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## Capstone Papers

### **Title**

Collaborative Tools for Climate Change Adaptation: Building Social-Ecological Resilience in the Tijuana Border Region

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# Collaborative Tools for Climate Change Adaptation

Building Social-Ecological Resilience in the Tijuana Border Region

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UC San Diego



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## Abstract

As impacts from climate change continue to present risks for global stability, synthesis of strategies for intervention at the community and societal level may be effective for mitigating current and future impacts. This report summarizes efforts to integrate social risk reduction and ecological resistance planning on a local scale for the San Diego-Tijuana border region. There are several environmental issues afflicting the binational region related to informal development that climate change can exacerbate, such as flooding, erosion, and pollution in the form of wastewater and trash. This project involved the assemblage of collaborative planning instruments and tools for effective management, identification, and access to common spatial assets to increase the amount and dissemination of social and ecological knowledge to develop appropriate community responses to climate change consequences. The tools have been compiled into climate adaptation strategy ‘toolkits’ and have been used to execute educational workshops to develop community-wide ecological fluency and forge social-ecological resilience.

The deployment of the tools aims to support cross-border planning and outreach in the Los Laureles Canyon, a series of informal neighborhoods situated in western Tijuana. Implementation has commenced in Miramar, an established community station, and will begin in the community stations within Divina and Alacrán in Summer 2022. The toolkits will be put to the test with the expectation that additional contributions will be required to advance the collaborative strategies utilized for risk abatement. The toolkits are designed to help create the conditions to promote engagement between the community and researchers to establish horizontal information exchanges, in which insight is gained on the community’s perspective. Future work will involve additional research to evaluate community responses and incorporate refinements to ensure subsequent deployments incite productive and meaningful change.

**Key words:** Social-ecological system, climate adaptation, environmental justice, adaptive governance, collaborative planning, participatory mapping

## Introduction

Climate change poses a mounting threat worldwide with the most severe harm falling disproportionately upon underserved communities who are the least able to prepare for and recover from devastating impacts. In the US-Mexico border region, socially vulnerable border communities face an unequal impact to projected climate change impacts and require immediate action towards adaptation planning for climate resiliency. The U.S.-Mexico border region is highly urbanized and faces high poverty rates, water insecurity issues, inadequate housing conditions, and experiences deficiencies in urban planning (Sánchez Rodríguez and Morales Santos 2018). Additionally, several asymmetries exist between both sides of the border that creates challenges for governance, planning, and effective communication. Hence, influences amplifying social vulnerabilities created by ecological change are comprised of rapid urban growth, informal development patterns, socio-economic factors, institutional diversity, and varying forms of governance across borders (Wilder et al. 2013).

In particular, the San Diego-Tijuana region has faced dramatic population growth in recent decades with estimates nearing 5 million inhabitants accounting for about 40% of the U.S.-Mexico border region (Valencia and Giner 2013). The region is a well-known international metropolitan area, acting as a commercial cultural center with millions of people crossing the border primarily for north-bound commerce, day-labor transit, and tourism. However, the adjoining cities differ largely in economic specialization and socio-economic status which generates challenges in the design of climate-related adaptation strategies (Eaton-Gonzalez and Mellink 2015). As Tijuana becomes more urbanized, residents are sprawling out towards the undeveloped margins of the city. Consequently, informal development has overwhelmed neighborhoods south of the border and has led to significant challenges to basic amenities, such as accessibility to clean water and sanitation services with downstream consequences for water quality and solid waste management in the US.

Rapid urbanization in the San Diego-Tijuana region has resulted in significant changes to the Tijuana River Estuary, a wetland situated in San Diego, fed by the Tijuana River and western canyon sub watersheds. Changes in land use practices coupled with the absence of proper environmental regulations and deficiencies in infrastructure have led to reduced water quality (Heyn et al. 2008). The topography of the canyon region in Tijuana combined with the reduced performance of the water shed due to informal development has prompted flows of trash, sewer, and other pollutants to flow downstream (north) towards the Tijuana Estuary (Callaway and Zedler, 2004). During storm events, pollutants in the form of sediment and debris from both sides of the border are transported through the Tijuana River Estuary and are released into the Pacific Ocean (Gersberg et al. 1994). The transboundary spillover affects San Diego County, particularly Imperial Beach, and prompts seasonal beach closures due to contaminated waters, impacting human health and ecosystems on both sides of the border.

Climate change is likely to increase the occurrence of extreme weather and storm events, with the potential for increasing cross border pollution and change landscape use, harm social infrastructure, elevate social tensions between neighbors, and increase vulnerability for border communities with the least capacity in terms of money, political connections, and housing insurance (Cavazos and Rivas 2004). The extreme rate of sedimentation into the estuary has resulted in cross border initiatives which aim to protect the water and environmental resources shared at the border. The U.S. EPA is working with its counterpart in Mexico to begin environmental review of projects that have the highest potential to stem transborder pollution, such as constructing new treatment plants in Tijuana, repairing portions of the collection system to prevent sewage leaks in Tijuana, finding ways to beneficially use treated wastewater, and many more (U.S. EPA 2021). These top-down solutions will partially address the impact of cross border flows and public health concerns on both sides of the border. Cross-border collaboration provides the opportunity to create targeted, decentralized infrastructure with social and ecological benefits.

Beyond national agreements, more localized and collaborative forms of binational cooperation will be necessary for cross-border adaptation planning, both to build the trust necessary to effectively work together and the basic capacities to do so as equals. Vulnerable communities at the border disproportionately face challenges to everyday livelihood and environmental health at many scales, ranging from the pressures of economic globalization, related housing and migration pressures leading to informality and unplanned urbanization, long-standing historical institutional inequalities between San Diego and Tijuana as well as between rich and poor communities within each city, and projected regional climate change effects on key resources like water. In these gaps, however, there are also opportunities to address these issues by engaging affected populations to recognize and understand the social and ecological issues produced from informal development and engage them in a long-term, collaborative project focused on integrating social risk reduction with conservation and ecological resilience strategies.

A community's response to climate change and variability can either increase or undermine the long-term resilience of a socio-ecological system (Adger et al. 2011). Populations facing climate related vulnerabilities will benefit from bridging organizations that encourage social learning, knowledge generation, and participative approaches to planning to build social capacity and ecological resiliency. By self-consciously employing an environmental justice approach that targets the basic needs of residents of informal neighborhoods, high-risk border communities like those housing the UCSD Community Stations in Tijuana can be engaged in collaborative strategies for intervention, risk reduction, resiliency to employ an auto-planning process to foster community recovery.

For climate adaptation to be realized, a collaborative planning process must occur between researchers and residents, where sites of social risk and unequal health consequences are prioritized with social-ecological planning for habitat restoration and ecological services. The

success of collaborative processes is enhanced through consistent, purposeful, and mutual support mechanisms. Collaborative efforts encourage input from diverse individuals and lead to improved communication, efficient processes, and increased success towards orienting and achieving goals. In this way, collaborative planning works towards integrating resident participation into planning and decision-making processes.

