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Cities all around the world are seeking ways to grow more sustainability while grappling with the increasing impacts of climate change. Some have taken bold steps to adapt to more unpredictable and severe climate: Kuala Lumpur for example has spent about \$500 million on new road infrastructure to help combat flash floodsⁱ. Others develop adaptation plans with broad goals which mostly sit on shelves and never get implementedⁱⁱ. Part of the challenge is the lack of data and information at the local level. Climate data is often collected at spatial and temporal resolutions that do not always provide relevant information for location-specific decision makingⁱⁱⁱ. Another common challenge is that the technical nature of climate science often inhibits the communication of climate data to lay people, decreasing climate awareness which has been deemed an essential factor for effective coping with climate change^{iv}.

Funded in part by a Tinker Field Research grant, I spent two months in Aguascalientes, Mexico learning about climate threats in the region and opportunities to improve current adaptation efforts. I worked with local researchers at the *Centro de Investigacion y Docencia Economicas* (CIDE) as part of a multi-year interdisciplinary pilot project to answer the following question: how do we make climate science more accessible and relevant at the local level to improve adaptation practices? To answer this question, we employed a community-based participatory approach, where we integrated local knowledge at the problem definition stage of the study.

The goals for the first part of this study were to 1) gather the specific concerns and research questions of vulnerable communities in Aguascalientes, to produce climate research targeted at their specific needs and 2) better understand the challenges and opportunities for systematizing the co-production and information sharing of climate research in Aguascalientes. Aguascalientes has a semi-arid climate characterized by high temperatures, low rainfall and water scarcity, making it particularly vulnerable to climate change. Studies show that areas with warmer climates may experience longer and more severe droughts, causing such areas to become drier in the long-term due to the intensification of the hydrological cycle^v. Consequently, warmer temperatures will likely exacerbate the existing lack of water availability in Aguascalientes and cause other challenges, impacting rural and urban communities alike.

As a first step, I reviewed development plans at the state, municipal and city level to better understand the environmental and social context of climate adaptation. I focused on climate indicators to understand the extent in which the plan analyzes the impact of rising temperatures and rainfall locally. Additionally, given the process-driven focus of our inquiry, I examined the level of citizen participation in the plan's development. Finally, I reviewed the strategies the plans put forth, analyzing how robust its actions for mitigation and adaptation were. We then used in-depth interviews to dig deep into issues of climate adaptation with both the government officials developing and implementing adaptation strategies and communities in rural and peri-urban areas that have a higher level of climate vulnerability.

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CIDE campus

My weeks were spent either at local coffee shops in the city's picturesque downtown neighborhoods or the CIDE campus, located about 20 minutes from the city's center. At first, Aguascalientes, a small city with relatively low climate impact at a global scale, and far away from the path of obvious climate induced natural disasters did not seem like the appropriate place to study adaptation. Though I was quickly reminded of the subtle manifestations of a changing climate when the street in front of my house flooded on my second night in town. In 80 minutes, the city got its monthly average amount of rain, affecting 200 houses and killing 2 people^{vi}. Population projections tell us that by 2050, 68% of the world's population will reside in urban areas, and most of this growth will happen in cities with less than 1 million inhabitants^{vii}. Thus cities like Aguascalientes, have an urgent need to ensure its infrastructure and economies can adequately absorb such growth in the context of an unpredictable climate.

Aguascalientes is a city of about 887,000 people and compared to most cities in Mexico it has enjoyed a relatively higher level of urban planning. Since the 1980s urban plans were developed to guide the city's growth, though the lack of oversight led to dispersed population centers with limited access to adequate services, socioeconomic fragmentation, land speculation, and urban expansion to areas with fertile land^{viii}. The city is one of the most densely populated cities in Mexico's north-central region with 108.2 people per acre^{ix}, though its growth has been characterized by sprawl. From 1970 to 2010, the city's population grew by 369% (181,277 to 747,519 habitants) while its surface area grew by 608% (from 1,889.83 to 11,490.33 acres) in the same period^x. This growth pattern has environmental consequences of course, as urbanization eats up proximate ecological sites with important local environmental functions like air quality and microclimate regulation, water filtration and aquifer repletion. Furthermore, services have failed to keep up with this pattern of growth. The municipal transportation system for example, offers inadequate services with 38% of its units operating below required standards. An unreliable transportation system is one factor contributing to the high rate of registered motor vehicles in Aguascalientes, putting it in 5th place nationally for car ownership^{xi}, and in turn exacerbating local Co2 emissions.

According to our interviews the most significant climate issues in Aguascalientes currently are water scarcity and rising temperatures. Aguascalientes extracts almost double the volume of the natural recharge of its aquifers, all of which were in deficit in 2013^{xii}. Farmers have been feeling this impact already, as rising temperatures are exacerbating water scarcity and unpredictable rain patterns are shortening the harvesting season. Some have started adapting by choosing different crop varieties while

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others have sought part-time employment in local industries. Furthermore, given inadequate city infrastructure and the growth of unregulated residences in flood prone areas, a large number of areas are at risk of flooding in the face of severe rain. Moreover, while development plans attempt to assess these risks and plan accordingly, many of the indicators used are based on interpolated data at much larger scales, with variables that are not relevant to the region. Thus, even when strategies are formed and implemented, they are somewhat misguided and inefficient. Most notably, our interviews revealed that political will is the major limitation to more sustainable development practice and prioritization of adaptation policies.

