

TOWARD URBAN CLIMATE RESILIENCE:  
A POLICY ASSESSMENT OF TUCSON, ARIZONA

By

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**Abstract**

Climate change is a phenomenon that threatens to alter the way societies exist and function in varied ways. As governments the world over scramble to find solutions in dealing with the effects of climate change, local climate policy arguably matters the most, at least on a short-term level. After all, cities and municipalities are the places in which localized climate effects are felt and seen by individuals. Urban climate resilience is an ideal that envisions cities that are prepared for the challenges that arise with a warming world. An emerging concept for guiding planners and policymakers for dealing with climate change, fostering urban climate resilience has gained traction in governance circles. This thesis focuses on the city of Tucson, Arizona, and the ways that the city has integrated climate resilience-building measures into its planning and policies.

## **Introduction**

Climate research has shown that the Southwest is headed towards a more arid environment, with extreme precipitation events during the monsoon season intensifying in the next century. With record to near record summer and winter temperatures in the last several years, the region is heading towards a climate change experience that is as unique as it is potentially calamitous.

With climate change being a widely accepted truth in academia and most parts of governance, questions about it have also emerged in social, economic, and political contexts. A concept gaining more importance in climate change literature, praxis, and policy as the social and political dimensions of climate change become more apparent is that of climate resilience. For simplicity's sake, I use the Intergovernmental Panel on Climate Change's (IPCC) definitions of the term in this paper. The IPCC, in its latest assessment report, defines resilience as "the capacity of social, economic, and environmental systems to cope with a hazardous event or trend or disturbance" (Field, Barros, Mastrandrea, et al 2014). When examined from any local standpoint, the term begins to take on added, nuanced, and even new meanings. In Tucson, Arizona, an urban setting in the desert where in 2017 the temperatures reached highs of 110 degrees Fahrenheit for several days in June and the rainfall totals broke records in July (Beamish 2017), investigating and assessing how the concept of resilience is applied may entail questions around human health and safety, ecological welfare, disaster preparedness, and infrastructure integrity.

The Intergovernmental Panel on Climate Change predicts that the American southwest in the summer is likely to experience a large amount of warming, as well as decreased total precipitation (Romero-Lankao, P., Smith, J. B., et al 2014). In an already very hot and dry

climate, the projections of an even hotter and drier future beg several questions as to how societies and governments in the Southwest will deal and have dealt with these changes. This thesis seeks answers to some of these questions with a focus on the city of Tucson, including: What actions is the City of Tucson taking, if any, to build resilience in a changing climate? What could be done better to create an urban environment that is better prepared for a future of climate change?

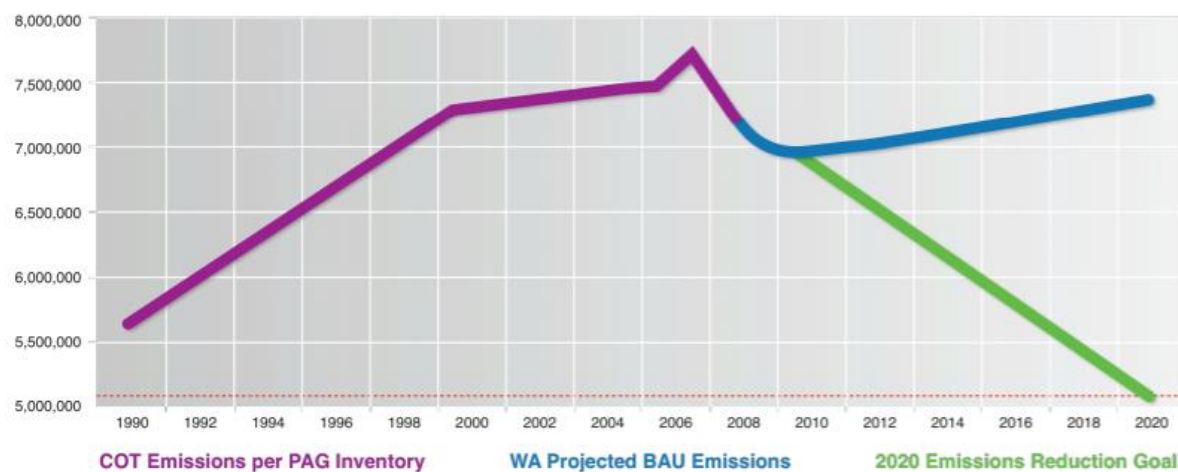
The emergence and growing ubiquity of resilience thinking as a guiding principle in the climate discourse, as well as several other discourses within a plethora of different disciplines, have opened the door to critical engagement with climate change as a phenomenon playing out within a social arena, not decoupled from unequal power dynamics, wealth disparities, and social inequity and injustice. I take special interest in resilience as well as vulnerability--the other side of the coin--as they may provide tools to map out sites where climate change policies may help some while failing (and sometimes even at the expense of) others. In conducting this research, I employ and maintain a critical lens that pays close attention to power, privilege, and oppression as they manifest in such things as race, class, and more peripherally, gender as they apply to climate resilience work. This lens will inform parts of the discussions of the research results.

*Research site: Tucson, AZ*

Tucson is a city in southeastern Arizona and the seat of Pima County made up of over 500,000 residents. Nestled in an alluvial plain on the eastern edge of the Sonoran Desert and surrounded by five mountain ranges, Tucson's climate is not unlike what you would expect for a desert city: hot, dry summers with an annual monsoon season that brings heavy precipitation events in the late summer months and mild winters with occasional rainfall throughout. Tucson

receives an average annual rainfall of 12 inches, though climate change threatens to alter this distribution.

Because of its location in the heart of the American southwest, Tucson falls under the “Southwest” category in all regionalized physical climate change research. Home to the University of Arizona, the state’s flagship university and home to the nation’s premier experts in the natural sciences, Tucson is no stranger to the arena of climate change research, especially pertaining to the Southwest. It is also host to the Climate Assessment of the Southwest (CLIMAS), which produces research on the status of the climate in the region. The University of Arizona is a top university for environmental research in the country and around the world (UA News 2013). It stands to reason that this wealth of environmental research within a sprawling desert metropolis at the very least informs the way that the city approaches city government.

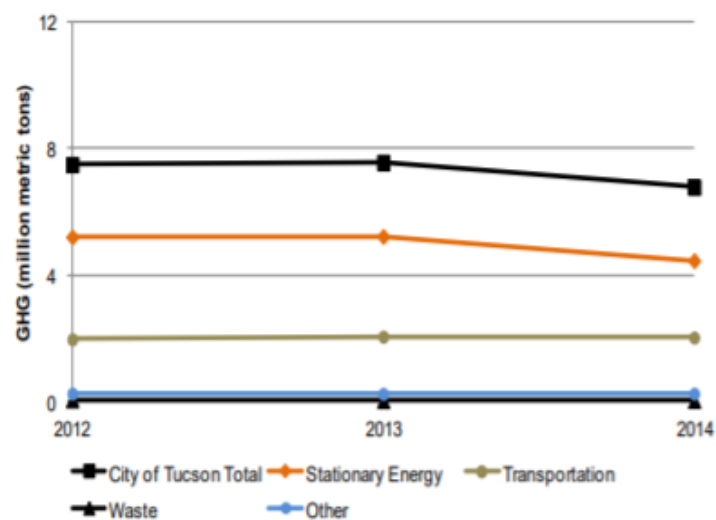


**Figure 1.** Projected City of Tucson greenhouse gas emissions in metric tons of CO<sub>2</sub>e, through 2020. Source: Westmoreland Associates 2011

