. In:*Climate Change 2022: Impacts, Adaptation, and Vulnerability.* Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press. In Press.

Seattle Office of Sustainability & Environment. (2017). *Seattle Climate Preparedness Strategy*.

Shi, L. (2021). From Progressive Cities to Resilient Cities: Lessons from History for New Debates in Equitable Adaptation to Climate Change. *Urban Affairs Review*, *57*(5), 1442–1479. https://doi.org/10.1177/1078087419910827

Shi, L., Chu, E., Anguelovski, I., Aylett, A., Debats, J., Goh, K., Schenk, T., Seto, K. C., Dodman, D., Roberts, D., Roberts, J. T., & van Deveer, S. D. (2016). Roadmap towards justice in urban climate adaptation research. *Nature Climate Change 2016 6:2*, *6*(2), 131–137. https://doi.org/10.1038/NCLIMATE2841

Steele, W., Maccallum, D., Byrne, J., & Houston, D. (2012). Planning the Climate-just City. *Http://Dx.Doi.Org/10.1080/13563475.2011.638188*, *17*(1), 67–83. https://doi.org/10.1080/13563475.2011.638188

Swanson, K. (2021). Equity in Urban Climate Change Adaptation Planning: A Review of Research. *Urban Planning*, *6*(4), 287–297. https://doi.org/10.17645/UP.V6I4.4399

Terama, E., Clarke, E., Rounsevell, M. D. A., Fronzek, S., & Carter, T. R. (2019). Modelling population structure in the context of urban land use change in Europe. *Regional Environmental Change*, *19*(3), 667–677. https://doi.org/10.1007/S10113-017-1194-5/FIGURES/6

The City of New York. (2014). *NYC Hazard Mitigation Plan*.

The City of New York. (2015). *OneNYC*.

Thomas, K. A., & Warner, B. P. (2019). Weaponizing vulnerability to climate change. *Global Environmental Change*, *57*, 101928. https://doi.org/10.1016/J.GLOENVCHA.2019.101928

Urich, C., & Rauch, W. (2014). Exploring critical pathways for urban water management to identify robust strategies under deep uncertainties. *Water Research*, *66*, 374–389. https://doi.org/10.1016/J.WATRES.2014.08.020

Vaismoradi, M., Turunen, H., & Bondas, T. (2013). Content analysis and thematic analysis: Implications for conducting a qualitative descriptive study. *Nursing & Health Sciences*, *15*(3), 398–405. https://doi.org/10.1111/NHS.12048

van Ruijven, B. J., Levy, M. A., Agrawal, A., Biermann, F., Birkmann, J., Carter, T. R., Ebi, K. L., Garschagen, M., Jones, B., Jones, R., Kemp-Benedict, E., Kok, M., Kok, K., Lemos, M. C., Lucas, P. L., Orlove, B., Pachauri, S., Parris, T. M., Patwardhan, A., … Schweizer, V. J. (2014). Enhancing the relevance of shared socioeconomic pathways for climate change impacts, adaptation and vulnerability research. *Climatic Change*, *122*(3), 481–494. https://doi.org/10.1007/S10584-013-0931-0/TABLES/1

van Vuuren, D. P., Kriegler, E., O'Neill, B. C., Ebi, K. L., Riahi, K., Carter, T. R., Edmonds, J., Hallegatte, S., Kram, T., Mathur, R., & Winkler, H. (2014). A new scenario framework for Climate Change Research: Scenario matrix architecture. *Climatic Change*, *122*(3), 373–386. https://doi.org/10.1007/S10584-013-0906-1/FIGURES/6

Ville de Dakar, & 100 Resilient Cities. (2017). *Dakar Resilience Strategy*.

VOSviewer. (2022). *VOSviewer - Visualizing scientific landscapes*. https://www.vosviewer.com/

Walker, W. E., Haasnoot, M., & Kwakkel, J. H. (2013). Adapt or Perish: A Review of Planning Approaches for Adaptation under Deep Uncertainty. *Sustainability 2013, Vol. 5, Pages 955-979*, *5*(3), 955–979. https://doi.org/10.3390/SU5030955

Wan, S., Radhakrishnan, M., Zevenbergen, C., & Pathirana, A. (2020). Capturing the changing dynamics between governmental actions across plausible future scenarios in urban water systems. *Sustainable Cities and Society*, *62*, 102318. https://doi.org/10.1016/J.SCS.2020.102318

Werners, S. E., Wise, R. M., Butler, J. R. A., Totin, E., & Vincent, K. (2021). Adaptation pathways: A review of approaches and a learning framework. *Environmental Science & Policy*, *116*, 266–275. https://doi.org/10.1016/J.ENVSCI.2020.11.003

Westman, L., & Castán Broto, V. (2021). Transcending existing paradigms: the quest for justice in urban climate change planning. *Https://Doi-Org.Zorac.Aub.Aau.Dk/10.1080/13549839.2021.1916903*, *26*(5), 536–541. https://doi.org/10.1080/13549839.2021.1916903

Westman, L., Patterson, J., Macrorie, R., Orr, C. J., Ashcraft, C. M., Castán Broto, V., Dolan, D., Gupta, M., van der Heijden, J., Hickmann, T., Hobbins, R., Papin, M., Robin, E., Rosan, C., Torrens, J., & Webb, R. (2022). Compound urban crises. *Ambio*. https://doi.org/10.1007/S13280-021-01697-6

Wolff, C., Nikoletopoulos, T., Hinkel, J., & Vafeidis, A. T. (2020). Future urban development exacerbates coastal exposure in the Mediterranean. *Scientific Reports 2020 10:1*, *10*(1), 1–11. https://doi.org/10.1038/S41598-020-70928-9

Xu, L., Cui, S., Wang, X., Tang, J., Nitivattananon, V., Ding, S., & Nguyen Nguyen, M. (2021). Dynamic risk of coastal flood and driving factors: Integrating local sea level rise and spatially explicit urban growth. *Journal of Cleaner Production*, *321*, 129039. https://doi.org/10.1016/J.JCLEPRO.2021.129039

Yan, B., Li, S., Wang, J., Ge, Z., & Zhang, L. (2016). Socio-economic vulnerability of the megacity of Shanghai (China) to sea-level rise and associated storm surges. *Regional Environmental Change*, *16*(5), 1443–1456. https://doi.org/10.1007/S10113-015-0878-Y/TABLES/5

Zhu, M., Zhang, Z., Zhu, B., Kong, R., Zhang, F., Tian, J., & Jiang, T. (2020). Population and Economic Projections in the Yangtze River Basin Based on Shared Socioeconomic Pathways. *Sustainability 2020, Vol. 12, Page 4202*, *12*(10), 4202. https://doi.org/10.3390/SU12104202

Appendix A: Systematic Review Included and Excluded Literature

This appendix lists the 41 publications that were included in the systematic review as well as the 76 publications that were excluded from the systematic review during the title and abstract review phase of the literature search and selection process. All data was collected from the Web of Science on February 28th, 2022.

Included Literature (41 publications)

Abadie, L. M. (2018). Sea level damage risk with probabilistic weighting of IPCC scenarios: An application to major coastal cities. Journal of Cleaner Production, 175, 582–598. https://doi.org/10.1016/J.JCLEPRO.2017.11.069

Apreda, C., D'Ambrosio, V., & di Martino, F. (2019). A climate vulnerability and impact assessment model for complex urban systems. Environmental Science & Policy, 93, 11–26. https://doi.org/10.1016/J.ENVSCI.2018.12.016

Banu, S., Hu, W., Guo, Y., Hurst, C., & Tong, S. (2014). Projecting the impact of climate change on dengue transmission in Dhaka, Bangladesh. Environment International, 63, 137–142. https://doi.org/10.1016/J.ENVINT.2013.11.002

Birkmann, J., Sauter, H., Garschagen, M., Fleischhauer, M., Puntub, W., Klose, C., Burkhardt, A., Göttsche, F., Laranjeira, K., Müller, J., & Büter, B. (2021). New methods for local vulnerability scenarios to heat stress to inform urban planning—case study City of Ludwigsburg/Germany. Climatic Change, 165(1–2), 1–20. https://doi.org/10.1007/S10584-021-03005-3/FIGURES/6