However, equal partnerships require transparency, the exchange of information, and equal commitment towards intent and shared goals. Given the socio-economic asymmetries abundant in the region, a reciprocal exchange must occur between officials and residents. As universities, non-profits, and local governments disseminate vital information, residents are provided with the opportunity to inform them of their perspectives, motivations, and ideas in conversations curated around walks, activities, and joint actions. This method of engagement seeks to improve local participation and institutional accountability. It does so through rigorous engagement with the specific sites of the UCSD Community Stations and is self-consciously part of a larger set of projects and conversations that will evolve and adapt over time with feedback from residents and specialties of researchers who follow in this long-term engagement.

## **Project Motivation & Goals**

The San Diego-Tijuana region is the largest bi-national transborder urban system along the U.S.-Mexico border, with various environmental issues impacting both sides. Sustainable and just interventions will be required on both sides of the border to mitigate and adapt to the varying degrees of climate change effects, specifically in disadvantaged communities. Rapid expansion and housing pressures have resulted in many challenges in areas of informal and unplanned development, like Los Laureles Canyon in Tijuana, which serves as an example of a community facing several vulnerabilities. According to studies performed by the UCSD Center on Global Justice in 2020, Los Laureles has lost several open spaces due to the increase in unregulated urban growth in the last few decades which has prompted flows of trash, sewer, and a series of other pollutants to flow upstream, directly impacting residents. Consequently, residents face significant challenges such as accessibility to basic services, such as clean water and sanitation.

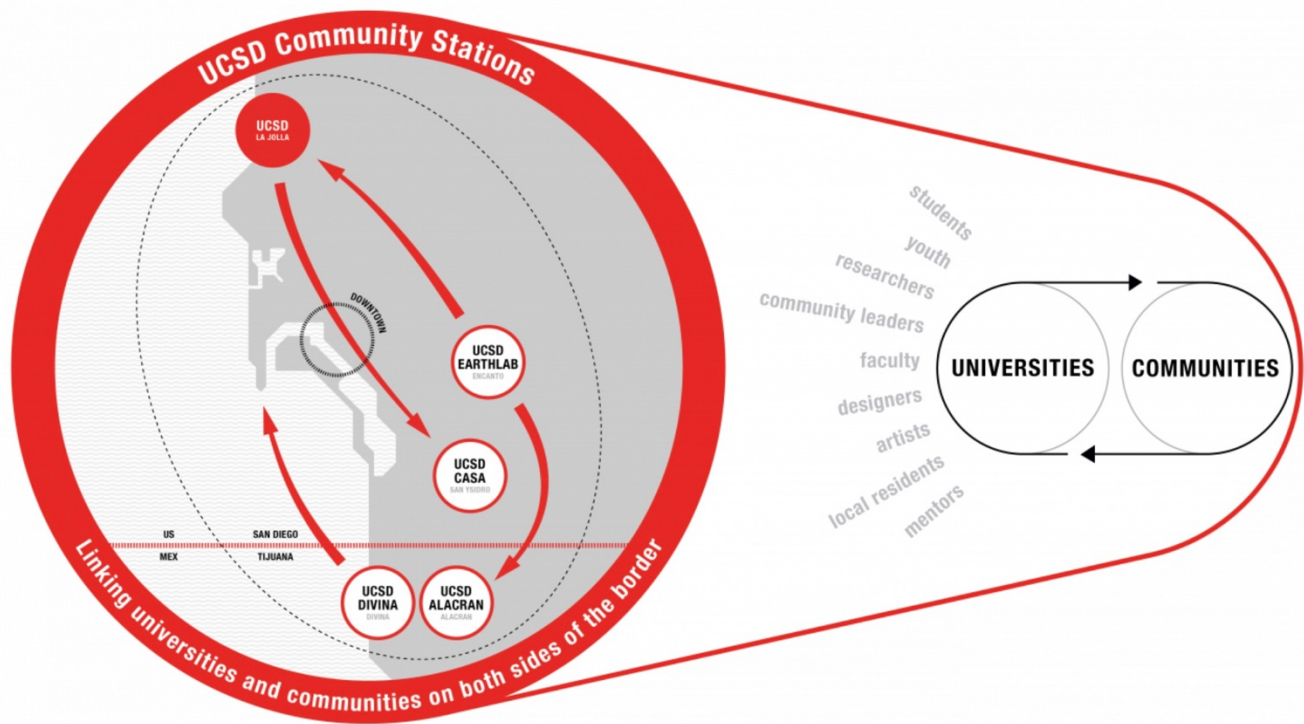
The goal of this project is to design a method for the development and implementation of climate adaptation workshops, some key general strategies for their deployment, and a set of background conditions for selection of specific activities and actions. These ‘climate adaptation toolkits’ thus are meant to serve as both a set of site-specific conditions and strategies as well as a flexible method for information and activity selection to facilitate workshops on climate adaptation, with an end goal to build local capacity to address urgent social risks and support long-term cross border planning across the binational canyon-estuary system. In this context, this project produces two distinct deliverables. First, a ‘toolkit’ or compendium of climate adaptation tools, conceived are activities aimed at exchanges of information and actions to implement nature-based



solutions to challenges in the area. The second deliverable consists of a method for selecting from this larger set of activities based on community social, ecological, and urban conditions.

A pilot of this canyon-scale method will be deployed over the 2022 summer period and will contribute to efforts by the UCSD Center on Global Justice and partners to build local capacity for just and collaborative adaptation planning in the binational canyon-estuary system. These pilot workshops will be facilitated through the UCSD Community Stations and Parque Hidro-Educativo Anexa Miramar projects in Laureles Canyon, in conjunction with social agencies embedded in three local communities, which are explored in the final section of this paper. Their purpose is to convene residents and researchers to walk together, exchange information, and begin common projects to decrease social risk and increase ecological resilience. Embedding the pilot toolkits in the Community Stations and Parque Miramar projects ensures, through years of prior engagement, that the tools selected are tailored to local conditions and, crucially, that the adaptive learning elements of the toolkit method are prioritized.

This project builds capacity for enhanced political accountability, both through an exchange of technical and local information, and through better understanding of mechanisms of public policy and political agency. As such, it is embedded in long term efforts at the Center on Global Justice and partners like Proyecto Fronterizo de Educacion Ambiental (PFEA), 4 Walls International, the Tijuana River National Estuarine Research Reserve (TRNNER), UABC Ensenada, and others to build a network of public parks and conservation spaces linking the canyon communities to the estuary (Figure 1). Further, these actions will serve to reactivate innovative political mechanisms for watershed management, the Consejo de la Cuenca Binacional, signed into law in 2006 but largely abandoned by subsequent administrations.



**Figure 1.** The UCSD Community Stations network provides the opportunity for high-impact, community-based research. Source: Figure courtesy of the UCSD Center on Global Justice.