Tucson has contributed its fair share to the climate change problem. According to Figure 1 above (Westmoreland Associates 2011), Tucson’s greenhouse gas emissions peaked in the mid-2000s, followed by a dramatic decline corresponding with the recession that happened a

decade ago. Since 2009, Tucson's greenhouse gas emissions have been slowly on the rise. The emissions reduction goal set by Westmoreland Associates--the group that published this chart which will be discussed further later in the thesis--is set at 5 million metric tons of carbon dioxide emissions by 2020. A report released in 2017 placed greenhouse gas emissions on a steady decline--from 2012 to 2014, greenhouse gas emissions in Tucson were down 10 percent, as shown in Figure 2 (PAG 2017). Though not quite close to the goals set forth in the Westmoreland report, this shows Tucson's commitment to doing its part in battling climate change, as demonstrated by the downward trends in emissions.

**Figure 2.** City of Tucson greenhouse gas emission trends, 2012-2014. *Source:* PAG 2017



### *The last decade in Tucson climate policy*

The City of Tucson's efforts to fight climate change date back to 2006, when the council signed the Mayors' Climate Protection Agreement, organized by the US Conference of Mayors (Arizona Daily Star 2017). The major stipulation of this pact was to reduce greenhouse gas emissions by 7 percent from 1990 levels by 2012. In 2008, the Climate Change Citizens' Advisory Committee was created after the adoption of the Framework for Advancing

Sustainability. The City's Office of Conservation and Sustainability sponsored this climate change committee for many years until budget cuts later eliminated this office. The committee commissioned a report from Westmoreland Associates, a climate and energy consulting group based in Tucson. Published in 2011 and titled, "Community Economic Security and Climate Action Analysis," the 360-page report laid out a variety of measures that the group recommended to the City of Tucson to increase the city's adaptive capacity in a time of climate change. They report proposed some regulatory measures, but mostly contains ambitious policy projects such as creating and supporting sustainable infrastructure around the city and instating programs. This report will be synthesized and employed in the research to evaluate some of the many measures that have been taken by the City and its partners to date. As well, other measures that may not necessarily have been included in the report but may contribute to reducing climate vulnerability while building resilience will also be explored and assessed.

In 2012, the City of Tucson partnered with CLIMAS to draft a vulnerability assessment for the community, however, that has not been published and it is an ongoing project. I was able to acquire a non-peer reviewed and unpublished draft prepared by Gregg Garfin and Taryn Kong from the University of Arizona.

Two years after the Westmoreland report was released, the City published a general and sustainability plan, "Plan Tucson," an almost 250-page document that maps out the directions in which the city is going. In this blueprint, mayor and council as well as the City's planners, attempt to envision a Tucson with high adaptive capacity to a changing climate. This document is also used in the thesis' assessment.

In 2017, the Commission on Climate, Energy, and Sustainability (CCES) was established; an advisory board for mayor and council, the 11-member commission was formed to

help inform the City administrators on how best to implement the climate, energy, and sustainability goals outlined in the planning document.

## **Methods**

Ultimately, this thesis attempts to assess the city of Tucson's approaches to addressing climate change; specifically, how the city's government and communities are working to reduce local climate vulnerability while building climate resilience. I begin the thesis by reviewing critical insights that we have gained from existing literature in resilience research. Using these insights, I review critical pieces of climate science research (including the most recent IPCC assessment report and National Climate Assessment) to qualify Tucson's susceptibility to climate change impacts in the next several decades. I then examine Tucson's climate resilience building approach by using the Westmoreland report and comparing the climate policies that the city has enacted since. I will also include some initiatives that do not necessarily involve policies, yet have the potential to build resilience on an urban scale. Through surveying climate change related documents, policies, and actions produced by the City of Tucson in the last decade or so, I assess how well the city addresses its vulnerability through resilience building. The thesis ends with a discussion on the implications of the research, including an evaluation of current climate change policy in Tucson and possible actions for the future to ensure that climate vulnerability and resilience are adequately prioritized and addressed in climate policy.

## **Literature review**

The importance of vulnerability and resilience as key considerations for climate change planning and policy is well documented and well established. Vulnerability research shows us that out of a combination of different factors (social, political, economic, geographic, and others) some regions, countries, and populations are more predisposed to suffering from extreme

weather events. For example, Honduras, Myanmar, and Haiti were three countries found to have been most affected by climate change-related extreme weather events over the last two decades (Kreft, S., Eckstein, D., Melchior, I. 2015). Nicaragua, the Philippines, and Bangladesh follow closely behind them.

While the United States sits far below the top of any climate vulnerability index, vulnerability can vary within individual countries, especially in a country like the US, where the climate varies geographically due to the vast land area and there exist conditions such as high social stratification, a highly diverse citizenry, and a democratic republic government with multiple scales of governance. For example, as a result of over-allocation and increasing demand, Phoenix and surrounding areas are especially vulnerable to water shortage in the next decade (Gober & Kirkwood 2010).

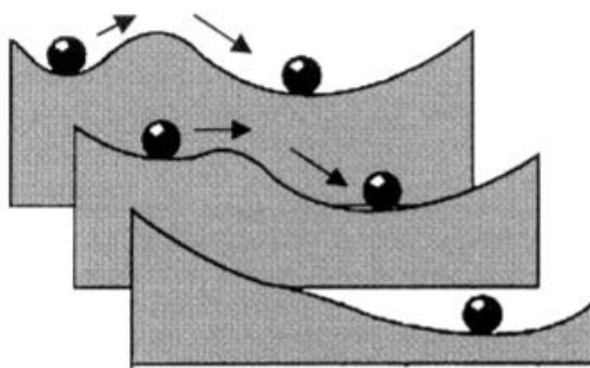
Central to this paper is the concept of resilience as the solution for vulnerability reduction in communities; in increasing its ability to “bounce back” from major disasters or disruptions in their way of life, the Tucson community becomes a more resilient system.

The body of literature on resilience is vast and multi-faceted, and thus terminology can differ as one ventures from field to field. The language of resilience can take on a technical and precise nature when considering urban design and systems, and transform into a universe of meanings in the context of human and/or community resilience. Keeping this in mind, in this thesis, I draw important distinctions between infrastructure or urban resilience and human or social resilience; I also pay attention to the resilience properties of the unique natural systems that abound the sprawling desert metropolis. All of these will be necessary considerations when assessing how Tucson approaches an altering climate and environment. Though economic resilience is also an important consideration in urban climate resilience, this part is excluded as a

distinct category in the thesis as I see economic resilience as ingrained in the social dimensions of urban life. Furthermore, economic perspectives too often erase the lived realities of poorer communities in multi-scalar processes that privileges sustained profits over prosperous and happy communities.

