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### Development of a Human Health-Centered Climate Resilience/ Vulnerability Framework for the Mexico City Region

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**Development of a Human Health-Centered Climate Resilience/Vulnerability Framework  
for the Mexico City Region**

**Alex Stever**

**June 2021**

**A Master's Paper**

**Submitted to the faculty of Clark University, Worcester, Massachusetts, in partial  
fulfillment of the requirements for the degree of Master of Science in the department of  
International Development, Community, and Environment**

**And accepted on the recommendation of**

**Professor Timothy Downs**

## Abstract

### **Development of a Human Health-Centered Climate Resilience/Vulnerability Framework for the Mexico City Region (MCR)**

**Alex Stever**

With climate change impacting every corner of the globe, the health and well-being of all humans is threatened, especially in heavily populated areas such as the Mexico City Region (MCR). With this threat continuously growing it is important to not only be aware of the problem and its complications but have a framework and process that will allow for rapid and well-rounded analyses of how at risk the residents of certain areas are to the threats of climate change. However, with analyzing the impacts of climate change on any sector, including human health and well-being, three conundrums arise: the socio-ecological complexity, varying temporal and spatial scales, and the stakeholder diversity conundrum. With no official framework to analyze the threat of climate change to human health and well-being in any setting, one was created combining aspects of both resilience and vulnerability frameworks while mitigating the conundrums that come with the process of carrying out this, or any, framework. With this framework completed, fieldwork can be conducted using it as a roadmap leading to not only an understanding of the threats against health and well-being in the MCR but help identifying existing and future sustainable, equitable solutions and may be altered to serve other areas and places of interest.

## Academic History

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## Acknowledgements

I would like to thank Dr. Timothy Downs for introducing me to the research happening in Mexico City and his continued patience, support, and guidance throughout the development of my research and the writing of this paper. Additionally, I would like to thank the members of the Mexico City Region (MCR) research group at Clark University for their continued support including Caleigh McLaren, Ryan Mitchell, Katarina Hou, Ethan Manley, Tsanta Rakotoarisoa, Virginia Streeter, Nada Haddad, Ravi Hanumantha, Dr. Yelena Ogneva-Himmelberger, Dr. Morgan Ruelle, and Dr. Timothy Downs. Additional thanks to Dr. Christian D. Guzman at University of Massachusetts Amherst and Dr. Paola García and Dr. Marisa Mazari Hiriati at the National Autonomous University of Mexico for their contribution to the larger research project.

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## Introduction

Climate change has impacted every region of the globe affecting not only animals and natural environments but people, the built environment, and society as well. Through warming temperatures, changes in weather patterns, and changes in vector habitats, every sector, community, and region has been and will continue to be impacted by climate change in their own unique ways (Hitz & Smith, 2004). Due to historical and current resource and living disparities among people of different socio-economic statuses, gender, sex, age, ability, race, and ethnicity, it is not easy, and often very difficult, to pinpoint the exact ways populations and sub-populations will be impacted by climate change and how easy it will be for them to recover from these impacts. However, while it is difficult to identify these impacts, it is critical to be able to acknowledge them and work to address them as effectively as possible.

Impacts of climate change on human health is often underestimated in global climate change conversations. The World Health Organization (WHO) estimates that over 150,000 people die every year due to climate change from various causes including extreme climatic events, vector-borne illnesses, and food and water stress (World Health Organization, 2021a). By identifying areas of human health that are currently and will likely be impacted by climate change and changing weather patterns, these risks can be mitigated. Additionally, by identifying impacts on human health in the present and projected future, plans can be made to adequately prepare for them which would likely save money and put significantly less strain on the healthcare and emergency response infrastructure (Hutton, 2011). Therefore, having a framework that can measure impacts of climate change on human health and well-being would be highly beneficial.

For the purposes of this paper, human health is defined as not only the absence of mental, emotional, and physical complications or obstructions but the ability to remain in a good mental,

physical, and emotional state (World Health Organization, 2021b). Well-being is defined as the degree of security - economic, social, or otherwise - experienced by an individual or community (Crisp, 2017). While the state of a community's well-being would likely factor into their mental, emotional, and physical health, it is important to separate the two as they can change independently of each other and change at different times depending on what impacts of climate change are driving those changes. Both well-being and health can be impacted by climate and are necessary for a community's ability to flourish now and in the future. Therefore, both will be at the center of this body of this research paper.