## Context

### Climate Change Vulnerability at the U.S.-Mexico Border

Global climate change is recognized as a large-scale problem with environmental, social, economic, and political implications. The regions across the U.S.-Mexico border face several impacts from climate change, ranging from increases in extreme heat, wildfires, sea level rise, and more frequent and intense storm events resulting in flooding and erosion (GNEB 2016). Additionally, climate effects are likely to affect air quality, water availability, and spread of infectious diseases. Many studies have been performed to assess the projected impacts of climate change, but less attention has been aimed towards existing conditions in vulnerable communities that make them more susceptible to the profound impacts of climate change (Valencia and Giner 2013).

Social vulnerability to climate change must be considered prior to the development of intervention and resiliency strategies. For proactive climate adaptation to occur, existing inequalities and vulnerabilities must be spatially located with an understanding of how they interact with specific climate consequences in the region. Social vulnerability, or the susceptibility of a population to uneven harm from exposure to a hazard that affects its ability to prepare for, respond to, and recover, is a function of diverse cultural, institutional, and socio-economic factors

that impact a given community's sensitivity to climate change (Cutter et al. 2009). The U.S.-Mexico border region continues to experience increasing levels of urbanization, economic activity and industrialization, and augmentation in agricultural production which intensifies "double exposure" to climatic and globalization processes (Leichenko and O'Brien 2008). Climate projections for the U.S. southwest and northwest Mexico show severe precipitation decreases and temperature increases. Probable impacts for the region include extended droughts, higher water and energy demand, decreased water availability, and increased social tensions and urban-agricultural water conflicts (Parry et al. 2007).

Increasing vulnerability to climate change at the border region has developed as a function of accelerated population growth and globalization. Rapid urban growth strains resources and exposes more people to climate-related risks, thereby worsening the impacts of climate change. As mentioned, the U.S.-Mexico border region has faced rapid urbanization in recent decades leaving public and natural resources in many cities highly constrained. Poverty and economic asymmetries at the border define the regions as an advanced industrialized economy bordering a developing economy (Wilder et al. 2020). The U.S. is comprised of more wealthy cities with stronger institutions, while Mexico continues to struggle with poverty and instability, particularly in regions along the border.

Further, socioeconomic vulnerability is conditioned by a community's demographic characteristics, such as age, ethnicity, gender, or class. The border region contains a high concentration of Hispanics, whether they exist in poor US counties or reside in informal settlements in Mexico, these populations are facing increased vulnerabilities from rapid urban growth. The region's capacity to effectively respond to these challenges depends largely on governance and managing institutions. Further understanding vulnerability factors that exist in informal populations is necessary in achieving climate and environmental justice, based on the premise that at-risk communities should not disproportionately bear the burden of climate impacts and their associated costs (Parry et al. 2007).

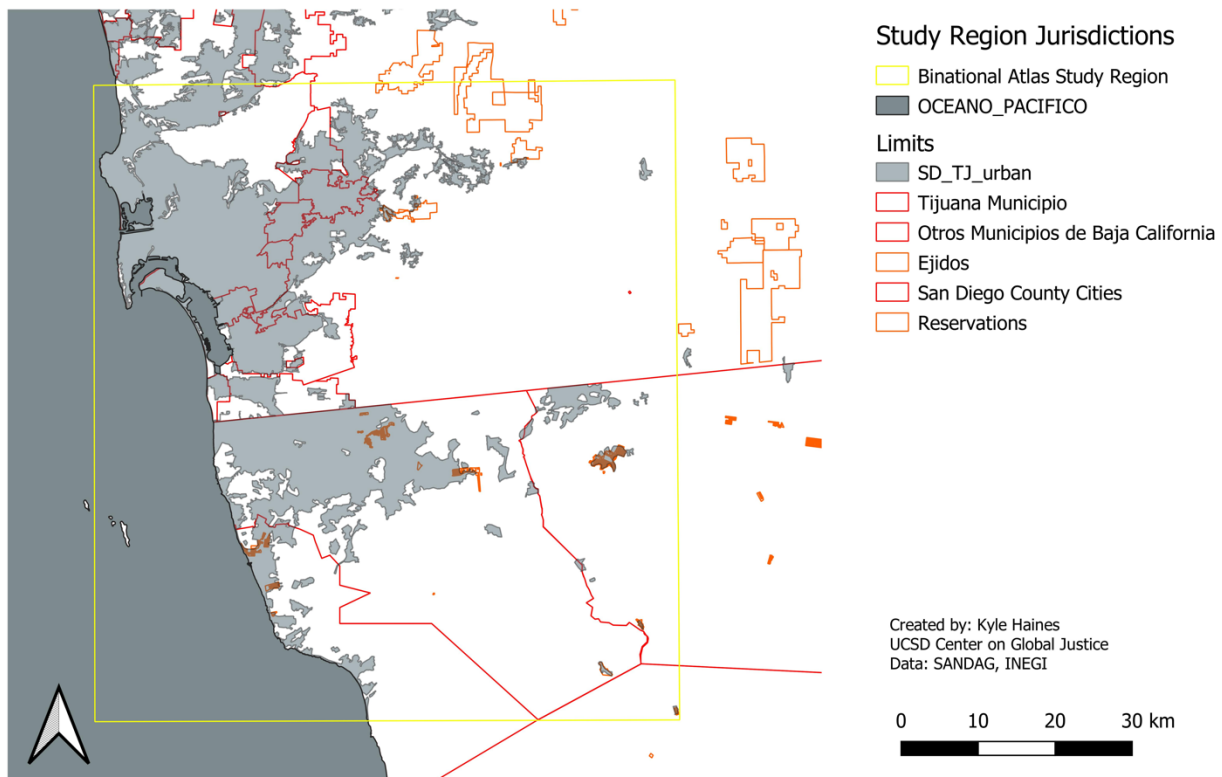
### **Sources of Vulnerability in the San Diego-Tijuana Region**

The San Diego-Tijuana region is rich with complexity as distinctive forms of social and economic interactions exist between the two cities, ranging from transmigrant workers, tourism, and international trade. From the perspective of the environment, the relationship between the two cities is largely interdependent and physically connected, despite the presence of a border wall. The binational watershed contains shared resources, such as the Tijuana River, and is home to the largest coastal wetland in California, the Tijuana River Estuary. Land use throughout the watershed has changed substantially, primarily from urbanization, with roughly 75% of urban growth occurring in the Mexican portion of the watershed (Farley et al. 2012). Shift in land use has been associated with increased habitat fragmentation, contributing to a loss of biodiversity (Ojeda-Revah and Espejel 2015).