**Figure 3.** Ball and cup heuristic for envisioning resilience. *Source:* Gunderson 2000

Resilience thinking emerged in the ecological sciences out of a discontent with the



prevailing methods of ecosystem dynamics in the 1970s (Cote & Nightingale 2012). C.S. Holling, a resource ecologist, lay the groundwork for resilience thinking in his seminal paper, “Resilience and Stability of Ecological Systems (1973). Using quantitative research, Holling concluded that populations oscillate in abundance within the boundaries of environmental cycles. The idea was a departure from a way of thinking that assumed a “balance of nature,” wherein dynamics simply tend towards stability and equilibrium. Resilience thinking argues that these dynamics should be thought of as undergoing multiple and varied states of stability (Botkin 1990, Conway 1987, Pimm 1991).

A popular visual representation used in resilience theory is the “ball and cup” heuristic, illustrated in Figure 3 (Gunderson 2000). Within this heuristic, the valleys in the figure represent domains of stability; the balls represent the system, and the arrows represent shocks or

disturbances to the system. Resilience is determined by the slopes within the stability landscapes. Depending on various factors that affect the strength of mechanisms safeguarding a system, the slope in this model can be thought of to change. Though this heuristic originated in ecology studies, as did resilience thinking itself, one can easily adopt it to be applicable to several different areas of study, not least of which are urban systems/planning, the social sciences, policy and law.

The relatively new resilience epistemology and approach gained traction in other fields outside of ecology in the 1990s as social science researchers adopted the framework to examine human-environment interactions and engender emerging socioecological discourses (Folke 2006, Stallins, Mast, & Parker 2013). With the development of better climate change assessment tools that eventually produced reliable climate science to support the notion of a changing climate all occurring in parallel with these other developments, the idea of urban resilience arrived. The United Nations now has an Urban Resilience Hub, which works towards fostering climate resilience on local scales. Examples of their work include getting urban resilience into the sustainable development goals put out in 2015, and publishing a *Planning for Climate Change* toolkit for city planners looking to better understand and take action on climate change on a local level. The Urban Resilience Hub defines urban resilience as “the measurable ability of any urban system, with its inhabitants, to maintain continuity through all shocks and stresses, while positively adapting and transforming towards sustainability” (UN Habitat, Urban Resilience Hub). Though climate change is not explicitly mentioned in this definition, perhaps because not all shocks are climate change related, climate change remains one of the largest threats to our urban environments, especially in the desert. Urban resilience melds together ecological, infrastructure, and human resilience. Embedded in this definition are notions of human

resilience, which entail personal, familial, and community wellness. There is no evidence to suggest that Tucson's city government has used or consulted with UN Habitat's resources or affiliates.

Systems, agents, and institutions are three critical components of building urban climate resilience (Tyler & Moench 2012). The Tyler & Moench paper provides us with a clear framework to envision an urban space prepared for a changing climate. Systems within this framework exhibit the following characteristics: flexibility and diversity (urban systems can meet service needs against a variety of climatic conditions), redundancy and modularity (the existence of spare capacity to accommodate unexpected demands), as well as safe failure (failure in a singular part of the system does not lead to cascading failures). Agents possess the following capacities: responsiveness (organizing or reorganizing in a timely manner), resourcefulness (mobilizing resources for action), and capacity to learn (evaluating and internalizing past experiences). Institutions factor into urban climate resilience in the following ways: system access (the rights and entitlements that determine who accesses what services or resources), decision-making processes (the political processes that affect urban development), information flows (general access to information), and ability to apply new knowledge (facilitating the generation, exchange, and application of new knowledge to enhance adaptive capacities). I use this framework in the thesis, however, I also address the dimensions of natural system, infrastructure, and social resilience that play out on the arena located in this framework.

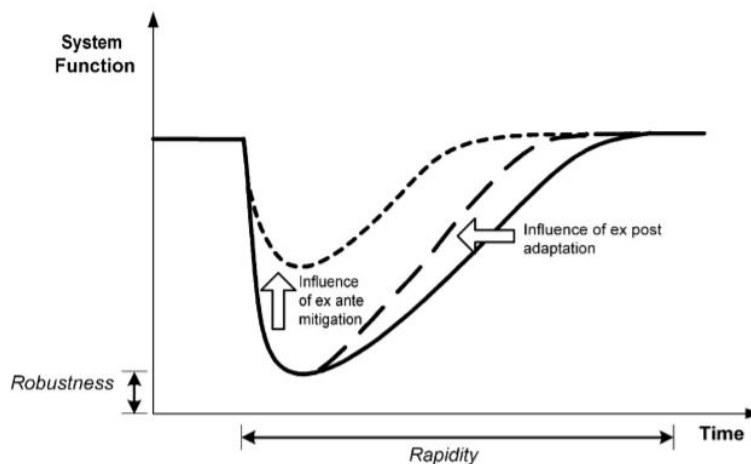
### *Natural/ecosystem resilience*

In a 2003 report titled, "Buying Time: A User's Manual for Building Resistance and Resilience to Climate Change in Natural Systems," the World Wildlife Fund places resilience

building in response to climate change (in the non-built environment) into three broad categories: 1) protecting adequate and appropriate space for biodiverse ecosystems; 2) limiting non-climatic stress such as overharvest, invasive species, and pollution; and 3) using active adaptive management and strategy testing, which entails a “responsive and flexible approach” to managing resources (Hansen & Biringer 2003). Though the framework they use was produced for natural resource managers with goals of fostering resilience in natural systems, urban planners and city governments can glean important lessons from the findings in the report as well. Furthermore, a city like Tucson is heavily influenced by the natural ecosystems within it and that surround it and hence, the city must carefully consider the impacts of a changing climate on the non-built environment.

The WWF report states that grasslands and deserts are especially vulnerable to climate change. With forecasted impacts associated with changing land use and a changing climate, the structure and function of grasslands such as those in the Sonoran Desert, are at stake. This could have serious implications for Tucson as it deals with altered fire regimes in nearby lands, a substantial decrease in arable land, an increase in extreme weather events, and the ever-present challenge of housing and feeding its populace. “Buying Time” provides us with a simple yet effective framework that allows us to consider not only the built environment but those natural environments--both embedded within and existing externally of the urban space--as well, as we examine the ways to build climate change resilience.

## Infrastructure resilience



**Figure 4.** Heuristic for thinking about infrastructure resilience. *Source:* McDaniels, Chang, et al 2008.

Urban infrastructure systems--that is, those structures collectively known as the built environment--are critical in building urban climate resilience. A framework for thinking about fostering urban resilience to extreme weather events can be understood in two dimensions: robustness, “the extent of system function that is maintained,” and rapidity, the “time required to return to full system operations and productivity” (McDaniels, Chang, et al 2007). McDaniels and colleagues put forth several methods for determining and evaluating resilience of infrastructure in urban systems, and Figure 4 illustrates the general effects of decision-making on a system’s resilience. The line indicates how the system functions in a time of disaster or shock: its robustness makes the system sustain damage at a lesser extent while its rapidity allows it to return to equilibrium faster. Mitigation efforts, according to this model, increases robustness, while adaptation efforts increase rapidity. Mitigation efforts are just as important as adaptation efforts in resilience building. I use this framework to evaluate the policies and actions being done in the Tucson community to build resilience into its urban design.

### *Human resilience - social, personal, familial*

For the purposes of this thesis, I use human, social, and community resilience interchangeably. After all, humans are social animals who organize ourselves into communities. In social work literature, personal attitude, spirituality and religion, education, and multilevel attachments are all factors that can determine individuals' personal resilience (Greene, Galambos, Lee 2004). Though there is a marked difference between individual resilience and community resilience, some of these factors can play significant roles to communities' resilience. For example, spirituality and religion are potentially essential to the resilience of communities in pockets of Tucson.