Birkmann, J., Sauter, H., Jamshed, A., Sorg, L., Fleischhauer, M., Sandholz, S., Wannewitz, M., Greiving, S., Bueter, B., Schneider, M., & Garschagen, M. (2020). Strengthening risk-informed decision-making: scenarios for human vulnerability and exposure to extreme events. Disaster Prevention and Management: An International Journal, 29(5), 663–679. https://doi.org/10.1108/DPM-05-2020-0147/FULL/PDF

Borris, M., Leonhardt, G., Marsalek, J., Österlund, H., & Viklander, M. (2016). Source-Based Modeling Of Urban Stormwater Quality Response to the Selected Scenarios Combining Future Changes in Climate and Socio-Economic Factors. Environmental Management, 58(2), 223–237. https://doi.org/10.1007/S00267-016-0705-3/TABLES/7

Casal-Campos, A., Fu, G., Butler, D., & Moore, A. (2015). An Integrated Environmental Assessment of Green and Gray Infrastructure Strategies for Robust Decision Making. Environmental Science and Technology, 49(14), 8307–8314. https://doi.org/10.1021/ES506144F/SUPPL_FILE/ES506144F_SI_001.PDF

Chen, K., Horton, R. M., Bader, D. A., Lesk, C., Jiang, L., Jones, B., Zhou, L., Chen, X., Bi, J., & Kinney, P. L. (2017). Impact of climate change on heat-related mortality in Jiangsu Province, China. Environmental Pollution, 224, 317–325. https://doi.org/10.1016/J.ENVPOL.2017.02.011

Chen, X., Zhang, H., Chen, W., & Huang, G. (2021). Urbanization and climate change impacts on future flood risk in the Pearl River Delta under shared socioeconomic pathways. Science of The Total Environment, 762, 143144. https://doi.org/10.1016/J.SCITOTENV.2020.143144

Chu, A., Lin, Y. C., & Chiueh, P. te. (2017). Incorporating the effect of urbanization in measuring climate adaptive capacity. Land Use Policy, 68, 28–38. https://doi.org/10.1016/J.LANDUSEPOL.2017.07.019

Ciumasu, I. M. (2013). Dynamic decision trees for building resilience into future eco-cities. Technological Forecasting and Social Change, 80(9), 1804–1814. https://doi.org/10.1016/J.TECHFORE.2012.12.010

Dubey, A. K., Lal, P., Kumar, P., Kumar, A., & Dvornikov, A. Y. (2021). Present and future projections of heatwave hazard-risk over India: A regional earth system model assessment. Environmental Research, 201, 111573. https://doi.org/10.1016/J.ENVRES.2021.111573

Egger, C., & Maurer, M. (2015). Importance of anthropogenic climate impact, sampling error and urban development in sewer system design. Water Research, 73, 78–97. https://doi.org/10.1016/J.WATRES.2014.12.050

El-Fadel, M., & Ghanimeh, S. (2013). Climate change and temperature rise in the Greater Beirut Area: Implications on heat-related premature mortality. Regional Environmental Change, 13(5), 1059–1067. https://doi.org/10.1007/S10113-013-0415-9/TABLES/4

Hadipour, V., Vafaie, F., & Kerle, N. (2020). An indicator-based approach to assess social vulnerability of coastal areas to sea-level rise and flooding: A case study of Bandar Abbas city, Iran. Ocean & Coastal Management, 188, 105077. https://doi.org/10.1016/J.OCECOAMAN.2019.105077

Hemmati, M., Mahmoud, H. N., Ellingwood, B. R., & Crooks, A. T. (2021). Shaping urbanization to achieve communities resilient to floods. Environmental Research Letters, 16(9), 094033. https://doi.org/10.1088/1748-9326/AC1E3C

Huang, C., Barnett, A. G., Wang, X., Vaneckova, P., Fitzgerald, G., & Tong, S. (2011). Projecting Future heat-related mortality under climate change scenarios: A systematic review. Environmental Health Perspectives, 119(12), 1681–1690. https://doi.org/10.1289/EHP.1103456

Jurgilevich, A., Räsänen, A., & Juhola, S. (2021). Assessing the dynamics of urban vulnerability to climate change: Case of Helsinki, Finland. Environmental Science & Policy, 125, 32–43. https://doi.org/10.1016/J.ENVSCI.2021.08.002

Kamei, M., Mastrucci, A., & van Ruijven, B. J. (2021). A Future Outlook of Narratives for the Built Environment in Japan. Sustainability 2021, Vol. 13, Page 1653, 13(4), 1653. https://doi.org/10.3390/SU13041653

Krummenauer, L., Costa, L., Prahl, B. F., & Kropp, J. P. (2021). Future heat adaptation and exposure among urban populations and why a prospering economy alone won't save us. Scientific Reports 2021 11:1, 11(1), 1–14. https://doi.org/10.1038/S41598-021-99757-0

Li, S., Juhász-Horváth, L., Pedde, S., Pintér, L., Rounsevell, M. D. A., & Harrison, P. A. (2017). Integrated modelling of urban spatial development under uncertain climate futures: A case study in Hungary. Environmental Modelling & Software, 96, 251–264. https://doi.org/10.1016/J.ENVSOFT.2017.07.005

Manocha, N., & Babovic, V. (2017). Development and valuation of adaptation pathways for storm water management infrastructure. Environmental Science & Policy, 77, 86–97. https://doi.org/10.1016/J.ENVSCI.2017.08.001

Meyer, I., Hama, M., Jandl, R., Leitner, M., Keuschnig, M., Anders, I., Fritz, O., Berthold, H., & Eder, B. (2019). Co-creating a desirable and resilient future for Lienz, Austria—a local case study in socio-

economic scenario development. Regional Environmental Change, 19(4), 1059–1071. https://doi.org/10.1007/S10113-018-1439-Y/FIGURES/1

Parandvash, G. H., & Chang, H. (2016). Analysis of long-term climate change on per capita water demand in urban versus suburban areas in the Portland metropolitan area, USA. Journal of Hydrology, 538, 574–586. https://doi.org/10.1016/J.JHYDROL.2016.04.035

Park, C. Y., Thorne, J. H., Hashimoto, S., Lee, D. K., & Takahashi, K. (2021). Differing spatial patterns of the urban heat exposure of elderly populations in two megacities identifies alternate adaptation strategies. Science of The Total Environment, 781, 146455. https://doi.org/10.1016/J.SCITOTENV.2021.146455

Parkinson, S. C., Johnson, N., Rao, N. D., Jones, B., van Vliet, M. T. H., Fricko, O., Djilali, N., Riahi, K., & Flörke, M. (2016). Climate and human development impacts on municipal water demand: A spatially-explicit global modeling framework. Environmental Modelling & Software, 85, 266–278. https://doi.org/10.1016/J.ENVSOFT.2016.08.002

Peng, L., & Li, Z. (2021). Ensemble Flood Risk Assessment in the Yangtze River Economic Belt under CMIP6 SSP-RCP Scenarios. Sustainability 2021, Vol. 13, Page 12097, 13(21), 12097. https://doi.org/10.3390/SU132112097

Reimann, L., Jones, B., Nikoletopoulos, T., & Vafeidis, A. T. (2021). Accounting for internal migration in spatial population projections—a gravity-based modeling approach using the Shared Socioeconomic Pathways. Environmental Research Letters, 16(7), 074025. https://doi.org/10.1088/1748-9326/AC0B66

Reimann, L., Vollstedt, B., Koerth, J., Tsakiris, M., Beer, M., & Vafeidis, A. T. (2021). Extending the Shared Socioeconomic Pathways (SSPs) to support local adaptation planning—A climate service for Flensburg, Germany. Futures, 127, 102691. https://doi.org/10.1016/J.FUTURES.2020.102691

Rohat, G., Flacke, J., Dosio, A., Dao, H., & van Maarseveen, M. (2019). Projections of Human Exposure to Dangerous Heat in African Cities Under Multiple Socioeconomic and Climate Scenarios. Earth's Future, 7(5), 528–546. https://doi.org/10.1029/2018EF001020

Rohat, G., Wilhelmi, O., Flacke, J., Monaghan, A., Gao, J., Dao, H., & van Maarseveen, M. (2019). Characterizing the role of socioeconomic pathways in shaping future urban heat-related challenges. Science of The Total Environment, 695, 133941. https://doi.org/10.1016/J.SCITOTENV.2019.133941