While the research into health and well-being impacts from climate change is critical, it is often very difficult for those who conduct research and implement policies to do so accurately due to key difficulties encountered. These three difficulties are confronted when trying to analyze the current and future impacts of climate change in any field of study, including human health. These three difficulties or "conundrums" are the socio-ecological complexity, varying temporal and spatial scales, and stakeholder diversity (Downs & Mazari-Hiriart, 2017). The socio-ecological complexity discusses how elements of life and living are impacted by climate and the environment and how the elements of life and living impact the climate and environment themselves. Within these interactions there are multiple ways in which every factor can impact many other factors in various ways. This can often lead to confusion due to feedback loops and multiple elements of society and environment constantly influencing each other. The complexity of varying temporal and spatial scales describes the variation of climate change's impacts and the chance of success of climate change mitigation and resilience projects among different geographic scales and time frames. With a variety of social hazards, environmental hazards, and climate projections, even within a single region, climate change impacts and needed initiatives



are difficult to foresee and the further out the impacts and successes are projected, the more uncertain they become. The final conundrum, the stakeholder diversity, discusses that when any research is conducted, decisions made, or projects implemented with regard to climate change, there are always going to be a variety of groups of people who differ in identity, job, government positions held, and perception of risk in terms of climate change.

Due to the variability of impacts and health risks, it is important for governments and citizens to work across geographic and temporal scales. One of the best ways to do this is using a climate vulnerability framework that can be adapted to those varying scales. This adaptation aspect of the framework used is critical because of the speed at which climate change will accelerate and the impacts it will have on people; having an adaptive framework that can be slightly altered and applied right away to an area would allow for more time, money, and resources to be allocated to preparing for these impacts. This paper seeks to answer what kind of framework may best measure and analyze the threat climate change has to human health and well-being for the Mexico City Region (MCR) - one that takes into account the three conundrums, including identifying indicators best suited to such a framework.

By creating an adequate framework, not only will governments be more prepared in terms of disaster response and resource allocation, but citizens will also be more informed of the risks they face. By understanding impacts they may face, residents of particular neighborhoods, municipalities, and regions will not only be more informed but can also hold government officials accountable and demand action with regard to protecting them and responding to climate change.

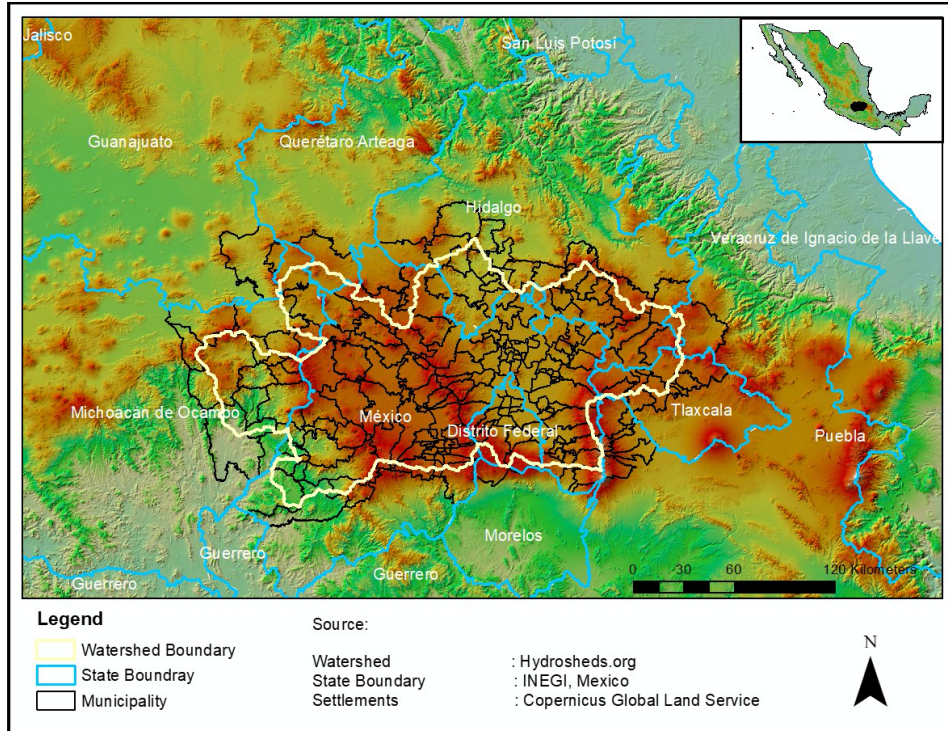
This paper will use Central Mexico, specifically the MCR as the case study region. It was chosen due to ongoing research being conducted by Clark faculty and students as well as the