The social dimensions of resilience is a critical piece of building urban climate resilience. Sociologist Eric Klinenberg studied the aftermath of deadly Chicago heat wave in July 1995, that killed nearly 800 people. Klinenberg found that neighborhood resilience played a key part in keeping people alive; those who died lacked community connections, and those who survived were more likely to have had stronger ties to their communities (Klinenberg 2003). The implications of this research could be major in Tucson and in the Southwest at large; as climate change threatens to bring on higher temperature summers, the deciding factor of who survives extreme heat events could be determined by the degree to which one's neighborhood is tightly knit.

Public health research from the Chicago heat wave case study revealed that race was also a factor: black Chicagoans were killed at higher rates by the heat wave than white Chicagoans (Whitman, Good, et al 1997). The same research suggests that many killed lived in poorer neighborhoods. Applying a critical lens to this allows one to see that climate resilience on a local scale has yet even smaller scales of impact to consider. In Tucson, a city of over 500,000

residents, vulnerability to climate change's impacts is disproportionately distributed on micro-scales that can differ depending on neighborhood income, racial makeup, and community ties. Investigating the community resilience in relation to extreme weather events in different Tucson neighborhoods is research that has yet to be conducted, but could have major implications that can inform future climate policy.

Further research points to social networks as potential tools for reducing climate change risks and vulnerability. In Southeastern Arizona, though Hispanic farmers and farmworkers' ethnicity and socioeconomic status make them highly vulnerable groups to the effects of climate change, they are able to access resources that are woven into their informal social networks (Vásquez-Léon 2009). Though this thesis does not conduct primary research into informal social networks around the neighborhoods in Tucson, this insight is helpful in the research in seeking out any initiatives that aim to create and cultivate social networks in neighborhoods around the city.

Mental health research suggests that a resilience-oriented approach that creates "safe havens"—effectively, spaces for families and community members to share their grief or pain—can encourage mutual support and help communities work through the trauma of major disasters (Walsh 2007). In the Southwest in general, where the most frequent "traumatic" or disastrous climate-related events are extreme heat events that are likely to occur in the summertime, it can be challenging to identify discrete points where strategies suggested in Walsh's paper can be easily applied. The Southwest's climatic shocks and traumas—such as heat-related deaths within the homeless or the elderly—are far more gradual, isolated, and difficult to locate within the discourse of trauma. Nonetheless, if major disaster in the form of a heat such as Chicago's 1995

heat wave were to occur in the Southwest, the importance of resilience-oriented approaches to recovery systems for communities and families is supported in the literature.

### *Contesting resilience*

In addressing issues that emerge out of the cross-cutting theory and practice of resilience, we must keep a careful and critical perspective. Existing literature casts a skeptical eye on the concept of resilience. For example, in urban design literature, critical scholars have problematized the effectiveness of resilience as a planning concept. Davoudi argues that the concept of resilience pre-supposes the occurrence of large and sudden events, also known as shocks, at the expense of considering smaller and more gradual changes while simultaneously biasing planners toward a certain equilibrium that must be restored via post-disaster emergency planning (2012). The multidisciplinary nature of the concept of resilience can subject practitioners to certain pitfalls, such as the very real risk of being “power-blind,” by paying little or no attention to the power relations and dynamics which produce outcomes in disaster planning. Though Davoudi is ultimately optimistic that resilience can be a bridging concept that can connect the natural sciences with the social sciences, she raises salient points about the problems that can stem from relying too greatly on positivistic and normative notions of resilience.

Shaw argues that resilience can be contested and ultimately reframed to become a radical agenda as opposed to a static concept; instead of viewing resilience as merely survival, as well as an eventual return to the status quo, Shaw stakes that resilience can be viewed as a tool for transforming and challenging power structures and norms (2012). As does Douvadi, Shaw also cautions against the sterile and depoliticized conceptions of resilience in theory and practice.

In maintaining a critical perspective simultaneously as I am gathering information about Tucson's resilience strategies, it is worthwhile to address the problems that can emerge out of resilience thinking.

## **Findings**

### *Climate change research*

This section analyzes the contents of three documents to guide us through the potential impacts for climate change on Tucson. The documents are arranged from broader to finer scales. The first report, from the Intergovernmental Panel on Climate Change, examines climate change impacts on North America; the second is a National Climate Assessment report on the Southwest, and the third takes from an unpublished report commissioned by the City of Tucson that examines climate change impacts on just Tucson. Worth noting is that Gregg Garfin authors both the NCA report and the unpublished paper, thus they will both contain similar information, though the Tucson report is more focused.

### Intergovernmental Panel on Climate Change, Assessment Report 5

The latest report by the IPCC was published and released in 2014 (IPCC, 2014). This section will use Chapter 26 of Part B of the Impacts, Adaptation, and Vulnerability segment of the report to examine the findings of an international community of climate researchers.

In the United States, IPCC scientists have declared with very high confidence that North America's climate has changed and that many of these changes are anthropogenic, or linked to human activities; they have also concluded with very high confidence that climatic stresses that carry risk such as severe heat, heavy precipitation, and declining snowpack will increase in frequency and/or severity in the region within the next decade. An increase of only 2 degrees

Celsius has the potential to trigger more frequent extreme weather events, particularly related to heat and precipitation over most of the North America.

Below is a brief and abridged compilation of some of the relevant findings and projections for the North American continent's climate and the ramifications these may have on Tucson's urban settlement, as well as the type of resilience theme embedded in the mitigation or adaptation measures around them (if applicable):

- The mean annual temperature has increased over the past century over most of North America (very likely).
  - Increased demand for air conditioning or cooling/shade structures: infrastructure resilience
  - Ecosystem impacts (stress on plants and animals, agricultural or otherwise): natural system resilience and infrastructure resilience
- There are earlier peak flows of snowmelt runoff in snow-dominated streams and rivers in western North America (very likely).
  - Decreased water supplies: natural system resilience and infrastructure resilience
- There have been and will continue to be declines in the amount of water stored in spring snowpack in snow-dominated areas of western North America (very likely).
  - Decreased water supplies: natural system resilience and infrastructure resilience
- Existing urban vulnerabilities can be compounded as a result of regional climatic stresses (high confidence).
  - Marginalization of communities unprepared to deal with a changing climate: social or human resilience

- Extreme heat events result in increases in mortality and morbidity in North America (very high confidence).
  - Heat-related illness and death in the Southwest: human resilience
- Adaptation can help to reduce risks in the current climate and to manage future risks associated with a changing climate (medium confidence).
- Most sectors of the economy in North America have been impacted by and responded to extreme weather (high confidence).
  - Threats to industries such as agriculture and tourism: infrastructure (and economic) resilience

### National Climate Assessment

For a more contextualized investigation into the potential regional impacts of climate change in the Southwest, we can turn to the National Climate Assessment (NCA). The NCA presented the following key findings for the Southwest region of the United States in their latest assessment (2014). Implications for Tucson are discussed with each of them.