A unique aspect driving the asymmetrical influences are disparities in structural and institutional provisioning. San Diego is a well-developed, wealthy city, with stronger governing institutions while Tijuana has struggled with economic instability, poverty, and centralized decision-making (Valencia and Giner 2013, see Figure 2). Tijuana is expanding and becoming much more densely urbanized compared to San Diego, but many inequalities exist in terms of economic development, societal infrastructure, and governance solutions. While development has been continuous on both sides, the two economies are far from integrated, which is demonstrated by the large differences in price for land, labor, goods, and services (Bae 2003). Further, the two countries contain incompatible government structures and institutions which makes it difficult to develop governance strategies to address transborder issues effectively (Ganster and Collins 2017). However, the most notable difference, is the deficiency of infrastructure south of the border.

Informal settlements present a multitude of vulnerabilities and require reliable governance solutions to incite change. The lack of housing investments and necessary planning from the municipal government has contributed to deficits in infrastructure. The gaps produced by this kind of rapid and unplanned development must be further investigated to identify the primary drivers, whether it is the lack of investment in societal infrastructure or the inability to keep up with migration patterns. The pressures that generate international migration from various locations in Latin America to the United States continue and cities with ports of entry, such as Tijuana, are heavily favored (Forman and Ramanathan 2019). Despite attempts to cross the border into the United States, many migrants remain in Tijuana. Increasing globalization and the low employment across the northern Mexico border has served as an incentive for migrants looking to stay and work. This accelerated growth has heightened the need for infrastructure in a region where allocated resources for basic services has been insufficient.

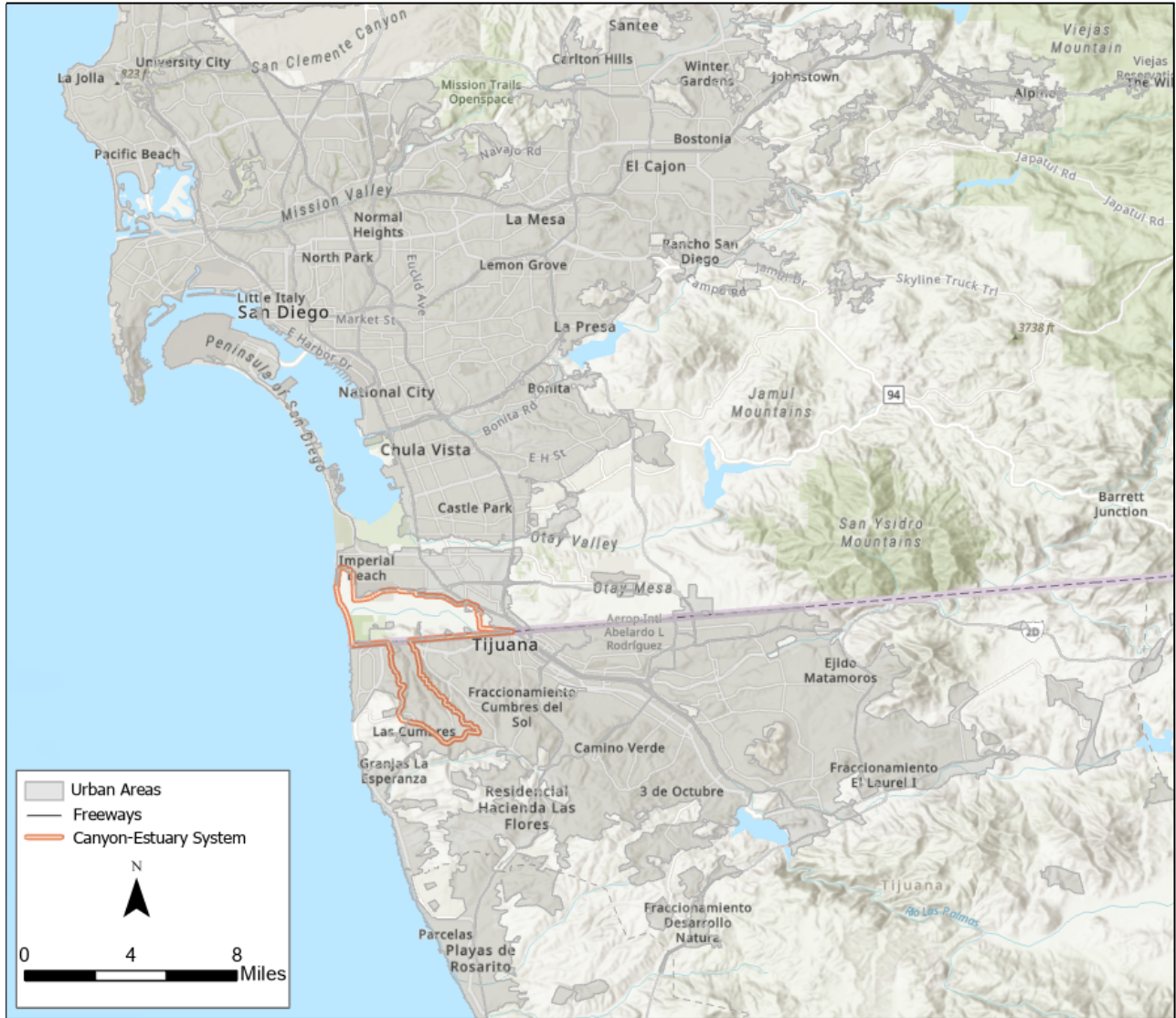
## Urban San Diego and Tijuana Region



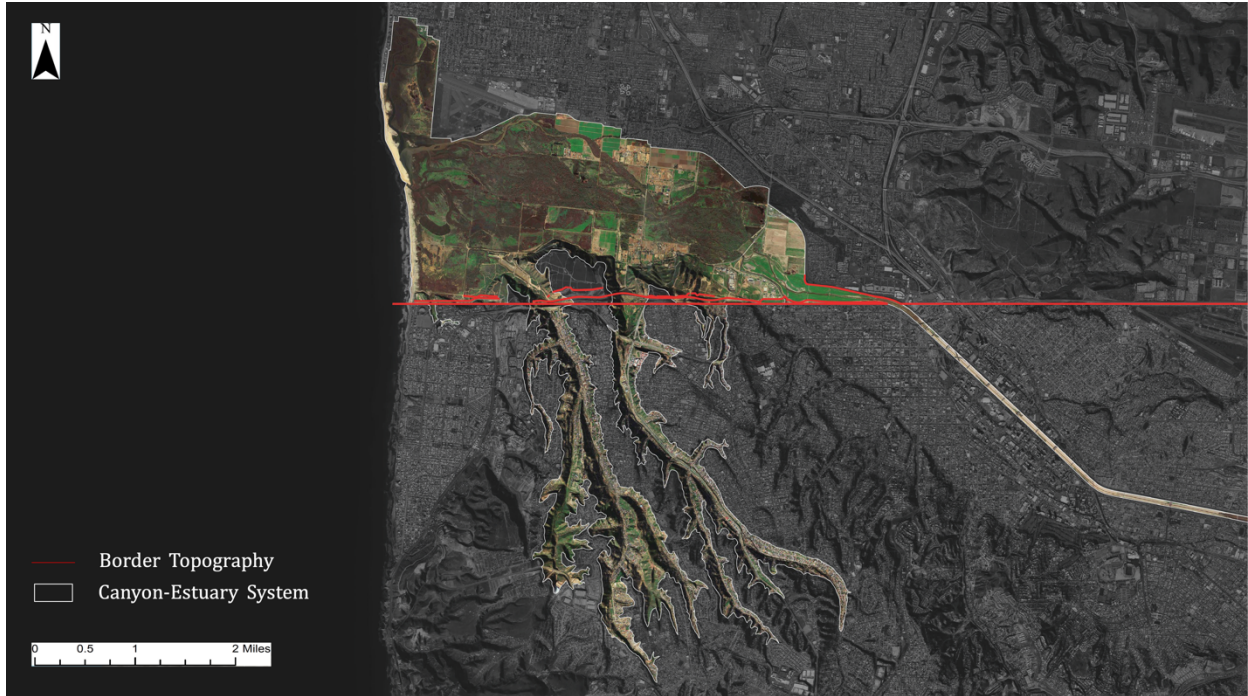
**Figure 2.** Binational jurisdiction map illustrates the problem of decision-making and fragmented policies through the centralized processes that exist in Tijuana, compared to more decentralized processes present in San Diego. Source: Figure produced by Kyle Haines in coordination with the UCSD Center on Global Justice.