National Autonomous University of Mexico (UNAM) in the MCR. The work presented in this paper will help advance the climate resilience and risk mitigation research being done as part of the larger research group and ensure a focus on human health for the larger project. As time goes on and when the state of global health is safe enough for travel, this framework can be used in the field.

## Background

The MCR is a large region that is made up of three watersheds and over 193 municipalities of varying population densities and land uses shown in **Figure 1** below. These municipalities can be characterized on an urban-to-rural spectrum and can be classified as urban, peri-urban, semi-rural, and rural. This classification can be identified based on population and land used for agriculture production. The work of classifying each municipality in the MCR is underway. Each municipality has their own specific infrastructure, resources, and government policies and initiatives that will impact their ability to adapt to climate change and other stressors. Additionally, each has different conditions and characteristics; these social, political, and natural differences will be critical in understanding how climate change impacts health and well-being of people in each municipality.

**Figure 1: Map of the MCR Study Region**



*Source: Ravi Hanumantha, Clark University*

Climate change in the MCR has significantly impacted many of the people in the area. Research focused on these specific impacts have identified vector-borne disease, change in precipitation patterns, flooding, increasing temperatures, and crop failure among the most impactful changes brought about by the changing climate (Bell et al., 2008; Diaz et al., 2018; Ivers & Ryan, 2006; Kraemer et al., 2015). Understanding the factors that contribute to the vulnerability of people to climate change health risks – existing and projected – is critical for resilience planning.

## Methods

To determine what type of framework would be best suited for analyzing the threat of climate change to human health and well-being, a multi-step approach was used. First, a literature review was done to understand the conceptual cornerstones that exist behind *vulnerability and resilience frameworks*, the two most common frameworks used when looking

at the impacts of climate change. Next, a review was done of common benefits and criticisms of both frameworks to consider how to integrate them. Finally, a review of current vulnerability and resilience frameworks applied to municipalities in Mexico was included. All of these analyses will allow a framework for the MCR context.

To begin, a literature review was done using Google Scholar and the journal catalog at Clark University's Goddard Library to gather information on, examples of, recommended criteria of, and the benefits and shortcomings of vulnerability and resilience frameworks. These two frameworks were chosen to be the focus of research and literature review due to the extensive use of both of them in the climate change arena. *Vulnerability*, the more common framework, measures the risk a certain area will experience a significant impact from natural disasters and climate change in the future measured predominantly by social, economic, natural, and infrastructural factors (Balica et al., 2012; Flanagan et al., 2011). *Resilience*, a framework that has come to prominence in recent years, measures the ability for a certain community to recover from or adequately prepare for climate change based primarily on different sectors collaborating and supporting each other and the community (Marzi et al., 2019). As proposed by Marzi et al, 2019, these sectors include but are not limited to social, legal, technological, economic, and political ones. A more nuanced difference between the two will be explored later.

## Results & Discussion

*Vulnerability frameworks* are comprised of using social, natural or physical, and governmental indicators reflecting current conditions in the study area. The first set of indicators are social, typically identified in vulnerability frameworks as the Social Vulnerability Index (SoVI or SVI). There is no set list of indicators that need to be included in the SoVI, so decisions are made by researchers conducting the analysis. Some of the indicators often used in SoVI

include socio-economic status, population, occupation distribution, and race and ethnicity (Boruff et al., 2005; *CDC CVI Documentation*, 2020; Cutter & Finch, 2000). There are also other indicators used to measure vulnerability that include elements of the natural and built environment (infrastructure, vegetation cover), government practices (emergency evacuation infrastructure, monetary support to in-need populations), and climatic events and patterns (precipitation, flooding incidence) (Boruff et al., 2005; Cutter et al., 2000; Manangan et al., 2014). Sometimes vulnerability of an area is determined based on one single set of these indicators, for example, just using SoVI or physical attributes of the area. However, there are many examples that show a combination of the sets of indicators produce a more well-rounded and thorough understanding of vulnerability in any given area since the impacts climate change has on a community are not dependent on one single aspect of the community (Manangan et al., 2014). Importantly for this work, there were no one set of indicators found that was specific to measuring the vulnerability of health and well-being of communities in response to climate change.