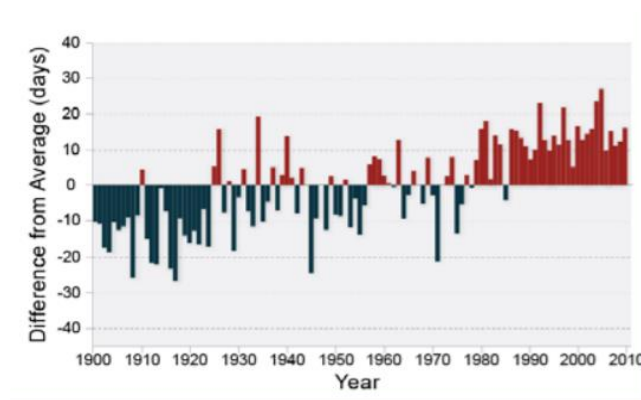
1. *Snowpack and streamflow amounts are projected to decline in parts of the Southwest, decreasing surface water supply reliability for cities, agriculture, and ecosystems.*

Though Arizona contributes much less to the Southwest's regional snow water equivalent (SWE) totals (SWE refers to the equivalent amount of water in a given volume of snow), the projections are yet dire for the state: a nearly 25% decrease in SWE is predicted between 2006 and 2035 as compared to between 1971 and 2000, on a downward trend as we move through the decade. By the last quarter of the 21st century, Arizona's SWE is projected to be 12% of what it was in the last quarter of the 20th century. Also, worth considering is the decrease in snowfall in Colorado, where snowpack and subsequent snowmelt influences the streamflow of the Colorado River and

its corollaries, upon which much of Arizona, including Tucson, relies for water. The last quarter of this century could see a one third reduction in SWE from pre-21st century levels. This has resulted in decreased streamflow totals (not only in the Colorado, but the Rio Grande and in the Great Basin).

This alarming decrease in snowfall is a classic example of how climate change seriously threatens the water supplies of many communities that rely on consistent snowpack melt in the springtime as river sources. Tucson relies on both groundwater and water from the Central Arizona Project (CAP) for its water. City planners, natural resource managers, farmers, and industry giants alike must consider these findings in collaboration with one another in becoming stewards of our water sources while simultaneously fostering resilient water infrastructure in Tucson and other Arizona cities.

2. *The Southwest produces more than half of the nation's high-value specialty crops, which are irrigation-dependent and particularly vulnerable to extremes of moisture, cold, and heat. Reduced yields from increasing temperatures and increasing competition for scarce water supplies will displace jobs in some rural communities.*



**Figure 5.** Yearly differences from average frost-free days in the Southwest. *Source:* NCA

Arizona's agriculture industry is as large and productive as it is thirsty. Though Tucson is not as large of an agricultural hub as other parts of Arizona, like in central Arizona, Tucson is growing to be more and more supportive of local food production and distribution through urban agriculture and local farms. The NCA predicts that the Southwest's vulnerability to extreme temperature and extreme temperature fluctuations could cause the perfect storm for agriculture. The figure above shows the frost-free day anomalies in the Southwest. The number of consecutive frost-free days per year in the past three decades has significantly increased, which has major implications for agriculture because of such phenomena as bud burst or bloom of some plants. A greater number of frost-free days render many species of plants underprepared for colder days in the spring, resulting in frost damage when these days occur.

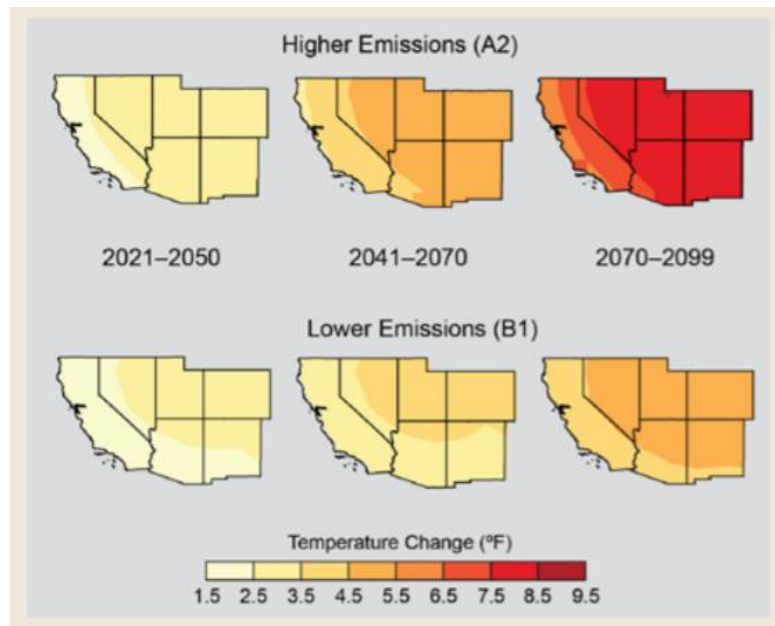
A changing climate that brings with it harsher conditions for plants to grow and thrive could hurt Tucson's agricultural economy as well as the livelihoods of local farmers who rely on a stable climate to produce food.

3. *Increased warming, drought, and insect outbreaks, all caused by or linked to climate change, have increased wildfires and impacts to people and ecosystems in the Southwest. Fire models project more wildfire and increased risks to communities across extensive areas.*

Perhaps the most relevant and most noticeable to desert-dwellers, the issue of drought and warming which consequently threaten the possibility of increased wildfires is one that bears immediate impacts on the Tucson community. The figure below, which the NCA adapted from Kunkel et al (2013--citation in the NCA), shows how a high emissions scenario could lead to an over 8.5 degree increase in Arizona temperatures--a change which could dramatically shift fire regimes for the catastrophic.

Though Tucson is not likely to experience wildfires that threaten to evacuate the city, it could yet experience wildfires in nearby non-built environments and systems. As well, it is forecasted that the region may experience extensive tree death due to warming and exacerbated insect outbreaks, such as bark beetles, which thrive under warmer conditions.

Trees, which provide the desert urban environment with natural cooling and shade structures, are at risk with a changing climate. This is something planners must grapple with as they seek to increase the aesthetic value of the cityscape whilst also decreasing the urban heat island effect.



**Figure 6.** Projected temperature increase in the Southwest. *Source:* Kunkel et al 2013.

4. *Flooding and erosion in coastal areas are already occurring even at existing sea levels and damaging some California coastal areas during storms and extreme high tides. Sea level rise is projected to increase as Earth continues to warm, resulting in major damage as wind-driven waves ride upon higher seas and reach farther inland.*

Though this finding is more relevant to coastal areas such as most of California, storm flooding is a serious issue that Tucson must attend to, especially during the summer monsoons. Existing infrastructure already has a difficult time dealing with the deluge of torrential downpour that frequent the city in the summer months. Future infrastructure must keep up with a changing climate. Not highlighted as much in the NCA report is the possibility of amplification of extreme weather events such as monsoon storms in the Southwest, which threaten infrastructure and community welfare.

5. *Projected regional temperature increases, combined with the way cities amplify heat, will pose increased threats and costs to public health in southwestern cities, which are home to more than 90% of the region's population. Disruptions to urban electricity and water supplies will exacerbate these health problems.*

The urban heat island effect, referred to earlier, refers to the warming that occurs as a result of the built environment. Concrete, asphalt, and other components of an urban system tend to absorb incoming heat and eventually contribute to the overall heat within a city. This is most exemplified in a place like Phoenix, where even the landscaping features a great deal of heat absorbing materials such as concrete.