### Understanding Social-Ecological Issues and Challenges in Los Laureles Canyon

Informal areas with major erosion and flooding risks create clear challenges for effective and collaborative adaptation. My work has centered around one such sub-watershed within the Canyon-Estuary system, the site of the UCSD Community Stations in Mexico and point of interest for regional organizations like PFEA, TRNNER, UABC Ensenada, and 4Walls International (Figure 3). The Tijuana border region contains 28 different canyons draining to the north, but Los Laureles Canyon was selected as the focal study area due to its comparatively immense vulnerabilities. Los Laureles Canyon covers a 4.6 square mile area within the Tijuana River Watershed, where cross-border flows travel into the Tijuana Estuary (Figure 4). Roughly 80,000 people reside in the canyon, who are exposed to a variety of environmental concerns due to the rapid growth under impoverished conditions. The population growth that has occurred in the area has resulted in significant change in land use and pressing social and environmental concerns.

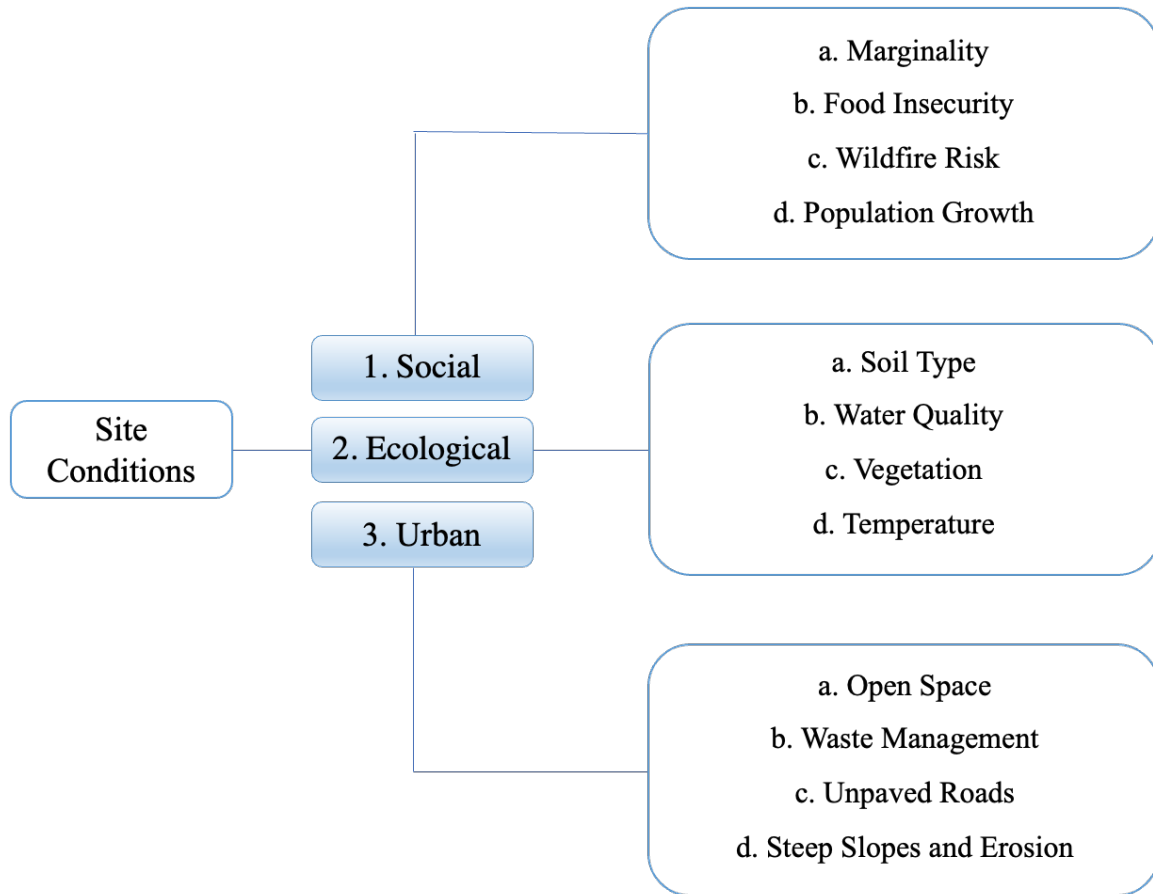


**Figure 3.** Canyon-Estuary system displayed within the binational San Diego-Tijuana region. Figure produced by Natalia Rangel with data provided by the UCSD Center on Global Justice.



**Figure 4.** The study region is located at the community level in Los Laureles Canyon, within the Canyon-Estuary system. The map illustrates the continuity of the Canyon-Estuary System with the Los Laureles and Matadero canyons entering the Tijuana Estuary. Source: Figure produced by the UCSD Center on Global Justice.

The impacts of climate change are increasing leaving susceptible populations vulnerable to its effects. Understanding the social, ecological, and urban conditions that vulnerable populations endure is critical to crafting effective approaches to intervention, adaptation, and disaster response (Figure 5). Many of these conditions are a result of the environmental degradation that has occurred in the binational watershed and the absence of adequate resources to address them, and thus are shared across the main pilot sites considered within the workshop tool selection addressed in this project (Figures 6 and 7). The tools for those common conditions trigger we named ‘core tools,’ and provide key benchmarks for similarities and differences in resident perspectives across the sites.