Typically, when combining the different vulnerability indices to understand the general vulnerability of an area, GIS is used to represent indicators and indices spatially. For example, in a study on the vulnerability of people in South Carolina, every hazard that was identified - storm surge, occurrence of earthquakes, proximity to chemical facilities, and more - were plotted by hazard on a map to identify which areas were most susceptible to each one (Cutter et al., 2000). After this was done for all the hazards, the layers were combined to understand the areas that were most vulnerable overall (ibid). Conversely, there are methods heavily involving a variety of statistics that measure vulnerability in terms of exposure, adaptive capacity, damage, and sensitivity/susceptibility, comparing one place to another using these criteria, also gauging what

percentage of land or population is vulnerable to a specific hazard (Bell et al., 2008; Ortega-Gaucin et al., 2018; Sánchez Rodríguez & Morales Santos, 2018). No articles were found describing the best method to use to carry out a final vulnerability analysis indicating there is no confirmed best practice.

By considering existing and projected impacts, through the lens of vulnerability indices at municipal and regional scales, municipal, regional and national governments can allocate monetary and additional resources to areas most at risk. This speaks to an important part of climate change impacts assessment: understanding of environmental injustice. A robust vulnerability assessment using indices should reveal inequities among communities with regard to socio-economic standing, the land they are living on, and the infrastructure and government that supports their community (Popke et al., 2016).

However, there are, of course, drawbacks to vulnerability frameworks. First, they are often hard to assemble if the researcher has limited access to current information about the area being studied. Without complete information of the different indicators a well-round analysis cannot be completed. This is exemplified by the MCR's 193 municipalities, few of which have sufficient secondary data available, requiring fieldwork. Little information is available on the internet or through journal articles about these smaller communities making conducting vulnerability at that scale difficult without fieldwork. The second drawback regarding vulnerability frameworks is they do not account for uncertainty in climate change impacts or the social, economic, and government structure in a specific area (Patt et al., 2005). Additionally, since socio-political-ecological systems are all interconnected, if one changes or is altered from the present in any way, it is likely that other aspects will change as well (ibid). While these drawbacks are certainly not a reason to discount the use of vulnerability frames completely, they

are important to acknowledge and work with in order to produce the most useful knowledge for areas that result in an action.

*Resilience frameworks* are usually comprised of identifying areas related to a specific area of concern, like health and well-being, and identifying entities and stakeholders that need to play a significant role in developing initiatives and actions that will address the area of concern. In the case of this research, our focus is human health and well-being. A critical element of a resilience framework is that the problems stakeholders deem the most relevant. Additionally, the elements of any specific resilience framework are dynamic since the impacts that are concerning to and experienced by the stakeholders may change over time. Often times, the resilience of a community, or lack thereof, is considered an integral part of vulnerability in that a community with a low resilience has a high vulnerability (Keim, 2008). While this is not categorically false, for the purposes of this research, it is important to first distinguish – then integrate - these two frameworks because they can each provide very different perspectives on the same concern of the same area. Resilience allows for uncertainty over a long period of time and multi-stakeholder collaboration which is critical for understanding climate change. Another key aspect of resilience involves investigating collaboration among stakeholders and governments among municipalities. For example, if the government of one municipality is committed to protecting water but does not communicate this to surrounding governments and stakeholders in other municipalities, they may have a difficult time carrying out their commitment, thus lowering the resilience of the municipality being studied and the surrounding ones. Since resilience requires *active collaboration, there is currently no specific framework which allows for a better understanding of the complex and interrelated systems that are inherent in any community.*

While there are benefits to resilience frameworks being used, there are also drawbacks. First, it is not quick to implement so if there are immediate answers needed, a resilience framework may not be the best way to obtain answers. Secondly, resilience frameworks are best implemented on a small scale due to the collaboration needed and the specific needs of any given community or region. Even in one watershed or state, due to the resources a community has and the way the climate impacts that area, what one community finds builds their resilience, another may not find helpful. Despite the shortcomings of a resilience frameworks, they provide a useful contextualized impact response to the areas that implement these types of frameworks.