The NCA proposes the following options for preparedness and response in dealing with urban heat and public health: 1) using white roofs, shade tree planting, and increased shading to deal with the more frequent and severe heat waves; 2) using ENERGY STAR rated appliances to reduce non-air conditioning demand as warming necessitates more air conditioning use; 3) applying smart grid technologies and adding solar power generation especially for summer peak demand; 4) increasing preparedness through providing cooling centers and promoting programs to check on elderly and at-risk residents.

## Unpublished Tucson Climate Impacts Study

Though a draft copy of this study was released in 2012, a final version was never published for public circulation (**Garfin 2012**). Here are the ten key findings from Garfin's research on the local impacts of climate change that Tucson's planners and administrators must keep in mind as they map out the city's future:

*1. The region has warmed significantly, and is likely only getting warmer.*

With an observed 2.7 degree Fahrenheit increase in 30-year averages in the last century alone, warming is a trend that has been happening for many decades in Tucson. Climate models put 30-year average temperatures at a 7.5 degree Fahrenheit increase by the last quarter of the 21st century. This warming is exacerbated by the urban heat island effect.

*2. Precipitation will decrease seasonally and aridity will increase*

Observed precipitation trends show increased aridity and drought events in and around Tucson. Though annual precipitation does not necessarily show decreasing trends, there is a consistent downward trend with winter and spring precipitation.

*3. Extreme climate-related events may be more frequent in the future*

Emerging climate models illustrate more severe and more frequent extreme weather events, not least of which are droughts, heat waves, and floods.

*4. Surface and groundwater supplies will both come under more stress*

A warming climate translates to such things as lower levels of and earlier snowmelt, which could potentially lead to decreased water supplies. This century could see a 7.7% decrease in the average runoff from the Colorado River, which Tucson primarily relies on for its surface water. The report also points to decreased winter precipitation and heightened evapotranspiration as likely culprits of current and future water stress.

5. *Human health risks associated with the climate may be exacerbated by climate change*

Public health is a major arena that could be seriously affected by warming temperatures. Health risks identified in the report include ozone exposure, heat stress, increased likelihood of contracting insect- and rodent-borne diseases, and increased likelihood of respiratory problems associated with airborne allergens. Elderly Tucsonans, those who are homeless, or those who cannot afford consistent air conditioning are especially vulnerable to these climate-related risks.

6. *Food security could be seriously affected by climate-related shocks*

Especially in lower income households, food access could become a serious issue in Tucson as food prices fluctuate with a changing climate. Climate change will negatively impact food production across multiple regions and locales.

7. *Food security vulnerability is related to food imports; new challenges emerge in adapting*

*Arizona food production to climate change*

With over 97% of food consumed in Tucson being imports, Tucson faces a climate change problem on scales much larger than the Southwest, and even the United States. Arizona's agricultural industry is particularly vulnerable to climate-related risks, including more erratic precipitation, increased evapotranspiration, and decreased soil moisture.

8. *Extensive wildfire risk and tree mortality events are expected to become increasingly likely*

More severe and frequent droughts and heating events could also mean a greater likelihood of tree death in the mountains surrounding the city, exacerbated by heat-driven insect outbreaks and wildfire. High fire risk days are expected to increase by up to two to three weeks by the year 2070. Tree mortality could be disastrous not only for key ecosystem services that trees provide such as carbon sequestration and erosion prevention, but tourism and recreational amenities.

9. *Even in non-fire adapted desert biota, fire risk is likely to increase*

The expansion of non-native and invasive species such as buffelgrass drives an increase in wildfire risk. The Sonoran Desert is expected to see a rise in the length and intensity of its fire season. The implications of this could be grave for the biodiversity, property, and human life in the desert.

10. *Water costs are likely to increase as the links within the water-energy nexus become strained by a warming climate*

Finally, the report identifies the deeply interconnected water supply system and energy production systems within Arizona that are expected to become increasingly strained with a warming climate. Nationally, power plants use 39% of the freshwater supply, as they rely on water for cooling. By 2030, this number is expected to increase by 50-80%. Decreasing water supplies could impact energy costs, and increasing energy costs could increase water prices.

Many of the vulnerabilities identified in these reports are components of physical processes that have been playing out since before humans had the tools to fully investigate and articulate them. In other words, some of the impacts are already happening in Tucson today, which is a serious consideration that city planners and administrators must take into account.

Though these reports do not directly or explicitly prescribe policy to decision-makers, they are useful in informing and focusing any policies that could emerge around climate planning.

*Tucson's policy responses*

The next segment of the thesis examines Tucson's approaches in building a more climate resilient urban system: a 2011 report commissioned by the City and produced by Westmoreland Associates, an energy consulting group based in Tucson, which outlines prescriptions for the city

to help mitigate the effects of climate change and the general sustainability plan issued by the City itself in 2013, an overarching agenda that provides a picture of the direction in which Tucson is heading. The table below identifies the major proposed resilience measures that have emerged in these documents and climate policy conversations in Tucson. It is a comprehensive list, but not complete.

Planned or proposed initiatives	Details	Westmoreland Report	Plan Tucson	Implementation
<b>MITIGATION</b>				
New construction permitting measures to promote energy efficiency	Rebates on new home construction permits for homeowners and developers using ENERGY STAR appliances	x	x	Not implemented, however Tucson policy aims to encourage increased energy efficiency in new private building construction
Rental housing energy efficiency initiative	A city-wide ordinance requiring landlords to disclose energy use for rental housing; the creation of a City-sponsored energy efficiency awareness program; and establishing a minimum energy efficiency retrofit requirements on transfers of rental property	x		Not implemented
"Climate Challenge" for businesses	Voluntary greenhouse gas mitigation reductions in the private sector	x		Not implemented
Applied efficiency initiative	Active promotion of the economic benefits of consumer upgrades to energy efficient appliances in addition to rebate and education efforts	x	x	Small scale implementation happening in partnership with TEP

Planned or proposed initiatives	Details	Westmoreland Report	Plan Tucson	Implementation
<b>MITIGATION</b>				
Community Climate Challenge	Designing and implementing a community-wide climate challenge; implementing a website where households can pledge a reduction, estimate their impact, and learn ways to promote energy efficiency and conserve energy	x		Not implemented
Residential solar street lights	Installing solar-powered LED streetlights whenever new streetlights are added to residential areas	x		"LED Lighting Project" ran through Tucson's Department of Transportation; not residential specific
Green Building Program expansion	Adopting the 2012 International Energy Conservation Code	x	x	Implemented with amendments
Mandatory cool/ENERGY STAR roofing	Mandating cool roofing systems on all future construction residential and commercial	x		Not implemented
Increased commercial recycling	Build on previous successes of voluntary commercial recycling by aggressively promoting recycling to all City commercial waste disposal accounts	x	x	Partially implemented; not as aggressively as proposed