Rohat, G., Wilhelmi, O., Flacke, J., Monaghan, A., Gao, J., van Maarseveen, M., & Dao, H. (2021). Assessing urban heat-related adaptation strategies under multiple futures for a major U.S. city. Climatic Change, 164(3–4), 1–20. https://doi.org/10.1007/S10584-021-02990-9/FIGURES/6

Ronco, P., Gallina, V., Torresan, S., Zabeo, A., Semenzin, E., Critto, A., & Marcomini, A. (2014). The KULTURisk Regional Risk Assessment methodology for water-related natural hazards - Part 1: Physical-environmental assessment. Hydrology and Earth System Sciences, 18(12), 5399–5414. https://doi.org/10.5194/HESS-18-5399-2014

Sampson, D. A., Quay, R., & White, D. D. (2016). Anticipatory modeling for water supply sustainability in Phoenix, Arizona. Environmental Science & Policy, 55(P1), 36–46. https://doi.org/10.1016/J.ENVSCI.2015.08.014

Terama, E., Clarke, E., Rounsevell, M. D. A., Fronzek, S., & Carter, T. R. (2019). Modelling population structure in the context of urban land use change in Europe. Regional Environmental Change, 19(3), 667–677. https://doi.org/10.1007/S10113-017-1194-5/FIGURES/6

Urich, C., & Rauch, W. (2014). Exploring critical pathways for urban water management to identify robust strategies under deep uncertainties. Water Research, 66, 374–389. https://doi.org/10.1016/J.WATRES.2014.08.020

Wan, S., Radhakrishnan, M., Zevenbergen, C., & Pathirana, A. (2020). Capturing the changing dynamics between governmental actions across plausible future scenarios in urban water systems. Sustainable Cities and Society, 62, 102318. https://doi.org/10.1016/J.SCS.2020.102318

Wolff, C., Nikoletopoulos, T., Hinkel, J., & Vafeidis, A. T. (2020). Future urban development exacerbates coastal exposure in the Mediterranean. Scientific Reports 2020 10:1, 10(1), 1–11. https://doi.org/10.1038/S41598-020-70928-9

Xu, L., Cui, S., Wang, X., Tang, J., Nitivattananon, V., Ding, S., & Nguyen Nguyen, M. (2021). Dynamic risk of coastal flood and driving factors: Integrating local sea level rise and spatially explicit urban growth. Journal of Cleaner Production, 321, 129039. https://doi.org/10.1016/J.JCLEPRO.2021.129039

Yan, B., Li, S., Wang, J., Ge, Z., & Zhang, L. (2016). Socio-economic vulnerability of the megacity of Shanghai (China) to sea-level rise and associated storm surges. Regional Environmental Change, 16(5), 1443–1456. https://doi.org/10.1007/S10113-015-0878-Y/TABLES/5

Zhu, M., Zhang, Z., Zhu, B., Kong, R., Zhang, F., Tian, J., & Jiang, T. (2020). Population and Economic Projections in the Yangtze River Basin Based on Shared Socioeconomic Pathways. Sustainability 2020, Vol. 12, Page 4202, 12(10), 4202. https://doi.org/10.3390/SU12104202

Excluded Literature (76 publications)

Andrijevic, M., Byers, E., Mastrucci, A., Smits, J., & Fuss, S. (2021). Future cooling gap in shared socioeconomic pathways. Environmental Research Letters, 16(9), 094053. https://doi.org/10.1088/1748-9326/AC2195

Bai, Y., Wang, W., Hu, Y., & Wang, Z. (2021). County-level estimates of population and economic scenarios under the shared socioeconomic pathways: A case study in Inner Mongolia, China. Physics and Chemistry of the Earth, Parts A/B/C, 122, 103017. https://doi.org/10.1016/J.PCE.2021.103017

Baron, S., Hoek, J., Alves, I. K., & Herz, S. (2016). Comprehensive scenario management of sustainable spatial planning and urban water services. Water Science and Technology, 73(5), 1041–1051. https://doi.org/10.2166/WST.2015.578

Bhave, A. G., Conway, D., Dessai, S., & Stainforth, D. A. (2018). Water Resource Planning Under Future Climate and Socioeconomic Uncertainty in the Cauvery River Basin in Karnataka, India. Water Resources Research, 54(2), 708–728. https://doi.org/10.1002/2017WR020970

Cervelli, E., Scotto di Perta, E., & Pindozzi, S. (2020). Energy crops in marginal areas: Scenario-based assessment through ecosystem services, as support to sustainable development. Ecological Indicators, 113, 106180. https://doi.org/10.1016/J.ECOLIND.2020.106180

Cogo, E., Quaranta, N., Brunori, R., & frulla, D. (2021). SALINE INTRUSION: A POTENTIAL RISK FOR COASTAL AQUIFER MANAGEMENT IN SEA LEVEL RISE SCENARIOS THE CASE STUDY OF AN

ADAPTATION PLAN FOR THE MUNICIPALITY OF FANO. Italian Journal of Engineering Geology and Environment, 1, 61–69. https://doi.org/10.4408/IJEGE.2021-01.O-04

Colenbrander, S., Gouldson, A., Roy, J., Kerr, N., Sarkar, S., Hall, S., Sudmant, A., Ghatak, A., Chakravarty, D., Ganguly, D., & Mcanulla, F. (2016). Can low-carbon urban development be pro-poor? The case of Kolkata, India: Http://Dx.Doi.Org/10.1177/0956247816677775, 29(1), 139–158. https://doi.org/10.1177/0956247816677775

Ćulibrk, A., Tzoraki, O., & Portman, M. E. (2021). Adaptation of a freshwater evaluation framework to a coastal system: The case of Kamari, Santorini. Journal of Environmental Management, 288, 112406. https://doi.org/10.1016/J.JENVMAN.2021.112406

Dau, Q. v., & Adeloye, A. J. (2021). Water security implications of climate and socio-economic stressors for river basin management. Https://Doi.Org/10.1080/02626667.2021.1909032, 66(7), 1097–1112. https://doi.org/10.1080/02626667.2021.1909032

Davila, F., Bourke, R. M., McWilliam, A., Crimp, S., Robins, L., van Wensveen, M., Alders, R. G., & Butler, J. R. A. (2021). COVID-19 and food systems in Pacific Island Countries, Papua New Guinea, and Timor-Leste: Opportunities for actions towards the sustainable development goals. Agricultural Systems, 191, 103137. https://doi.org/10.1016/J.AGSY.2021.103137

de Cian, E., Pavanello, F., Randazzo, T., Mistry, M. N., & Davide, M. (2019). Households' adaptation in a warming climate. Air conditioning and thermal insulation choices. Environmental Science & Policy, 100, 136–157. https://doi.org/10.1016/J.ENVSCI.2019.06.015

Dong, N., Liu, Z., Luo, M., Fang, C., & Lin, H. (2019). The Effects of Anthropogenic Land Use Changes on Climate in China Driven by Global Socioeconomic and Emission Scenarios. Earth's Future, 7(7), 784–804. https://doi.org/10.1029/2018EF000932

Dong, N., You, L., Cai, W., Li, G., & Lin, H. (2018). Land use projections in China under global socioeconomic and emission scenarios: Utilizing a scenario-based land-use change assessment framework. Global Environmental Change, 50, 164–177. https://doi.org/10.1016/J.GLOENVCHA.2018.04.001

Du, S., Scussolini, P., Ward, P. J., Zhang, M., Wen, J., Wang, L., Koks, E., Diaz-Loaiza, A., Gao, J., Ke, Q., & Aerts, J. C. J. H. (2020). Hard or soft flood adaptation? Advantages of a hybrid strategy for Shanghai. Global Environmental Change, 61, 102037. https://doi.org/10.1016/J.GLOENVCHA.2020.102037

Dunford, R., Harrison, P. A., & Rounsevell, M. D. A. (2015). Exploring scenario and model uncertainty in cross-sectoral integrated assessment approaches to climate change impacts. Climatic Change, 132(3), 417–432. https://doi.org/10.1007/S10584-014-1211-3/FIGURES/3