Finally, in searching for vulnerability or resilience frameworks applied in Mexico, two were found: 1) the *National Vulnerability Atlas* published in 2019 by the Secretary of Environment and Natural Resources and the National Institute of Ecology and Climate Change and 2) the *Climate Change Atlas* published in 2014 by the Center for Environmental and Atmospheric Science Information at UNAM together with the National Water Commission. Several other vulnerability analyses for certain environmental conditions such as drought have been done by independent researchers.

#### Developing and Integrated Framework

Using the information gathered from the research described in the above section, a well-rounded framework can be developed. However, there are some limitations to address before proceeding forward. First, mental health is hard to measure and doing so takes time and requires fieldwork. Therefore, in this paper, the potential impacts of mental health will not be discussed but it should by no means be dismissed. Secondly, it is important to note the discrepancies in dates when including relevant population and climate data. It is not unusual for data from multiple timepoints to be used when utilizing these frameworks which could produce misleading



results. Finally, due to the variability in infrastructure and social indicators mentioned above that often contribute significantly to vulnerability and resilience, ideally any framework can be used at a neighborhood scale. Unfortunately, due to the lack of information available about differences among municipalities of the MCR, it is not possible to adequately demonstrate this in this paper. However, there are many aspects of what will be discussed in the upcoming section that can be adjusted to a municipal scale. Due to the COVID-19 pandemic, travel to the MCR to use any framework that is created or already in existence and get feedback and input from stakeholders was not possible. The ways in which to follow-up with regard to this shortcoming will be addressed in the Suggestions section of this paper.

Neither the *National Vulnerability Atlas* nor the *Climate Change Atlas*, nor the additional papers using a vulnerability or resilience framework, specifically measured health and well-being rather instead measured general vulnerability to climate change. Therefore, the useful aspects of each that pertain to health and well-being will be used in conjunction with other information that would help in this analysis. When analyzing the best way to create a framework, it is critical to revisit the three conundrums introduced in the introduction. Since those three aspects are what often stop environmental impacts from being fully known, they must be able to be overcome by the framework that follows.

The literature has reflected that *vulnerability frameworks* seem best suited for large geographic scales and shorter term due to vulnerability's lack of attention to uncertainty in moderate- to long-term future conditions, e.g. how frequently certain storms will occur. Conversely, *resilience* is beneficial because variability in future conditions is worked into resilience frameworks by regularly meeting with stakeholders over a long period of time within a municipality and possibly even within different stakeholder groups in the same municipality.

Additionally, the scale that a vulnerability framework is being used for can be scaled down to a certain extent, such as to a watershed, while resilience can be scaled up to a certain extent, possibly to include multiple municipalities. The ability for vulnerability to focus on larger scales and near future conditions while resilience focuses on far future conditions on a smaller scale, plus scalability up or down, addresses the varying spatial and temporal conundrum (Downs & Mazari, 2017).

The stakeholder diversity conundrum is addressed primarily through incorporation of the resilience perspective; multiple stakeholders of varying different roles need to meet with each other to discuss the problems they face and possible solutions and initiatives to mitigate adverse climate impacts to health and well-being. While conventional vulnerability analyses exclude stakeholder dialogue, within municipal, state, and national governments there are multiple MCR agencies dealing with relevant sectors likely to be impacted by climate change, e.g. Secretariat of Health, Secretariat of Agrarian Reform, Secretariat of Social Development, and Secretariat of Communication and Transportation to name a few. Based on the vulnerability results covering different areas of interest, for example health or infrastructure, the federal offices can send support to the municipalities most in need of help in their respective area of interest.

The third conundrum is the socio-ecological complexity. Unfortunately, it is difficult for the vulnerability aspect of this framework address this conundrum since vulnerability analysis is involved mostly with identifying hazards and risks without modeling how they might be intertwined. However, the resilience aspect of this framework does acknowledge this conundrum to a certain extent. By having conversations with multiple stakeholders of various expertise and experiences and focusing on uncertainty, resilience recognizes how complex and reinforcing interactions are between humans, climate, and environment. Using resilience to “solve” this

conundrum is dependent on how communities that utilize this framework progress with its use. By acknowledging this complexity, it allows local government, whether they are municipal governments or a small set of municipalities, as well as other policy-makers and those leading initiatives to adequately capture the diverse aspects that influence the health and well-being of residents with regard to climate change.