**Figure 5.** Site conditions afflicting susceptible populations in Los Laureles Canyon in Tijuana.

Informal settlements are located on steep, unvegetated slopes with inefficient infrastructure to provide access to basic amenities, such as running water or sewage treatment (Heyn et al. 2008). The absence of proper regulation or suitable infrastructure has greatly reduced the water quality due to the presence of heavy metals, sewage, and other forms of contamination. Storm events contribute to the transport of pollutants causing harmful impacts on human health and ecosystems. Storm events lead to flooding and destruction of canyon walls and channels, largely due to the type of soil present in the canyon which is susceptible to erosion and other hazards connected to degradation of factors contributing to destabilization of the steep sided banks (Taniguchi et al. 2018). Road washouts often occur due to the abundance of unpaved roads exacerbating issues related to travel and accessibility (Gudino-Elizondo et al. 2018). These intense erosion events have led to significant landslides that have displaced vulnerable populations because the landscape is unable to support the rapid growth and development (Gudino-Elizondo et al. 2022). The loss of green, open spaces attributed to unregulated growth in the area has cleared out existing native vegetation which had previously served as natural solutions to erosion control and prevention of water run-off. Additionally, water quantity needs for nearby communities and flood control have been issues of concern. Despite the significance of these issues, management of the polluted waters has proven to be difficult.





**Figure 6.** Trash accumulation in Los Laureles canyon, with erosion cuts visible in the soil. Source: Photo courtesy of UCSD Center on Global Justice.



**Figure 7.** Canal junction in the canyon with visible trash polluting the waterway. Source: Photo courtesy of UCSD Center on Global Justice.



**Figure 8.** Photo of Anexa Miramar displaying the site of a major landslide that occurred in 2015 with many homes destroyed and residents displaced. The area succumbed to an erosion event. Source: Photo taken by Natalia Rangel.

The asymmetries that exist between San Diego and Tijuana are compounded on a local level, particularly in Los Laureles Canyon since it experiences a variety of challenges. The socioeconomic differences are more apparent in this series of informal neighborhoods. Residents often view social and political processes differently due to the incidences of neglect from governing municipalities. As mentioned earlier, a hierarchical separation exists and is apparent amongst officials and residents. Understandably, residents are hesitant with officials entering a space with claims to improve it with previous instances displaying the opposite. Past programs have been implemented without maintenance or follow up and this has led to distrust within the community. Thus, it is imperative to build successful community partnerships and create a safe space for residents to participants to engage in collaborative intervention strategies.

## **Theoretical Approach**

### **Social-Ecological Issues at Different Scales**

This project proposes to integrate social risk reduction and ecological resiliency planning at a local scale for Los Laureles Canyon situated in Tijuana. The study has largely utilized a theory-driven approach to conceptualize the nature of the issues being discussed and provides the basis for the methods that will be implemented in-situ. To achieve the coordination required to build transborder capacity, an exchange of information is necessary between the different scales of analysis, at the global, regional, and local levels, to achieve the coordination required to build

capacity on both sides. Operative terms, such as resilience and climate adaptation were utilized to provide theoretical support to begin engaging in an adaptation planning process.

## **Definitions and Concepts**

### *Resilience*

A resilience thinking approach considers the method in which social-ecological systems, or interacting systems of people and nature, can best be managed under disturbance or uncertainty. In this context, resilience is defined as the capacity of a social-ecological system to absorb and respond to disturbance while undergoing change to maintain the same structure, function, and identity (Walker et al. 2004). Resilience is regarded as a way of thinking to analyze interacting systems and is considered as an attribute that governs the system's dynamics and determines its future trajectory. Here, we consider resilience in the design of climate adaptation strategies, or tools, and method in which they're selected for distribution at the Los Laureles Canyon, which may be applicable and scalable to other at-risk informal development communities. At the site-specific level, it is necessary to maintain consistency, manage connectivity, foster adaptive systems thinking, encourage learning, and broaden participation during implementation to realize the extent of this approach. Resilience thinking can support effective and efficient problem-solving and must encompass collaboration and effort at every scale. In this context, resilience can be applied to the issue of climate change, which can then be assessed at the site level and develop strategies to adapt and build community resilience.

### *Environmental Justice*

An empirical relationship exists when discussing social-ecological resilience and environmental justice as they relate to issues such as climate change vulnerability and adaptation (Hesed 2016). In this context, the U.S. Environmental Protection Agency's definition is followed, "fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies". Disadvantaged communities that are negatively impacted can exert more influence by building alliances or synergistic coalitions with more powerful actors. For this project, an environmental justice perspective is undertaken in developing intervention and adaptation strategies to promote social-ecological resilience. Environmental justice has become a powerful lens to recognize the struggles and negative impacts that certain societal changes have imposed on people and the environment (Martinez-Alier et al. 2016). Ecological conflicts and environmental degradation are related to changes in the social metabolism, such as an increase in growth and population density which may lead to resource scarcity and lack of institutional support. This is apparent at the U.S.-Mexico border and at finer scales within at-risk communities. An environmental justice framework can be used to explore vulnerabilities to environmental change.

## *Social Vulnerability*

Adger (2006) defines vulnerability as the susceptibility to harm from exposure to difficulties related to environmental and social change and from the absence of capacity to adapt. Vulnerability, as a concept, can be used as an analytical tool to describe susceptibilities to marginality of social and ecological systems, and for guiding the analysis of strategic interventions to enhance capacity and security through risk reduction (Adger 2006). In social-ecological systems, vulnerability as a function of resilience is proportionately responsive to disruptions in the system and the adaptive-potential of the affected community. Events in nature can expose underlying vulnerability and drive systems into situations where resilience may be reduced (Adger 2006). For instance, an increase in temperature can prompt food insecurity and worsen existing marginality. Events such as these are becoming more prevalent in a world of global change.

In the context of global climate change, social vulnerability, equity, and adaptation are significant, because susceptible communities may have less capacity to prepare, respond, and recover from climate-related effects. The complexity of climate change requires overcoming socio-political barriers within existing governance institutions while focusing on the social, economic, and moral components of vulnerability to climate change. Understanding the sources of vulnerability in an area is key to being able to conceptualize climate change effects from the perspective of residents, and thus drives synthesis for approaches or strategies to policy or adaptation planning are most effective (Kehler and Birchall 2021). Climate change adaptation is largely considered as a physical response to vulnerability to the environmental risks and hazards posed by project climate change impacts. In discussing climate adaptation, it is pertinent to include adaptive capacity, or the ability to reduce climate-related vulnerability through intervention strategies such as application of social, technical, or financial resources (Wilder et al 2013). However, the lack of political will to legislate policy for climate adaptation planning is significant a barrier to adaptive capacity (Ford and King 2015). Vulnerabilities must be effectively addressed prior to the implementation of adaptation and relief policy measures as attempts to increase resilience can be hindered by social stressors and issues related to marginality (Kehler and Birchall 2021).