Estoque, R. C., Gomi, K., Togawa, T., Ooba, M., Hijioka, Y., Akiyama, C. M., Nakamura, S., Yoshioka, A., & Kuroda, K. (2019). Scenario-based land abandonment projections: Method, application and implications. Science of The Total Environment, 692, 903–916. https://doi.org/10.1016/J.SCITOTENV.2019.07.204

Fabre, J., Ruelland, D., Dezetter, A., & Grouillet, B. (2016). Reducing the gap between water demand and availability under climate and water use changes: assessing the effectiveness and robustness of adaptation. La Houille Blanche, 2016-January(6), 21–29. https://doi.org/10.1051/LHB/2016056

Falconnier, G. N., Descheemaeker, K., Traore, B., Bayoko, A., & Giller, K. E. (2018). Agricultural intensification and policy interventions: Exploring plausible futures for smallholder farmers in

Southern Mali. Land Use Policy, 70, 623–634. https://doi.org/10.1016/J.LANDUSEPOL.2017.10.044

Fontaine, C. M., & Rounsevell, M. D. A. (2009). An Agent-based approach to model future residential pressure on a regional landscape. Landscape Ecology, 24(9), 1237–1254. https://doi.org/10.1007/S10980-009-9378-0/FIGURES/11

Gulacha, M. M., & Mulungu, D. M. M. (2017). Generation of climate change scenarios for precipitation and temperature at local scales using SDSM in Wami-Ruvu River Basin Tanzania. Physics and Chemistry of the Earth, Parts A/B/C, 100, 62–72. https://doi.org/10.1016/J.PCE.2016.10.003

Hanasaki, N., Fujimori, S., Yamamoto, T., Yoshikawa, S., Masaki, Y., Hijioka, Y., Kainuma, M., Kanamori, Y., Masui, T., Takahashi, K., & Kanae, S. (2013). A global water scarcity assessment under Shared Socio-economic Pathways - Part 1: Water use. Hydrology and Earth System Sciences, 17(7), 2375–2391. https://doi.org/10.5194/HESS-17-2375-2013

Harrison, P. A., Berry, P. M., Henriques, C., & Holman, I. P. (2008). Impacts of socio-economic and climate change scenarios on wetlands: linking water resource and biodiversity meta-models. Climatic Change 2008 90:1, 90(1), 113–139. https://doi.org/10.1007/S10584-008-9454-5

Harrison, P. A., Dunford, R., Savin, C., Rounsevell, M. D. A., Holman, I. P., Kebede, A. S., & Stuch, B. (2015). Cross-sectoral impacts of climate change and socio-economic change for multiple, European land- and water-based sectors. Climatic Change, 128(3–4), 279–292. https://doi.org/10.1007/S10584-014-1239-4/FIGURES/2

Heidari, H., Arabi, M., & Warziniack, T. (2021). Vulnerability to Water Shortage Under Current and Future Water Supply-Demand Conditions Across U.S. River Basins. Earth's Future, 9(10), e2021EF002278. https://doi.org/10.1029/2021EF002278

Hernández-Bedolla, J., Solera, A., Paredes-Arquiola, J., Pedro-Monzonís, M., Andreu, J., & Sánchez-Quispe, S. T. (2017). The Assessment of Sustainability Indexes and Climate Change Impacts on Integrated Water Resource Management. Water 2017, Vol. 9, Page 213, 9(3), 213. https://doi.org/10.3390/W9030213

Ho, H. C., Abbas, S., Yang, J., Zhu, R., & Wong, M. S. (2019). Spatiotemporal Prediction of Increasing Winter Perceived Temperature across a Sub-Tropical City for Sustainable Planning and Climate Change Mitigation. International Journal of Environmental Research and Public Health 2019, Vol. 16, Page 497, 16(3), 497. https://doi.org/10.3390/IJERPH16030497

Honjo, K., Gomi, K., Kanamori, Y., Takahashi, K., & Matsuhashi, K. (2021). Long-term projections of economic growth in the 47 prefectures of Japan: An application of Japan shared socioeconomic pathways. Heliyon, 7(3), e06412. https://doi.org/10.1016/J.HELIYON.2021.E06412

Huang, Q. X., He, C. Y., Liu, Z. F., & Shi, P. J. (2014). Modeling the impacts of drying trend scenarios on land systems in northern China using an integrated SD and CA model. Science China Earth Sciences 2014 57:4, 57(4), 839–854. https://doi.org/10.1007/S11430-013-4799-7

Jayasankar, C. B., Rajendran, K., & Sajani, S. (2021). Does increasing the spatial resolution in dynamical downscaling impact climate change projection of Indian summer monsoon, population and GDP? Theoretical and Applied Climatology, 145(1–2), 441–453. https://doi.org/10.1007/S00704-021-03633-W/FIGURES/6

Jiang, L. (2014). Internal consistency of demographic assumptions in the shared socioeconomic pathways. Population and Environment, 35(3), 261–285. https://doi.org/10.1007/S11111-014-0206-3/TABLES/3

Jiang, L., & O'Neill, B. C. (2017). Global urbanization projections for the Shared Socioeconomic Pathways. Global Environmental Change, 42, 193–199. https://doi.org/10.1016/J.GLOENVCHA.2015.03.008

Ju, Y., Lindbergh, S., He, Y., & Radke, J. D. (2019). Climate-related uncertainties in urban exposure to sea level rise and storm surge flooding: a multi-temporal and multi-scenario analysis. Cities, 92, 230–246. https://doi.org/10.1016/J.CITIES.2019.04.002

Karanja, J., & Kiage, L. (2021). Perspectives on spatial representation of urban heat vulnerability. Science of The Total Environment, 774, 145634. https://doi.org/10.1016/J.SCITOTENV.2021.145634

Kim, S. M., Kang, M. S., & Jang, M. W. (2018). Assessment of agricultural drought vulnerability to climate change at a municipal level in South Korea. Paddy and Water Environment, 16(4), 699–714. https://doi.org/10.1007/S10333-018-0661-Z/TABLES/8

Koks, E. E., de Moel, H., Aerts, J. C. J. H., & Bouwer, L. M. (2014). Effect of spatial adaptation measures on flood risk: Study of coastal floods in Belgium. Regional Environmental Change, 14(1), 413–425. https://doi.org/10.1007/S10113-013-0514-7/TABLES/3

Kumar, K. V., Preuss, K., Titirici, M. M., & Rodríguez-Reinoso, F. (2017). Nanoporous Materials for the Onboard Storage of Natural Gas. Chemical Reviews, 117(3), 1796–1825. https://doi.org/10.1021/ACS.CHEMREV.6B00505/SUPPL_FILE/CR6B00505_SI_001.PDF

Lambin, E. F., D'haen, S. A. L., Mertz, O., Nielsen, J. Ø., & Rasmussen, K. (2014). Scenarios on future land changes in the West African Sahel. Https://Doi.Org/10.1080/00167223.2013.878229, 114(1), 76–83. https://doi.org/10.1080/00167223.2013.878229

Lincke, D., & Hinkel, J. (2018). Economically robust protection against 21st century sea-level rise. Global Environmental Change, 51, 67–73. https://doi.org/10.1016/J.GLOENVCHA.2018.05.003

Liu, X., Liang, X., Li, X., Xu, X., Ou, J., Chen, Y., Li, S., Wang, S., & Pei, F. (2017). A future land use simulation model (FLUS) for simulating multiple land use scenarios by coupling human and natural effects. Landscape and Urban Planning, 168, 94–116. https://doi.org/10.1016/J.LANDURBPLAN.2017.09.019

Liu, X. Q., Pei, T., Zhou, C. H., Du, Y. Y., Ma, T., Xie, C. J., & Xu, J. (2017). A systems dynamic model of a coal-based city with multiple adaptive scenarios: A case study of Ordos, China. Science China Earth Sciences 2017 61:3, 61(3), 302–316. https://doi.org/10.1007/S11430-016-9077-5

Lyu, H., Dong, Z., & Pande, S. (2021). Securing food under adverse climate and socioeconomic scenarios in Jiangsu Province, China: Critical role of human adaptation under change. Journal of Hydrology, 598, 126344. https://doi.org/10.1016/J.JHYDROL.2021.126344

Marcotullio, P. J., Keßler, C., & Fekete, B. M. (2021). The future urban heat-wave challenge in Africa: Exploratory analysis. Global Environmental Change, 66, 102190. https://doi.org/10.1016/J.GLOENVCHA.2020.102190