Creating a dual framework by combining aspects of a vulnerability framework and resilience framework would be beneficial for two main reasons. One, it captures the benefits of both the vulnerability and resilience frameworks while they balance each other's drawbacks out. Two, this dual framework acknowledges and makes progress on tackling the three major conundrums identified. The following section will look at designing such a framework.

#### Design of the Framework

The vulnerability part of this dual framework will include social, governmental, infrastructure, and weather and climate indices to measure the vulnerability of health and well-being. The indicators chosen were based on work done on vulnerabilities to climate change as well as literature that supported the use of other indicators that may not have been part of original indicators (*CDC CVI Documentation*, 2020; Fernández Eguiarte, Romero Centeno, Zavala Hidalgo, et al., 2014; Ortega-Gaucin et al., 2018). The biggest difference between previous vulnerability indices and the new proposed one is the presence of local government policy in an area with regard to climate change plans. There are some mixed findings in how much government policy plays into the vulnerability of a certain area so it was decided that it would be included here (Schneider et al., n.d., p. 3; Thomas et al., 2019). It is important to note that when measuring these indicators, future projections should be taken into account. For example, when measuring precipitation patterns, projected amounts should be used since a major

purpose of vulnerability-resilience mapping is to plan ahead. Multiple projections should be used since a municipality that is the most vulnerable in the next two years might not be the municipality that’s most vulnerable twenty-five years out. Additionally, when data are being gathered on government plans and initiatives for combatting climate change and its impacts, capacity to actually implement their plans is also crucial. Ideally, the data gathered for this area would be gathered from work done in the field and from trusted literature sources. The indicators chosen for this project are shown in **Table 1**:

**Table 1: Indicators Used in Measuring the Vulnerability of Health and Well-Being in Mexico City Region (MCR)**

<b>Socio-Demographic</b>	<b>Governmental</b>	<b>Weather &amp; Climate</b>
Socioeconomic Status (V)	Climate Change Policy (R)	Change of precipitation rates and patterns (V)
Change in Population (V)	Human Health Policy (R)	Vector Presence and Threat (V)
Rural or Urban (V)	Emergency Preparedness (R)	Urban Heat Island (UHI) Impacts (V)
Race/Ethnicity (V)	Infrastructure Stability and Quality (V)	Percent of Municipal Population Living in Flood Zone (V)
Female Head of Household (V)		Temperature Increase (V)
Access to Healthcare (V)		
Occupation (V)		
Age Distribution (V)		
Housing Status and Quality (V)		
Proximity to Water Source/Piped Water in Home (V)		

Percent of Food Locally Sourced  (V)		
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Data for these indicators should be gathered from the most up-to-date available information with the results shared with municipal and federal government, organizations that work in the community, and the public. This is important so the data that are gathered and the conclusions that are reached can become actionable. Ideally, any vulnerability analysis should be carried out every five years to reassess the way resources are being allocated to ensure the communities that are getting the most are still at highest risk which may change based on local projects and initiatives regarding resilience or may change due to weather patterns and climatic events not following the modeled path. GIS is applied to map vulnerability at municipal and MCR scales, with each criterion in **Table 1** assigned measurable indicators. For example, change of precipitation rates and patterns have natural units of depth and duration while many of the social hazards can be measured in presents. While the governmental aspects may be more difficult to measure since they do not have natural units, a qualitative method can be used. As described in the Methods section, the maps should be standardized to all represent a degree of vulnerability and then those maps be layered on top of each other and summed to get the final vulnerability of each municipality based on the chosen criteria.

The key questions that need to be answered with a resilience framework is “resilience of what, to what, for whom, and what can be done” about these resilience issues (St. George Freeman et al., 2020). When determining resilience to what, the area being studied and problems identified by the community are key to first determine. In the example of this research, the area of interest is fairly easy to determine: individual municipalities within the MCR. As mentioned previously, a key aspect of resilience is meeting with a variety of stakeholders to first understand