The disconnect between the reality of climate change and the lag in policy implementation is well illustrated by the ongoing effort to protect Los Cobos—a low forest area of about 5,000 acres located 20 minutes south of the city. In July, I attended a City Council meeting where citizens were given 5 minutes to express their concerns on different matters.

Environmental activist made up the majority of the audience and of the six people speaking, five spoke of environmental concerns. Most notably, the plan to construct 14,000 new housing units in this natural area has made Los Cobos a battleground for environmental

groups and developers. Not only would such development destroy unique biodiversity and important geological, paleontological and archeological patrimony of this region, but it is utterly unnecessary—there are currently 55,000 empty residents in the city of Aguascalientes. Still, environmental groups have had difficulty convincing policymakers to prohibit land use changes that would allow for such urban encroachment on natural areas. Economically, the development makes sense. The new residences would house a large number of employees who currently travel long distances to reach the industries located south of the city. Furthermore, Los Cobos is home to a community of about 500 people, who are marginalized from the services of the nearby city and would benefit from the services and amenities that such large development would bring. Nonetheless, as the closest ecological site to the city, the ecosystems of Los Cobos are worthy of protecting, and environmental groups have been doing so vehemently.



Aguascalientes City Council meeting

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Watershed in the Los Cobos area



Eating Nopal which is native to Los Cobos

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The level of fervor of environmental activists may give the impression that there is a wide level of citizen participation in these processes, though to the frustration of these more dedicated groups, the level of citizen engagement is relatively low. For most of the people I spoke to, climate change and environmental protection is simply not something they think about very often and there is little urgency from the government to engage citizens in such matters. In fact, many people spoke of urban policies cynically, contending that voicing their opinion would be a waste of time since the government decisions based solely on political interests. The situation at Los Cobos, is not directly related to adaptation but it reveals important insight for the challenges to and potential utility of our study. How do we engage citizens in climate research when the culture of participation doesn't exist? How do we make this study relevant, when there is such limited awareness of the gravity of climate change? And finally, how can whatever method we devise for involving communities in climate research serve and incentivize local governments and communities to collaborate on future adaptation planning?

It's projected that by 2040, the population of the city of Aguascalientes will be 1,310,823 which will put additional pressure on its natural and capital resources and require a concerted effort to deal with climate threats. The challenge of adaptation is significant, but we hope that our research will help bridge both the gap in local information and in citizen participation that currently exists Aguascalientes's urban and environmental planning process. In the next stage of our study, we will analyze what local communities revealed about their barriers to adaptation. We believe that this analysis will inform a new protocol that facilitates citizen involvement in climate adaption and policy creation, and guides climate data collection that is relevant for local communities.



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ⁱ <https://blogs.imf.org/2018/03/20/adapting-to-climate-change-three-success-stories/>

ⁱⁱ <https://insideclimatenews.org/news/20130620/6-worlds-most-extensive-climate-adaptation-plans>

ⁱⁱⁱ Marin, 2010; Miriam Kalanda-Joshua, 2011; Nichols et. al 2004

^{iv} (Ayanlade, 2017; Lasage et al. 2015)

^v Dai A (2013a) Increasing drought under global warming in observations and models. *Nat Clim Change* 3(1):52–58; Seager R, Naik N, Vecchi GA (2010) Thermodynamic and dynamic mechanisms for large-scale changes in the hydrological cycle in response to global warming. *J Clim* 23(17):4651–4668

^{vi} <https://noticieros.televisa.com/ultimas-noticias/inundaciones-aguascalientes-deja-dos-muertos/>

^{vii} <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>

^{viii} Programa De Desarrollo Urbano De La Ciudad De Aguascalientes 2040 Ciudad Que Evolucionara: Instituto Municipal De Planeación, Implan, 2015

^{ix} Plan Estatal de Desarrollo 2016-2022. DR. Gobierno del Estado de Aguascalientes, 2017.

^x Programa De Desarrollo Urbano De La Ciudad De Aguascalientes 2040 Ciudad Que Evolucionara: Instituto Municipal De Planeación, Implan, 2015;

^{xi} Plan De Desarrollo Municipal 2017-2019. Aguascalientes, El Corazón De México. H. Ayuntamiento del Municipio de Aguascalientes. Primera Edición, Marzo de 2017.

^{xii} J. Sainz-Santamaria, A.L. Martinez-Cruz, How far can investment in efficient irrigation technologies reduce aquifer overdraft? Insights from an expert elicitation in Aguascalientes, Mexico, *Water Resources and Economics* (2017), <https://doi.org/10.1016/j.wre.2017.10.003>