Merkens, J. L., Reimann, L., Hinkel, J., & Vafeidis, A. T. (2016). Gridded population projections for the coastal zone under the Shared Socioeconomic Pathways. Global and Planetary Change, 145, 57–66. https://doi.org/10.1016/J.GLOPLACHA.2016.08.009

Modeling Impact of Climate Change on Water Resources and Agriculture Demand in the Volta Basin and Other Basin Systems in Ghana - UNU Collections. (n.d.). Retrieved April 18, 2022, from http://collections.unu.edu/view/UNU:3654

Molina, C. M., & Galiana-Martín, L. (2016). Fire Scenarios in Spain: A Territorial Approach to Proactive Fire Management in the Context of Global Change. Forests 2016, Vol. 7, Page 273, 7(11), 273. https://doi.org/10.3390/F7110273

Moors, E. J., Groot, A., Biemans, H., van Scheltinga, C. T., Siderius, C., Stoffel, M., Huggel, C., Wiltshire, A., Mathison, C., Ridley, J., Jacob, D., Kumar, P., Bhadwal, S., Gosain, A., & Collins, D. N. (2011). Adaptation to changing water resources in the Ganges basin, northern India. Environmental Science & Policy, 14(7), 758–769. https://doi.org/10.1016/J.ENVSCI.2011.03.005

Muñoz, I., Hernández, P., Pérez-Iribarren, E., Pedrero, J., Arrizabalaga, E., & Hermoso, N. (2020). Methodology for integrated modelling and impact assessment of city energy system scenarios. Energy Strategy Reviews, 32, 100553. https://doi.org/10.1016/J.ESR.2020.100553

Neumann, B., Vafeidis, A. T., Zimmermann, J., & Nicholls, R. J. (2015). Future Coastal Population Growth and Exposure to Sea-Level Rise and Coastal Flooding - A Global Assessment. PLOS ONE, 10(3), e0118571. https://doi.org/10.1371/JOURNAL.PONE.0118571

Paranunzio, R., Dwyer, E., Fitton, J. M., Alexander, P. J., & O'Dwyer, B. (2021). Assessing current and future heat risk in Dublin city, Ireland. Urban Climate, 40, 100983. https://doi.org/10.1016/J.UCLIM.2021.100983

Pervin, I. A., Rahman, S. M. M., Nepal, M., Haque, A. K. E., Karim, H., & Dhakal, G. (2020). Adapting to urban flooding: a case of two cities in South Asia. Water Policy, 22(S1), 162–188. https://doi.org/10.2166/WP.2019.174

Phan, T. D., Smart, J. C. R., Sahin, O., Capon, S. J., & Hadwen, W. L. (2018). Assessment of the vulnerability of a coastal freshwater system to climatic and non-climatic changes: A system dynamics approach. Journal of Cleaner Production, 183, 940–955. https://doi.org/10.1016/J.JCLEPRO.2018.02.169

Phan, T. D., Smart, J. C. R., Stewart-Koster, B., Sahin, O., Hadwen, W. L., Dinh, L. T., Tahmasbian, I., & Capon, S. J. (2019). Applications of Bayesian Networks as Decision Support Tools for Water Resource Management under Climate Change and Socio-Economic Stressors: A Critical Appraisal. Water 2019, Vol. 11, Page 2642, 11(12), 2642. https://doi.org/10.3390/W11122642

Quinn, J. D., Reed, P. M., Giuliani, M., Castelletti, A., Oyler, J. W., & Nicholas, R. E. (2018). Exploring How Changing Monsoonal Dynamics and Human Pressures Challenge Multireservoir Management for Flood Protection, Hydropower Production, and Agricultural Water Supply. Water Resources Research, 54(7), 4638–4662. https://doi.org/10.1029/2018WR022743

Ramakreshnan, L., Aghamohammadi, N., Fong, C. S., Ghaffarianhoseini, A., Wong, L. P., Noor, R. M., Hanif, N. R., Azriyati Wan Abd Aziz, W. N., Sulaiman, N. M., & Hassan, N. (2019). A qualitative exploration on the awareness and knowledge of stakeholders towards Urban Heat Island phenomenon in Greater Kuala Lumpur: Critical insights for urban policy implications. Habitat International, 86, 28–37. https://doi.org/10.1016/J.HABITATINT.2019.02.007

Reckien, D. (2014). Weather extremes and street life in India—Implications of Fuzzy Cognitive Mapping as a new tool for semi-quantitative impact assessment and ranking of adaptation measures. Global Environmental Change, 26(1), 1–13. https://doi.org/10.1016/J.GLOENVCHA.2014.03.005

Reimann, L., Merkens, J. L., & Vafeidis, A. T. (2018). Regionalized Shared Socioeconomic Pathways: narratives and spatial population projections for the Mediterranean coastal zone. Regional Environmental Change, 18(1), 235–245. https://doi.org/10.1007/S10113-017-1189-2/FIGURES/3

Reintinger, C., Berghammer, A., & Schmude, J. (2016). Simulating changes in tourism demand: a case study of two German regions. Http://Dx.Doi.Org/10.1080/14616688.2016.1169312, 18(3), 233–257. https://doi.org/10.1080/14616688.2016.1169312

Rocha, A., Pereira, S. C., Viceto, C., Silva, R., Neto, J., & Marta-Almeida, M. (2020). A Consistent Methodology to Evaluate Temperature and Heat Wave Future Projections for Cities: A Case Study for Lisbon. Applied Sciences 2020, Vol. 10, Page 1149, 10(3), 1149. https://doi.org/10.3390/APP10031149

Roshan, G. R., Oji, R., & Fdez-Arróyabe, P. (2022). Future impact of cloudiness and wind changes on thermal comfort conditions in the city of Tabriz (Iran) in the frame of climate change. Sustainable Cities and Society, 77, 103575. https://doi.org/10.1016/J.SCS.2021.103575

Ruane, A. C., Teichmann, C., Arnell, N. W., Carter, T. R., Ebi, K. L., Frieler, K., Goodess, C. M., Hewitson, B., Horton, R., Kovats, R. S., Lotze, H. K., Mearns, L. O., Navarra, A., Ojima, D. S., Riahi, K., Rosenzweig, C., Themessl, M., & Vincent, K. (2016). The Vulnerability, Impacts, Adaptation and Climate Services Advisory Board (VIACS AB v1.0) contribution to CMIP6. Geoscientific Model Development, 9(9), 3493–3515. https://doi.org/10.5194/GMD-9-3493-2016

Saha, A., & Ghosh, S. (2020). Relative Impacts of Projected Climate and Land Use Changes on Terrestrial Water Balance: A Case Study on Ganga River Basin. Frontiers in Water, 2, 12. https://doi.org/10.3389/FRWA.2020.00012/BIBTEX

Shih, W. Y., & Mabon, L. (2017). Land-use planning as a tool for balancing the scientific and the social in biodiversity and ecosystem services mainstreaming? The case of Durban, South Africa. Https://Doi.Org/10.1080/09640568.2017.1394277, 61(13), 2338–2357. https://doi.org/10.1080/09640568.2017.1394277

Smolenaars, W. J., Lutz, A. F., Biemans, H., Dhaubanjar, S., Immerzeel, W. W., & Ludwig, F. (2021). From narratives to numbers: Spatial downscaling and quantification of future water, food & energy security requirements in the Indus basin. Futures, 133, 102831. https://doi.org/10.1016/J.FUTURES.2021.102831

Snoussi, M., Ouchani, T., & Niazi, S. (2008). Vulnerability assessment of the impact of sea-level rise and flooding on the Moroccan coast: The case of the Mediterranean eastern zone. Estuarine, Coastal and Shelf Science, 77(2), 206–213. https://doi.org/10.1016/J.ECSS.2007.09.024

Stuart, M. E., Gooddy, D. C., Bloomfield, J. P., & Williams, A. T. (2011). A review of the impact of climate change on future nitrate concentrations in groundwater of the UK. Science of The Total Environment, 409(15), 2859–2873. https://doi.org/10.1016/J.SCITOTENV.2011.04.016

Tan, X., Gan, T. Y., & Horton, D. E. (2018). Projected timing of perceivable changes in climate extremes for terrestrial and marine ecosystems. Global Change Biology, 24(10), 4696–4708. https://doi.org/10.1111/GCB.14329