the issues they view as most critical. These could range anywhere from concerns on the stability of infrastructure and its impact on their health, their livelihoods becoming more difficult to sustain, or ways that climate change is directly negatively impacting their health. These interactions can be held as informal interviews, formal interviews, or group meetings. The answers from these interactions will answer what people are concerned about being at risk from. The answers can be divided into different subsections such as occupational concerns, infrastructural concerns, general health concerns, and food security concerns to ease understanding on how these concerns are distributed as opposed to just a long list of concerns. Once these concerns are identified, uncertainty can be taken into account for each of these issues and they can be explored in more depth. This expands more on some of the concepts that are introduced into the vulnerability aspect of this framework because uncovering the uncertainty is not limited to what is known about the near future. A variety of possible futures for each area of concern is in fact necessary to build proper resilience since the sole purpose of resilience is to be prepared for a variety of outcomes so that no community is caught off-guard. Finally, after the uncertainty is explored, the resilience aspects of the framework calls for actions to be planned and carried out to build resilience against the specific concerns of the environment. Ideally, these actions surrounding the concerns of stakeholders would be formulated in large part by the communities and individuals identifying the problems since they have a greater understanding of the specific social-ecological interactions that occur in the area than outside researchers and potentially more than members of the government. Actions taken to improve resilience can be government policies, initiatives put in place by NGOs or other entities, and commitments made by the greater community. It is critical that these actions are able to be implemented or the community will not actually become more resilient. Additionally, the resilience aspect of the

framework allows the degree to which governments are enacting and funding climate change policies and collaborating with neighboring municipalities to be explored due to the more qualitative nature of this information. These aspects are critical to resilience and vulnerability since there is significant potential in increasing the preparedness of a local area.

## Suggestions

As discussed in the Methods section, this framework was not able to be created while doing field work in the MCR due to the global COVID-19 pandemic. Therefore, alterations to some of the elements of the framework may need to be made when implementing it when travel and field research is possible once again. Additionally, when data is able to be collected on the ground, more information will be able to be collected on the mental and emotional impact of climate change on people's health which is a critical aspect of health and well-being but one that is difficult to measure without being in the area. Second, an attempt to gather all necessary data from the same set of years should be a goal since discrepancies and inaccurate conclusions may arise due to the variability in the dates of the data. Finally, when in the field, ideally the resilience would be measured at not just an individual municipality level but a neighborhood level as well since there are many demographic, socio-economic, and environmental differences that can exist between places.

Stakeholder participation is key for the implementation of this dual framework, specifically the resilience aspect of it. Since travel to MCR was not possible and stakeholders could not be identified while in the area, some suggestions are made here to help initiate data gathering once travel is possible. First, the residents of the MCR, especially the disadvantaged communities, are important to include since they have a first-hand account of the types of stresses that climate change has put on them, their families, and their neighbors. Additionally,

they may have insight that previous research missed which may help in gaining a better understanding of where residents of the MCR stand now. Second, the local government, specifically at the municipal level, is important to engage since they would likely have the historical information of an area and they are key in formulating and communicating climate change policy. Within the local government, involving leaders in charge of health, infrastructure, and the economy are key due to the direct interplay between those areas, the environment, and climate change. Thirdly, research and education institutions, such as UNAM, should continue to be involved due to their permanence in the study area and their ability to collect data that can benefit the overall project. Finally, any local NGOs or other organizations who deal with analyzing health of the local communities is imperative since they may be able to offer more nuanced information on certain topics that need to be addressed.

Fourthly, this type of analysis can be used to look at many areas of interest including hydrology, infrastructure, and agriculture. Since there are both qualitative and quantitative aspects to it, a well-rounded conclusion is more likely than just coming at these areas from one particular angle. This has implications for not just the MCR project but also other projects that are looking at specific impacts from climate change which is ideal so problems can be understood and solutions can be identified easier. Finally, the results from any vulnerability or resilience analysis should be made available to the public so they are aware of the threats they are at risk of and can continue to be active stakeholder in building up resilience of their community.

## Conclusion

The framework described and applied above was the first to measure health and well-being in the MCMA. It can be used to help identify gaps in the data and literature that are



available as well as provide concrete aspects to look for when it becomes safe to conduct field work. Most importantly, by combining vulnerability and resilience criteria a more well-rounded process for gauge not only the threats of climate change at municipal and regional levels, but also the responses to it. There is undoubtedly room for improvement of this proposed framework since it was not able to be carried out in the field, but it provides not only a place to start but a template for beginning research in other areas when there is not a significant amount of literature or data yet available.

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