## *Green Infrastructure*

Green infrastructure can play an important role in advancing climate adaptation planning, specifically for urban regions. In the context of climate change adaptation, Matthews and Byrne 2015 defines green infrastructure as “the biological resources in urban areas that are human-modified and primarily serve an overt ecological function”. Institutional barriers exist towards this concept as confusion exists among policy makers; however, adopting green infrastructure in adaptation planning is an adaptive response to climate change (Matthews and Byrne 2015). Similarly, nature-based solutions, described as approaches to beneficially manipulate natural processes to address socio-environmental challenges, have shown potential for mitigating climate

driven effects and contributing to the adaptation and resilience of a community (Kabisch et al. 2016). Implementing nature-based solutions would address sources of vulnerabilities, such as mitigating urban heat islands, which occurs when cities cover natural areas with dense areas of impermeable surfaces. Green infrastructure and other forms of nature-based solutions should complement the work of other cultural-based and technology-based solutions. Combining multiple solutions will maximize the impact of climate change adaptation planning and generation innovation (Kabisch et al. 2016).

### *Adaptive Governance and Co-Management*

The capacity to adapt and respond to changing conditions is an important component of resilience in a social-ecological system. Governing institutions hold power in providing a vision and directives to work towards a more sustainable future. Adaptive co-management is an emergent governance approach for social-ecological systems that connects the learning function of adaptive management and the linking function of co-management (Plummer et al. 2012). This approach provides a flexible structure for learning and preparing for responses to changing spaces. In this context, adaptive co-management is important to consider as the concept relies on the collaboration of a diverse set of stakeholders operating at different scales which range from local municipalities, regional organizations, and international bodies (Folke et al. 2005). Although adaptive management focuses on understanding ecosystem dynamics and disseminating ecological knowledge, adaptive governance focuses on the real-world conflict among diverse stakeholders and adapts to social nuisances to resolve issues concerning dynamic systems (Folke et al. 2005). This concept is important as it's produced from bottom-up processes by informal structures that emerge in response to failures of institutional structures dominated by top-down processes. Here, the aim is to encourage bottom-up planning, the participative planning approach where planning is developed at the lower level and funneled upwards.

### *Linking Collaborative Planning and Participatory Mapping*

Collaborative planning, as a concept, has evolved over time with Godschalk and Mills (1966) asserting that “meaningful and effective planning must be based on a two-way communication flow between the public and the planning agency”. Arnstein (1969) has argued for the public to have a more functional role in the planning and decision-making process. As the concept continues to advance, the core message is clear in that planning must act as a collaborative process. In this context, collaborative planning is defined as the synergistic process of consensus building, in which all interests are met, public and stakeholder involvement drives development and implementation (Margerum 2002). Effective collaborative planning creates positive rapport between the public and planning agencies, opens new channels for communication, and leads to problem-solving within the community. Success of collaborative planning is dependent on long-term commitment and dedication from all those involved. The process of collaborative planning is classified into three phases: first, the problem must be jointly identified, then a path to move

forward must be set with all in consensus, and lastly, stakeholders work to implement individual and joint actions with the community (Margerum 2002).

Collaborative planning recognizes the importance of community, including its involvement in discourse that seek to create sustainable and resilient communities. Various tools exist for engagement and community empowerment that can be utilized within a collaborative planning approach. Participatory mapping, a bottom-up form of map-making, can enable local communities to be directly involved in adaptation planning processes. Participatory mapping is defined as the creation of maps by local communities often with the involvement of various organizations at different levels to provide introductory support (Corbett 2009). Participatory maps provide a valued representation of what a community perceives as its sense of place, or the attachments that people develop or experience in particular locations or environments. Participatory maps provide a depiction of the significant natural and socio-cultural features within a community. Further, these end products can provide additional insight into an area's historical ecology, such as the changes within an environment from anthropogenic effects. It is essential that community members can determine ownerships of the maps they produce. Therefore, a participatory mapping process has the potential to strongly influence the internal dynamics of a community and work towards cohesion and unity (Corbett 2009). In turn, this stimulates community members to raise awareness surrounding issues in its community, engage in processes related to decision-making, and ultimately empower fellow community members to follow suit.

The theoretical concepts form a network of interests and concerns that elucidates analysis and enables efficient communication when adopted by partners. The development of the toolkit follows the central principles of resilience, environmental justice, and collaborative planning to build capacity for resilient adaptation. To pursue just adaptation requires dual goals of social vulnerability reduction and ecological resilience. This can be targeted through participatory, collaborative mapping and planning of interventions aimed at integrated goals for producing public space, reduced risk, and local adaptive governance, like green infrastructure.

## **Designing and Implementing Climate Change Adaptation Toolkits**

### **Design and Methodology**

The tools presented encompass a broad range of applications by addressing ecological management, disaster risk reduction, and site assessment based on varying social, ecological, and urban conditions. More specifically, some tools address themes related to climate scenario data while others speak to waste management issues and more. However, they all call for collaboration, exchange of knowledge, and promote community cohesion. The toolkit is designed to introduce the capacity to effectively reach solutions by reinforcing partnerships and working together to achieve common goals. This will require mutual trust and implementation of collaborative

strategies for social-ecological resilience. Thus, the toolkit explores and responds to themes of social risk reduction, building community capacity, promoting ecological resiliency, and protection of vital services. Table 1 features the strategies built into the foundation of the toolkit with Table 2 presenting the general framework towards creation of the toolkit.

**Table 1.** Guiding strategies for assembling the climate adaptation strategy toolkits.

Strategy	Description
<b>Informational</b>	Promote the horizontal exchange of knowledge by creating evidence, learning from the space and residents, and providing useful information
<b>Ethnographic</b>	Understanding the area from the viewpoint of the residents
<b>Institutional Accountability</b>	Hold governing institutions accountable to pursue the best interests of the citizens
<b>Collaborative Planning</b>	Working and learning together, form partnerships, consensus building

**Table 2.** Framework with steps detailing the nested process to assemble toolkits

<p><b>1. Identify Conditions</b></p>
<p>This step involved generating base information from an existing binational climate vulnerability assessment for the San Diego-Tijuana region. The climate atlas contains synthesized social, structural, ecological, and climate information. The information was downscaled to the community level in Los Laureles Canyon to assess existing conditions. Classify existing vulnerabilities and group site conditions into social, ecological, and urban categories to better assess which function as “triggers” for specific tools.</p>
<p><b>2. Activities and Information (Tools)</b></p>
<p>Develop engaging activities with corresponding information that support the exchange of knowledge to advance adaptation planning.</p>
<p><b>3. Method for Selection</b></p>
<p>Each site was explored in detail and draft decision matrices were composed for each community station to identify site conditions and select specifically tailored tools to implement into the community.</p>

The conditions, strategies, and activities and information are nested elements. The conditions present within Los Laureles Canyon serve as the triggers for specific tools when groups of applicable conditions exist and are categorized into social, ecological, and urban issues. Social conditions are comprised of issues of marginality, vulnerability, and capacity (Cutter et al. 2003). The issues associated with urbanization and informal development relate to social and ecological attributes of the community through the loss of green space, changes in the environment, and possibly changes in living conditions. Here, an example of a collaborative tool within the “toolkit” is engaging in storytelling where residents create their own narrative and reflect on how a space has changed from informal development. The stories and experiences assist facilitators in obtaining a community perspective to develop insight to the issues impacting the community. Sharing stories allows for the transmission of technical information in an informal, colloquial manner and identifies other challenges relevant to the community.