Toboso-Chavero, S., Villalba, G., Gabarrell Durany, X., & Madrid-López, C. (2021). More than the sum of the parts: System analysis of the usability of roofs in housing estates. Journal of Industrial Ecology, 25(5), 1284–1299. https://doi.org/10.1111/JIEC.13114

Torresan, S., Furlan, E., Critto, A., Michetti, M., & Marcomini, A. (2020). Egypt's Coastal Vulnerability to Sea-Level Rise and Storm Surge: Present and Future Conditions. Integrated Environmental Assessment and Management, 16(5), 761–772. https://doi.org/10.1002/IEAM.4280

Vannier, C., Bierry, A., Longaretti, P. Y., Nettier, B., Cordonnier, T., Chauvin, C., Bertrand, N., Quétier, F., Lasseur, R., & Lavorel, S. (2019). Co-constructing future land-use scenarios for the Grenoble region, France. Landscape and Urban Planning, 190, 103614. https://doi.org/10.1016/J.LANDURBPLAN.2019.103614

Wagner, P. D., Reichenau, T. G., Kumar, S., & Schneider, K. (2015). Development of a new downscaling method for hydrologic assessment of climate change impacts in data scarce regions and its application in the Western Ghats, India. Regional Environmental Change, 15(3), 435–447. https://doi.org/10.1007/S10113-013-0481-Z/FIGURES/11

Ward, P. J., Marfai, M. A., Yulianto, F., Hizbaron, D. R., & Aerts, J. C. J. H. (2011). Coastal inundation and damage exposure estimation: A case study for Jakarta. Natural Hazards, 56(3), 899–916. https://doi.org/10.1007/S11069-010-9599-1/FIGURES/7

Watkiss, P., & Hunt, A. (2012). Projection of economic impacts of climate change in sectors of Europe based on bottom up analysis: Human health. Climatic Change, 112(1), 101–126. https://doi.org/10.1007/S10584-011-0342-Z/TABLES/9

Xu, Q., Jiang, Q., Cao, K., Li, X., & Deng, X. (2013). Scenario-based analysis on the structural change of land uses in China. Advances in Meteorology, 2013. https://doi.org/10.1155/2013/919013

Yang, H., Villamor, G. B., Su, Y., Wang, M., & Xu, J. (2016). Land-use response to drought scenarios and water policy intervention in Lijiang, SW China. Land Use Policy, 57, 377–387. https://doi.org/10.1016/J.LANDUSEPOL.2016.05.027

Ye, L., Xiong, W., Li, Z., Yang, P., Wu, W., Yang, G., Fu, Y., Zou, J., Chen, Z., van Ranst, E., & Tang, H. (2013). Climate change impact on China food security in 2050. Agronomy for Sustainable Development, 33(2), 363–374. https://doi.org/10.1007/S13593-012-0102-0/FIGURES/4

Zhu, J., Wang, S., Wang, D., Zeng, X., Cai, Y., & Zhang, B. (2021). Upholding labor productivity with intensified heat stress: Robust planning for adaptation to climate change under uncertainty. Journal of Cleaner Production, 322, 129083. https://doi.org/10.1016/J.JCLEPRO.2021.129083

Appendix B: Systematic Review Critical Appraisal

Critical appraisal of study quality is conducted by measuring total and average citations of included publications. Total citations represents the total number of times a publication has been cited, as indexed in Web of Science. Average citations represents yearly average citation count. Average citations is calculated by dividing total citations by the number of years since publication. The year of publication is included when calculating the number of years since publication.

Table B1: Systematic Review Critical Appraisal. Data collected February 28th, 2022 from Web of Science.

Article	Total Citations	Average Citations per year
(Huang et al., 2011)	206	18.73
(Casal-Campos et al., 2015)	76	10.86
(Banu et al., 2014)	63	7.88
(Urich & Rauch, 2014)	56	7.00
(Chen et al., 2017)	41	8.20
(Ronco et al., 2014)	32	4.00
(Rohat, Flacke, et al., 2019)	30	10.00
(Manocha & Babovic, 2017)	24	4.80
(Parandvash & Chang, 2016)	24	4.00
(Hadipour et al., 2020)	21	10.50
(Parkinson et al., 2016)	19	3.17
(Abadie, 2018)	18	4.50
(Wolff et al., 2020)	18	9
(Sampson et al., 2016)	16	2.67
(Li et al., 2017)	15	3.00
(Borris et al., 2016)	14	2.33
(Apreda et al., 2019)	14	4.67
(Terama et al., 2019)	13	4.33
(Rohat, Wilhelmi, et al., 2019)	13	4.33
(Chen et al., 2021)	13	13.00
(Egger & Maurer, 2015)	13	1.86
(Yan et al., 2016)	11	1.83

(Ciumasu, 2013)	9	1.00
(Chu et al., 2017)	8	1.60
(El-Fadel & Ghanimeh, 2013)	8	0.89
(Birkmann et al., 2020)	4	2.00
(Zhu et al., 2020)	3	1.50
(Reimann, Vollstedt, et al., 2021)	3	3.00
(Wan et al., 2020)	3	1.50
(Dubey et al., 2021)	2	2.00
(Birkmann et al., 2021)	2	2.00
(Meyer et al., 2019)	2	0.67
(Hemmati et al., 2021)	1	1.00
(Rohat et al., 2021)	1	1.00
(Park et al., 2021)	1	1.00
(Krummenauer et al., 2021)	0	0.00
(Peng & Li, 2021)	0	0.00
(Kamei et al., 2021)	0	0.00
(Xu et al., 2021)	0	0.00
(Reimann, Jones, et al., 2021)	0	0.00
(Jurgilevich et al., 2021)	0	0.00

Appendix C: Systematic Review Literature Categorization

The following tables record the categorization of literature according to scenario development type and planning stage at which socio-economic projections are applied. Huang et al. (2011) is excluded from the categorization of types of scenario development as this article is a systematic review and does not apply a specific type of projection. All articles are categorized according to the planning stage at which they discuss socio-economic projections. All data was collected from Web of Science on February 28th, 2022.

Participatory scenario development

Table C1: Literature Using Participatory Scenario Development

Type	Methods (#)	Use of SSPs/SRES (#)	Scenario Output (#)	Sources (#)
Participatory scenario development	**Stakeholder workshop (8)** (Birkmann et al., 2020) (Birkmann et al., 2021) (Egger & Maurer, 2015) (Jurgilevich et al., 2021) (Kamei et al., 2021) (Li et al., 2017) (Meyer et al., 2019) (Reimann, Vollstedt, et al., 2021)	**Yes (5)** (Birkmann et al., 2021) (Kamei et al., 2021) (Li et al., 2017) (Meyer et al., 2019) (Reimann, Vollstedt, et al., 2021) **No (3)** (Birkmann et al., 2020) (Egger & Maurer, 2015) (Jurgilevich et al., 2021)	**Qualitative (8)** (Birkmann et al., 2020) (Birkmann et al., 2021) (Egger & Maurer, 2015) (Jurgilevich et al., 2021) (Kamei et al., 2021) (Li et al., 2017) (Meyer et al., 2019) (Reimann, Vollstedt, et al., 2021) **Quantitative (5)** (Birkmann et al., 2020) (Birkmann et al., 2021) (Egger & Maurer, 2015) (Jurgilevich et al., 2021) (Li et al., 2017) **Spatial (2)** (Birkmann et al., 2021) (Jurgilevich et al., 2021)	**(8)** (Birkmann et al., 2020) (Birkmann et al., 2021) (Egger & Maurer, 2015) (Jurgilevich et al., 2021) (Kamei et al., 2021) (Li et al., 2017) (Meyer et al., 2019) (Reimann, Vollstedt, et al., 2021)
	Stakeholder consultation/questionnaire (6) (Ciumasu, 2013) (Hadipour et al., 2020) (Reimann, Vollstedt, et al., 2021) (Rohat, Wilhelmi, et al., 2019) (Ronco et al., 2014) (Wan et al., 2020)	**Yes (2)** (Rohat, Wilhelmi, et al., 2019) (Reimann, Vollstedt, et al., 2021) **No (4)** (Ciumasu, 2013) (Hadipour et al., 2020) (Ronco et al., 2014) (Wan et al., 2020)	**Qualitative (2)** (Ciumasu, 2013) (Wan et al., 2020) **Quantitative (4)** (Hadipour et al., 2020) (Rohat, Wilhelmi, et al., 2019) (Ronco et al., 2014) (Wan et al., 2020) **Spatial (3)** (Hadipour et al., 2020) (Rohat, Wilhelmi, et	**(6)** (Ciumasu, 2013) (Hadipour et al., 2020) (Reimann, Vollstedt, et al., 2021) (Rohat, Wilhelmi, et al., 2019) (Ronco et al., 2014) (Wan et al., 2020)

		al., 2019) (Ronco et al., 2014)	
Participatory mapping (1) (Jurgilevich et al., 2021)	**Yes (0)** **No (1)** (Jurgilevich et al., 2021)	**Qualitative (1)** (Jurgilevich et al., 2021) **Quantitative (1)** (Jurgilevich et al., 2021) **Spatial (1)** (Jurgilevich et al., 2021)	**(1)** (Jurgilevich et al., 2021)