Planned or proposed initiatives	Details	Westmoreland Report	Plan Tucson	Implementation
<b>MITIGATION</b>				
Mandatory construction and demolition recycling	Increasing C&D rates from the assumed 50% to either 80 or 100%	x		Not implemented
Voluntary travel carbon offset program	Implementing a web-based site to enable community members to offset carbon expenditures from travel	x	x (mentions long-term goals, general carbon offsets)	Not implemented
Vehicle Maintenance and Behavior Education Program	Implementing an educational program focusing on improving vehicle fuel efficiency for vehicles registered in the City	x		Not implemented
Double bike lane usage	Double bike lane usage by 2015, achieved by supporting the efforts of the City Bike/Pedestrian Coordinator	x	x	Not implemented; though many bicycle-related projects ongoing
Anti-idling Ordinance	A city-wide ordinance establishing time restrictions on voluntary idling; a series of graduated penalties	x		Not implemented
Transit-oriented development initiative	Maximizing the city's promotion and support of transit-oriented development and supporting mass transportation development	x	x	Partially implemented with SunLink Streetcar project; ongoing projects related to but not specifically meeting the proposal

Planned or proposed initiatives	Details	Westmoreland Report	Plan Tucson	Implementation
<b>MITIGATION</b>				
Car Sharing Program	Establishment of a private Car Sharing program to begin in 2012, growing to 3,600 members by 2015	x		Not implemented, however Tucson's support of private entities such as ZipCar, Uber, and Lyft have helped meet some goals
Intersection roundabouts	Constructing three roadway roundabouts instead of signalized intersections	x		Partially implemented in new developments
Bike share program	Integrating a bike share program with 600 bikes to compliment current public transportation systems and the UA bike share program	x		TuGo bicycle share program implemented in late 2017
Telework program	Implement a telework program for City employees to reduce emissions and restore worker productivity lost to commuting	x		
Solar permit flat fee	Adopting cost-recovery solar permit flat fee		x	Implemented in 2013
Solar requirements	Adopting 5% solar requirements for City buildings		x	Implemented

Planned or proposed initiatives	Details	Westmoreland Report	Plan Tucson	Implementation
<b>ADAPTATION</b>				
Reduce urban heat island effect	Minimizing heat generation and retention from the built environment		x	Not implemented / ongoing
Community solar	Facilitating community use of solar power and other renewable energy sources for City infrastructure, facilities, and operations		x	Ongoing
Vulnerability inventory	Assessing and addressing the vulnerability of community health and safety, economy, and natural resources to climate change and developing assurances that vulnerable and disadvantaged populations are not disproportionately impacted		x	Ongoing
Conservation programs	Developing community energy conservation education and energy efficiency retrofit programs and identify appropriate new financing opportunities for energy efficiency and solar energy installations		x	Ongoing

Planned or proposed initiatives	Details	Westmoreland Report	Plan Tucson	Implementation
<b>ADAPTATION</b>				
Community resilience support	Equipping neighborhoods to with the knowledge and skills to be able to recover from extreme weather events, such as extreme heat			Though not City-supported, Building Resilience Neighborhoods is a workshop program run by Physicians for Social Responsibility that helps neighborhoods around Tucson prepare for extreme heat
Long-term water infrastructure planning	Managing and planning the city's water supplies, quality, and infrastructure for long-term reliability and efficiency		x	Ongoing
Water conservation programs	Expanding effective water efficiency and conservation programs for City operations and for the residential, commercial, and industrial sectors		x	Ongoing through multi-level partnerships
Climate variability planning	Conducting ongoing drought and climate variability planning		x	Ongoing
Green infrastructure support	Encouraging green infrastructure and low impact development techniques for stormwater management in new development		x	Ongoing

Planned or proposed initiatives	Details	Westmoreland Report	Plan Tucson	Implementation
<b>ADAPTATION</b>				
Diversified energy sources	Diversifying the city's energy portfolio such that the city is not reliant on any single energy source in times of climate-related extreme weather events, with a focus on increasing renewable energy source infrastructure		x	Ongoing
Expanded cooling center facilities	Creating more spaces for those with low or no access to air conditioning to go in times of extreme heat, especially in the summer			Currently, public or private structures such as libraries, businesses, churches, and hospitals function as "cooling centers" but there is little to no political push to create places specifically for community members to cooling off in times of extreme heat
Climate change-adapted emergency services	Acknowledging the impacts that a warming climate may have in managing emergency services; expanded emergency services and appropriate training for times of extreme weather, heat waves, or otherwise.			Not implemented

Planned or proposed initiatives	Details	Westmoreland Report	Plan Tucson	Implementation
<b>ADAPTATION</b>				
Food system resiliency	Supporting and expanding local and/or urban agriculture with respect to future projections of a warming climate		x	Ongoing
Native vegetation support	Increasing the use and protection of desert-adapted and native plantlife that are better able to withstand climate change impacts, and complement the built environment with cooling benefits		x	Ongoing
Traditional ecological knowledge	Looking to Native peoples of the Southwest for adaptation strategies, as they have lived in the desert for many centuries and have valuable knowledge for sustaining healthy communities in the desert			Not implemented

**Figure 7.** This table outlines many of the proposed and/or ongoing climate mitigation and adaptation measures that could potentially build Tucson’s urban climate resilience and reduce vulnerabilities. Most proposals are drawn from the Westmoreland Associates report or Plan Tucson. The last column indicates their implementation status.

## Discussion

A glance at the table shows that though some of the measures proposed in the Community Economic Security and Climate Action Analysis did make it into the Plan Tucson document, they often did so in unspecified, vague, or general ways. While the Westmoreland report is specific, detailed, and calculated, the general plan was general unfocused on any single message. Worth mentioning is that Plan Tucson made no mention of the 2011 report, and strayed from making specific commitments. The plan does mention the City's aims to reduce carbon emissions and improve green infrastructure, but does not go very deeply into the specific steps toward implementing these policies. This is to be expected, as the document is written in such a way to be comprehensive of all general policies for guiding Tucson development, and it is not only focusing on the challenge of climate resilience. The document sets goals toward which various committees will work. There is also mention of collaborating with various entities, private or public, to work toward a climate change-resilient community.

The Westmoreland report, a straightforward and technical report that cost the City of Tucson \$48,000, was aimed at reducing Tucson's greenhouse gas footprint in an effort to dampen future climate change effects. The proposed measures include tables on emissions reduction potentials, annual average implementation costs, net annual savings. Included in the report are other cities or municipalities in the United States where the proposed measures have been implemented, an analysis of "business as usual," and other economic analyses of each measure. The focus on this analysis is on decreasing community greenhouse gas emissions, a key mitigation strategy that can also be reframed as an adaptation strategy.

Though there was momentum around the report and the proposed strategies, it became apparent after its release that these actions were not top priorities for the City government. Most

of the measures recommended were either never adopted into policy or never fully implemented as the consulting group envisioned it. In the summer of 2017, David Schaller, the lead author of the report, lamented the City's almost wholesale abandonment of the document's recommendations, in an Arizona Daily Star article (2017). The team that wrote the report was hopeful that the proposals would not only be fiscally viable, but ultimately helpful in cutting costs down the line for Tucson. A few factors can be attributed to this loss in momentum. Foremost is the tightening of budgets, which eliminated the Office of Conservation and Sustainability, as mentioned in the introduction. For some time, the dedicated positions that would hold the City accountable in implementing these mitigation standards and goals were all but absent. Another factor is the natural return to the everyday issues faced by the City, many of which may be symptomatic of broader issues like climate change. Filling potholes, housing the homeless, expanding development, and growing the economy to be competitive are all concerns on the table for the City that may, at least in the short term, take precedence over climate readiness planning. Another issue was that the report's proposals were deemed too ambitious or even radical. Curtis Lueck, who is a transportation consultant and was a member of the climate committee, left the committee after feeling that the strategies were "ill-conceived, draconian, and impossible to fund at the time." Almost immediately after the report's release, it drew some criticism for its possibly unrealistically optimistic projections of the decrease in carbon emissions by 2020. Regardless of the City's failure to implement most of the recommendations, Tucson's carbon emissions have been on a slow yet steady decline, as referred to earlier in the thesis.