Modeling-based scenario development

Table C2: Literature Using Modeling-Based Scenario Development

Type	Methods (#)	Use of SSPs/SRES (#)	Scenario Output (#)	Sources (#)
Modeling-based scenario development	**Downscaling (12)** (Borris et al., 2016) (Chen et al., 2017) (Dubey et al., 2021) (El-Fadel & Ghanimeh, 2013) (Krummenauer et al., 2021) (Park et al., 2021) (Parkinson et al., 2016) (Peng & Li, 2021) (Rohat, Flacke, et al., 2019) (Rohat et al., 2021) (Terama et al., 2019) (Wolff et al., 2020)	**Yes (12)** (Borris et al., 2016) (Chen et al., 2017) (Dubey et al., 2021) (El-Fadel & Ghanimeh, 2013) (Krummenauer et al., 2021) (Park et al., 2021) (Parkinson et al., 2016) (Peng & Li, 2021) (Rohat, Flacke, et al., 2019) (Rohat et al., 2021) (Terama et al., 2019) (Wolff et al., 2020) **No (0)**	**Qualitative (1)** (Borris et al., 2016) **Quantitative (12)** (Borris et al., 2016) (Chen et al., 2017) (Dubey et al., 2021) (El-Fadel & Ghanimeh, 2013) (Krummenauer et al., 2021) (Park et al., 2021) (Parkinson et al., 2016) (Peng & Li, 2021) (Rohat, Flacke, et al., 2019) (Rohat et al., 2021) (Terama et al., 2019) (Wolff et al., 2020) **Spatial (9)** (Dubey et al., 2021) (El-Fadel & Ghanimeh, 2013) (Park et al., 2021) (Parkinson et al., 2016) (Peng & Li, 2021) (Rohat, Flacke, et al., 2019) (Rohat et al., 2021) (Terama et al., 2019) (Wolff et al., 2020)	**(12)** (Borris et al., 2016) (Chen et al., 2017) (Dubey et al., 2021) (El-Fadel & Ghanimeh, 2013) (Krummenauer et al., 2021) (Park et al., 2021) (Parkinson et al., 2016) (Peng & Li, 2021) (Rohat, Flacke, et al., 2019) (Rohat et al., 2021) (Terama et al., 2019) (Wolff et al., 2020)

Predictive/ statistical modeling (13) (Abadie, 2018) (Apreda et al., 2019) (Banu et al., 2014) (Casal-Campos et al., 2015) (Chen et al., 2021) (Chu et al., 2017) (Hemmati et al., 2021) (Parandvash & Chang, 2016) (Reimann, Jones, et al., 2021) (Sampson et al., 2016) (Xu et al., 2021) (Yan et al., 2016) (Zhu et al., 2020)	**Yes (4)** (Chen et al., 2021) (Reimann, Jones, et al., 2021) (Yan et al., 2016) (Zhu et al., 2020) **No (9)** (Abadie, 2018) (Apreda et al., 2019) (Banu et al., 2014) (Casal-Campos et al., 2015) (Chu et al., 2017) (Hemmati et al., 2021) (Parandvash & Chang, 2016) (Sampson et al., 2016) (Xu et al., 2021)	**Qualitative (0)** **Quantitative (13)** (Abadie, 2018) (Apreda et al., 2019) (Banu et al., 2014) (Casal-Campos et al., 2015) (Chen et al., 2021) (Chu et al., 2017) (Hemmati et al., 2021) (Parandvash & Chang, 2016) (Reimann, Jones, et al., 2021) (Sampson et al., 2016) (Xu et al., 2021) (Yan et al., 2016) (Zhu et al., 2020) **Spatial (8)** (Apreda et al., 2019) (Chen et al., 2021) (Chu et al., 2017) (Hemmati et al., 2021) (Reimann, Jones, et al., 2021) (Xu et al., 2021) (Yan et al., 2016) (Zhu et al., 2020)	**(13)** (Abadie, 2018) (Apreda et al., 2019) (Banu et al., 2014) (Casal-Campos et al., 2015) (Chen et al., 2021) (Chu et al., 2017) (Hemmati et al., 2021) (Parandvash & Chang, 2016) (Reimann, Jones, et al., 2021) (Sampson et al., 2016) (Xu et al., 2021) (Yan et al., 2016) (Zhu et al., 2020)
Adaptation pathway modeling (2) (Manocha & Babovic, 2017) (Urich & Rauch, 2014)	**Yes (0)** **No (2)** (Manocha & Babovic, 2017) (Urich & Rauch, 2014)	**Qualitative (1)** (Manocha & Babovic, 2017) **Quantitative (2)** (Manocha & Babovic, 2017) (Urich & Rauch, 2014) **Spatial (1)** (Urich & Rauch, 2014)	**(2)** (Manocha & Babovic, 2017) (Urich & Rauch, 2014)

Planning stages

Table C3: Use of Socio-Economic Projections throughout the Adaptation Planning Process

Planning Stage	Sources (#)
Preparing the ground for adaptation	**(0)**
Assessing climate change risks and vulnerabilities	**(32)** (Abadie, 2018) (Banu et al., 2014) (Birkmann et al., 2020) (Birkmann et al., 2021) (Borris et al., 2016) (Chen et al., 2017) (Chen et al., 2021) (Chu et al., 2017) (Ciumasu, 2013) (Dubey et al., 2021) (El-Fadel & Ghanimeh, 2013) (Hadipour et al., 2020) (Huang et al., 2011) (Jurgilevich et al., 2021) (Kamei et al., 2021) (Krummenauer et al., 2021) (Meyer et al., 2019) (Parandvash & Chang, 2016) (Park et al., 2021) (Parkinson et al., 2016) (Peng & Li, 2021) (Reimann, Vollstedt, et al., 2021) (Reimann, Jones, et al., 2021) (Rohat, Flacke, et al., 2019) (Rohat, Wilhelmi, et al., 2019) (Ronco et al., 2014) (Sampson et al., 2016) (Terama et al., 2019) (Wolff et al., 2020) (Xu et al., 2021) (Yan et al., 2016) (Zhu et al., 2020)
Identifying adaptation options	**(7)** **(**Birkmann et al., 2021) (Hadipour et al., 2020) (Li et al., 2017) (Park et al., 2021) (Peng & Li, 2021) (Urich & Rauch, 2014) (Wolff et al., 2020)
Assessing and selecting adaptation options	**(10)** **(**Apreda et al., 2019) (Casal-Campos et al., 2015) (Egger & Maurer, 2015) (Hemmati et al., 2021) (Li et al., 2017) (Manocha & Babovic, 2017)

	(Rohat, Wilhelmi, et al., 2019) (Rohat et al., 2021) (Urich & Rauch, 2014) (Wan et al., 2020)
Implementing adaptation	**(0)**
Adaptation monitoring, evaluation and learning	**(0)**