Worth noting is that though the report extensively addresses infrastructure resilience building—and, to an extent, even natural system resilience building—it excluded analyses pertaining to social dimensions of resilience building. The economic nature of the report left out

crucial questions from the climate change preparedness calculus, such as those concerning public health, disproportionate contributions of greenhouse gas emissions, and disproportionate impacts of climate change. The measures, in some ways, whitewash the dynamics of power engendered by multi-scalar differences of race, socioeconomic class, and space and the various inequities that emerge out of these differences. For example, the question of access to the proposed programs is not addressed. How will educational programs ensure broad reach and penetration, especially into lower income neighborhoods? If certain programs are web-based, such as the energy efficiency community challenge program, how will it be inclusive of neighborhoods that house mostly the elderly or those with limited access to the Internet? What neighborhoods will be left out of if not negatively impacted by new mandates on construction? In some ways, the benefits of the kind of sustainability proffered by the report are felt only by those who have the educational resources, power, and ability to access them.

On the other hand, because the document addresses more than the built environment or natural systems, Plan Tucson does more to identify and address inequalities and injustices that may result in disproportionate impacts. A stated goal of the document is to build a climate resilient city while mitigating disproportionate impacts of climate change. Though it makes crystal clear its acknowledgment of vulnerable communities in Tucson, the document does not delve any deeper down this road. Little is said about the way that climate impacts on indigenous communities in and around Tucson are not addressed. As well, City administrators have yet to fully tap into the wealth of traditional ecological knowledge that has sustained Native communities in the Sonoran Desert for many centuries. Albeit, there has been a major push toward climate adaptation strategies that emerged out of a turn toward traditional ecological knowledge in other sectors. We can turn to the example of water management, especially

harvesting. Organizations such as Watershed Management Group have taken on efforts to educate Tucsonans on wiser water management practices such as installing cisterns and landscaping that is adapted for heavy monsoonal rains. These seemingly small steps have increased individual households and neighborhoods' adaptive capacities and are rooted in the indigenous traditional knowledge.

The unspecific nature of the Plan Tucson document makes it difficult to determine the implementation status of the policies set forth in it. While many steps are being taken towards the policy goals within the document, one cannot with full confidence declare that any one of these goals have been met in the five years since the document's release. In the document, the City offers this disclaimer:

**Mayor and Council Priorities:** While Plan Tucson provides the long-range vision for the City, the Mayor and Council will need to set shorter term priorities for the Plan's implementation, taking into consideration the current environment, pressing issues, and resource levels. This direction by the governing body will guide the development of the Action Plan and the operating Budget and Capital Improvement Program. (Plan Tucson, 2013)

These pressing issues include things mentioned earlier, like the ever-present development and redevelopment of districts, economic growth, and immediate crises. These short-term agenda items are meant to inch the City closer to the goals it set for itself, but in many ways, they impede the City's ability to work on multiple levels with multiple partners toward these broader and longer-term goals.

Worth asking, now, is the question of whether Tucson's City government adequately addresses the dire forecasts in the IPCC, NCA, and Gafford report. In my assessment, I

determine that while a great deal of effort has been placed on policy-crafting around building urban climate resilience, little has been implemented on the ground. Though the City's policy goals position it towards a climate resilient urban environment in the near future on paper, many of these goals have remained just that—on paper, or, have not been implemented at a satisfactory pace.

To be sure, there are many parts of Tucson existing independently of policy that increase its urban climate resilience. Close-knit neighborhoods, desert-adapted agricultural practices, heat-resistant building materials, and Tucson's impressive capacity to cool its buildings on the hottest days all contribute to a climate resilient desert city. In considering "business as usual," Tucson is not in the worst shape for dealing with a changing climate. Much of Tucson's development has occurred with respect to an already harsh desert climate, which positions the city more favorably in the face of a changing climate. However, caution must be taken to ensure that the City government does not rest on its laurels; climate change-related governance must still be pushed and implemented.

Another issue that may be causing climate change inaction in Tucson is that there is a lack of accountability. City actors must consistently be held accountable for implementing the policies they set out to accomplish in the planning documents, and accountability mechanisms that exist outside of electoral politics may be difficult to institute. A major factor leading to this may include the fact that Tucson is not only a college town, but a popular destination for retirees in the winter months who tend to leave in the summer months (affectionately nicknamed "snowbirds"). It may also be that Tucson's K-12 curriculum needs retooling to be inclusive of emerging environmental challenges and the implications these challenges bear on governance on multiple scales.

In examining Tucson's climate resilience building policies and implementation, I have gleaned the following lessons:

- Collaboration is essential in following through with climate resilience policy, not only across the City of Tucson government, but with stakeholders, businesses, organizations, local communities, and larger governments (county, state, etc.).
- Resilience thinking has gradually but steadily made its way into the planning and policy language of the City, though there is yet more potential to further emphasize resilience.
- Though natural system and infrastructure resilience are addressed well in planning conversations and documents, social resilience is not receiving as much attention.
  - Though there is grassroots movement to prepare small communities for extreme heat events, there is no direct City government support for these initiatives.
- Climate resilience measures are hampered by such things as budget cuts, political opposition, and more “pressing” priorities that push climate resilience further down the list of priorities.
- Lack of accountability may be a factor into why urban climate resilience building is stalling in Tucson.
- The city has not yet fully assessed vulnerability and existing social networks that might improve resilience.

## **Conclusion**

Resilience thinking must be further integrated into the City of Tucson's climate change approaches if the City is to thrive in the next ten, fifty, or one hundred years. The looming threat

of a warming climate and its implications on the fabric of desert society cannot be ignored any longer. If a city cannot adapt to a changing natural environment, it will face collapse, as we have learned from societies that have risen and fallen in the centuries preceding ours. It may not happen overnight, but be a gradual slip that just may sneak up on the City.

Warming temperatures, decreasing water supplies, habitat loss, and the various deleterious effects associated with climate change identified in the research all have grave implications for the people and ecosystems of the Sonoran Desert. However, how these impacts are distributed among different social groups will become a major point of contention and will need considerable attention from decision makers. Even if Tucson accomplishes many major infrastructure and natural system resilience building measures, it is critical that policy leaders keep in mind the social systems in place that inhibit how these resilience measures are implemented across social groups—especially within marginalized communities.

Tucson, a beautiful desert cityscape, is faced now with a choice of how it will approach the problem of climate change. As we move through the 21<sup>st</sup> century and the climate is only projected to get warmer and extreme weather is projected to visit more frequently and more intensely, Tucson must attend to those components of the city's political, economic, social, and infrastructural fabric that it will need to retool to rise to the challenge. The city is facing a ticking clock: without the timely adoption of climate resiliency measures, it is bound for a breaking point wherein the city succumbs to the water stress, extreme heat, and extreme weather events that climate change brings with it.

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