Appendix D: Policy Analysis Categorization

Types of socio-economic projections

Table D1: Policies Using Participatory Scenario Development Approaches

Type	Methods (#, Policy Name)	Use of SSPs/SRES (#, Policy Name)	Scenario Output (#, Policy Name)	Policies (#, Policy Name)
Participatory scenario development	**Stakeholder workshop (2)** (Plan Estratégico Distrital (PED)) (Plano de Ação Vitória Sustentável)	**Yes (0)** **No (2)** (Plan Estratégico Distrital (PED)) (Plano de Ação Vitória Sustentável)	**Qualitative (2)** (Plan Estratégico Distrital (PED)) (Plano de Ação Vitória Sustentável) **Quantitative (2)** (Plan Estratégico Distrital (PED)) (Plano de Ação Vitória Sustentável) **Spatial (2)** (Plan Estratégico Distrital (PED)) (Plano de Ação Vitória Sustentável)	**(2)** (Plan Estratégico Distrital (PED)) (Plano de Ação Vitória Sustentável)
	Stakeholder consultation/questionnaire (2) (Auckland Plan 2050) (Plan Estratégico Distrital (PED))	**Yes (0)** **No (2)** (Auckland Plan 2050) (Plan Estratégico Distrital (PED))	**Qualitative (2)** (Auckland Plan 2050) (Plan Estratégico Distrital (PED)) **Quantitative (1)** (Plan Estratégico Distrital (PED)) **Spatial (1)** (Plan Estratégico Distrital (PED))	**(2)** (Auckland Plan 2050) (Plan Estratégico Distrital (PED))

Table D2: Policies Using Modeling-Based Scenario Development Approaches

Type	Methods (#, Policy Name)	Use of SSPs/SRES (#, Policy Name)	Scenario Output (#, Policy Name)	Policies (#, Policy Name)
Modeling-based scenario development	**Downscaling (3)** (City of Melbourne Climate Change Adaptation Strategy) (The City of London Climate Change Adaptation Strategy) (Growing Stronger: Toward a Climate Ready Philadelphia)	**Yes (3)** (City of Melbourne Climate Change Adaptation Strategy) (The City of London Climate Change Adaptation Strategy) (Growing Stronger: Toward a Climate Ready Philadelphia) **No (0)**	**Qualitative (0)** **Quantitative (3)** (City of Melbourne Climate Change Adaptation Strategy) (The City of London Climate Change Adaptation Strategy) (Growing Stronger: Toward a Climate Ready Philadelphia) **Spatial (0)**	**(3)** (City of Melbourne Climate Change Adaptation Strategy) (The City of London Climate Change Adaptation Strategy) (Growing Stronger: Toward a Climate Ready Philadelphia)
	Predictive/statistical modeling (5) (City of Virginia Beach Comprehensive Plan) (The Fourth Regional Plan) (Climate Change Adaptation Strategy for the City of Rio de Janeiro) (Davao City Climate Change Action Plan) (Plan de Acción "Panamá Ciudad Sostenible")	**Yes (0)** **No (5)** (City of Virginia Beach Comprehensive Plan) (The Fourth Regional Plan) (Climate Change Adaptation Strategy for the City of Rio de Janeiro) (Davao City Climate Change Action Plan) (Plan de Acción "Panamá Ciudad Sostenible")	**Qualitative (1)** (Plan de Acción "Panamá Ciudad Sostenible") **Quantitative (5)** (City of Virginia Beach Comprehensive Plan) (The Fourth Regional Plan) (Climate Change Adaptation Strategy for the City of Rio de Janeiro) (Davao City Climate Change Action Plan) (Plan de Acción "Panamá Ciudad Sostenible") **Spatial (3)** (The Fourth Regional Plan) (Climate Change Adaptation Strategy for the City of Rio de Janeiro) (Plan de Acción "Panamá Ciudad Sostenible")	**(5)** (City of Virginia Beach Comprehensive Plan) (The Fourth Regional Plan) (Climate Change Adaptation Strategy for the City of Rio de Janeiro) (Davao City Climate Change Action Plan) (Plan de Acción "Panamá Ciudad Sostenible")

Table D3: Policies Using Existing Socio-Economic Projections

Type	Methods (#, Policy Name)	Use of SSPs/SRES (#, Policy Name)	Scenario Output (#, Policy Name)	Policies (#, Policy Name)
Use of existing projections	**Use of existing projections (9)** (City of Melbourne Climate Change Adaptation Strategy REFRESH) (OneNYC) (Resilient San Francisco) (National Capital Region Climate Change Report) (NYC Hazard Mitigation Plan) (New Orleans Master Plan) (Dakar Resilience Strategy) (Surat Resilience Strategy) (100 Resilient: Resilient Bangkok Strategy)	**Yes (0)** **No (9)** (City of Melbourne Climate Change Adaptation Strategy REFRESH) (OneNYC) (Resilient San Francisco) (National Capital Region Climate Change Report) (NYC Hazard Mitigation Plan) (New Orleans Master Plan) (Dakar Resilience Strategy) (Surat Resilience Strategy) (100 Resilient: Resilient Bangkok Strategy)	**Qualitative (0)** **Quantitative (9)** (City of Melbourne Climate Change Adaptation Strategy REFRESH) (OneNYC) (Resilient San Francisco) (National Capital Region Climate Change Report) (NYC Hazard Mitigation Plan) (New Orleans Master Plan) (Dakar Resilience Strategy) (Surat Resilience Strategy) (100 Resilient: Resilient Bangkok Strategy) **Spatial (0)**	**(9)** (City of Melbourne Climate Change Adaptation Strategy REFRESH) (OneNYC) (Resilient San Francisco) (National Capital Region Climate Change Report) (NYC Hazard Mitigation Plan) (New Orleans Master Plan) (Dakar Resilience Strategy) (Surat Resilience Strategy) (100 Resilient: Resilient Bangkok Strategy)

Stages of the planning process

Table D4: Use of Socio-Economic Projections by Policies throughout the Adaptation Planning Process

Planning Stage	Sources (#, Policy Name)
Preparing the ground for adaptation	**(0)**
Assessing climate change risks and vulnerabilities	**(20)** (Auckland Plan 2050) (City of Melbourne Climate Change Adaptation Strategy) (City of Melbourne Climate Change Adaptation Strategy REFRESH) (OneNYC) (Resilient San Francisco) (National Capital Region Climate Change Report) (NYC Hazard Mitigation Plan) (City of Virginia Beach Comprehensive Plan) (New Orleans Master Plan) (The Fourth Regional Plan) (The City of London Climate Change Adaptation Strategy) (Climate Change Adaptation Strategy for the City of Rio de Janeiro) (Dakar Resilience Strategy) (Surat Resilience Strategy) (Growing Stronger: Toward a Climate Ready Philadelphia) (Davao City Climate Change Action Plan) (100 Resilient: Resilient Bangkok Strategy) (Plan de Acción "Panamá Ciudad Sostenible") (Plan Estratégico Distrital (PED)) (Plano de Ação Vitória Sustentável)
Identifying adaptation options	**(2)** (Plan Estratégico Distrital (PED)) (Plano de Ação Vitória Sustentável)
Assessing and selecting adaptation options	**(4)** (Auckland Plan 2050) (Plan de Acción "Panamá Ciudad Sostenible") (Plan Estratégico Distrital (PED)) (Plano de Ação Vitória Sustentável)
Implementing adaptation	**(0)**
Adaptation monitoring, evaluation and learning	**(1)** (City of Melbourne Climate Change Adaptation Strategy REFRESH)

Policies considering equity or justice

Table D5: Consideration of Equity or Justice by Policies

Considers equity or justice (#, Policy Name)	Does not consider equity or justice (#, Policy Name)
(13) (Plano de Ação Vitória Sustentável) (Climate Change Adaptation Strategy for the City of Rio de Janeiro) (Plan Estratégico Distrital (PED)) (Plan de Acción "Panamá Ciudad Sostenible") (City of Virginia Beach Comprehensive Plan) (New Orleans Master Plan) (Resilient San Francisco) (OneNYC) (The Fourth Regional Plan) (City of Melbourne Climate Change Adaptation Strategy) (Surat Resilience Strategy) (100 Resilient: Resilient Bangkok Strategy) (Auckland Plan 2050)	**(7)** (Dakar Resilience Strategy) (The City of London Climate Change Adaptation Strategy) (National Capital Region Climate Change Report) (Growing Stronger: Toward a Climate Ready Philadelphia) (NYC Hazard Mitigation Plan) (City of Melbourne Climate Change Adaptation Strategy REFRESH) (Davao City Climate Change Action Plan)