Ecological conditions involve issues related to habitat fragmentation, local consequences of future climate projections, habitat integrity and quality, the loss of biodiversity, and other ecosystem services like water quality. Many of the potential tools are applicable given poor ecological conditions, including activities to demonstrate the necessity for water filtration, shade, and erosion prevention. Urban conditions encompass concerns related to risk, level of development, public health, human hazards, and vital services, such as water and sewage management. Some examples of applicable tools to respond to an urban challenge would include the erosion activity to demonstrate the risk of residing on a steep, unvegetated slope or waste sorting to understand how quickly trash accumulates and introduce methods to reduce and reuse.

The tools, or activities coupled with information, are practical and hands-on to reinforce learning and engagement. Hands-on activities bring life into learning and will engage participants to understand the process and relate it to a relevant situation to overcome challenges. To follow principles of environmental justice and build trust with community partner organizations and residents over time, it will be vital to deliver the information that is most important to the community to enable a collaborative process that is not dominated by experts or government officials. From the engagement and reciprocal exchange of knowledges that the activities facilitate, residents can begin to understand the changes occurring in the canyon and realize the importance of working together to implement adaptation strategies to secure a more sustainable future.

In the spirit of this commitment to horizontal relationships, information and activities will be presented colloquially which will further sharing of community perspectives. By ‘walking together’ with residents, meaning working together on shared projects without collapsing differences of opinion and vulnerability, certain social attributes and conditions will be clearer, and facilitators will be better able to locate the wounds and fissures of the site, in both physical terms and in the collective psychology of people living, working, and playing in these vulnerable places.





## Tools

### Social Agency:

- 1 Mapping challenges and opportunities
- 2 Photovoice and sense of place
- 3 Climate storytelling
- 4 Diagramming networks

### Eco-strategies:

- 5 Native plants and shade
- 6 Water and erosion
- 7 Trash management
- 8 Biodiversity

### Public Space:

- 9 Clean up and reforestation
- 10 Denuncias exercise
- 11 Land use mapping walk
- 12 Co-management and space adoption

## Conditions

### Ecological:

- a Water quality
- b Temperature and heat extremes
- c Soil type
- d Existing vegetation

### Social:

- e Marginality
- f Food insecurity
- g Fire vulnerability
- h Population growth

### Urban:

- i Paving and impermeable surfaces
- j Parks and conserved areas
- k Trash and dumpsites
- l Slopes and hillsides

## Workshop Tool Selections

### Anexa Miramar

- 7.16 Workshop*
- 6 Water and erosion
  - 5 Native plants and shade
- Other workshops (PFEA)*
- 1 Mapping challenges and opportunities
  - 3 Climate storytelling
  - 4 Diagramming networks
  - 7 Trash management
  - 12 Co-management and space adoption

### Community Stations

- 8.1 and 8.3 Workshops*
- 6 Water and erosion
  - 7 Trash management
- Residents present Photovoice and Map
- Summer internship*
- 1 Mapping challenges and opportunities
  - 2 Photovoice and sense of place
  - 3 Climate storytelling
  - 5 Native plants and shade

**Figure 9.** Overview of the three sites where workshops will be implemented this summer. The box on the bottom right corner shows specific detail for 6 out of 12 tools that will be deployed. Through implementation, we will learn how the sites are different and how they can learn from each other. Source: Figure produced by Kyle Haines and Jona Maier in coordination with the UCSD Center on Global Justice.

### 1. Identify Conditions

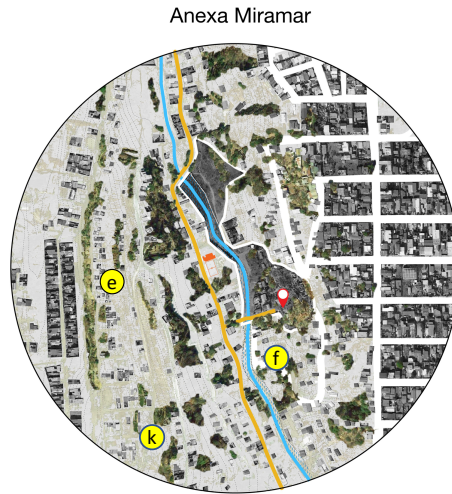


### 2. Activities and Information (Tools)



### 3. Method for Selection

- I. Social**
  - a. Marginality
  - b. Food Insecurity
  - c. Wildfire Risk
  - d. Population Growth
- II. Ecological**
  - e. Soil Type
  - f. Water Quality
  - g. Vegetation
  - h. Temperature
- III. Urban**
  - i. Open Space
  - j. Waste Management
  - k. Unpaved Roads
  - l. Steep Slopes and Erosion



#### I. Social Agency

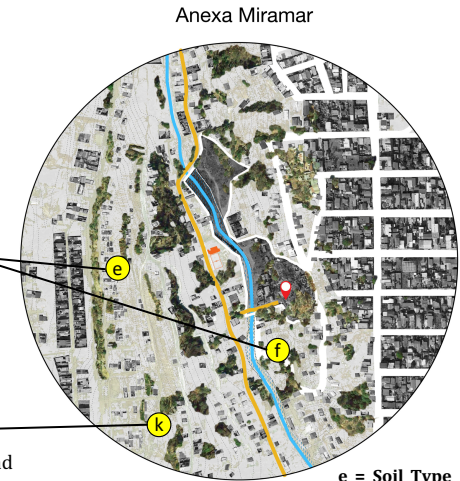
1. Mapping Challenges + Opportunities
2. Photovoice + Sense of Place
3. Climate Storytelling
4. Diagramming Networks

#### II. Eco-Strategies

5. Native Plants
6. Water + Erosion
7. Trash Management
8. Biodiversity

#### III. Public Space

9. Clean Up + Planting
10. Denuncias Exercise
11. Land Use Walk
12. Co-management + Adoption and Donation



e = Soil Type  
f = Water Quality  
k = Unpaved Roads

**Figure 10.** This example specifically looks at Miramar to view the framework in action. **First**, the conditions are identified, highlighted, and the conditions are denoted in the map as example of where the conditions are present in the community. For instance, letter f represents reduced water quality and is denoted along the canal. **Second**, once the conditions have been identified in the site, tools are selected to address specific challenges and advance solutions. Like the conditions, the tools are categorized within social agency, eco-strategies, and public space. **Third**, the tools are linked to the conditions. Letter e is denoted as an erodible soil type. The corresponding tool is to deliver an erosion demonstration, which is a hands-on activity and emphasizes the challenges associated with storm and erosion events.

**Table 3.** The list below contains a more detailed and extensive list of potential tools to be implemented in future workshops. The tool is comprised of the activity and the information that will be disseminated to the community.

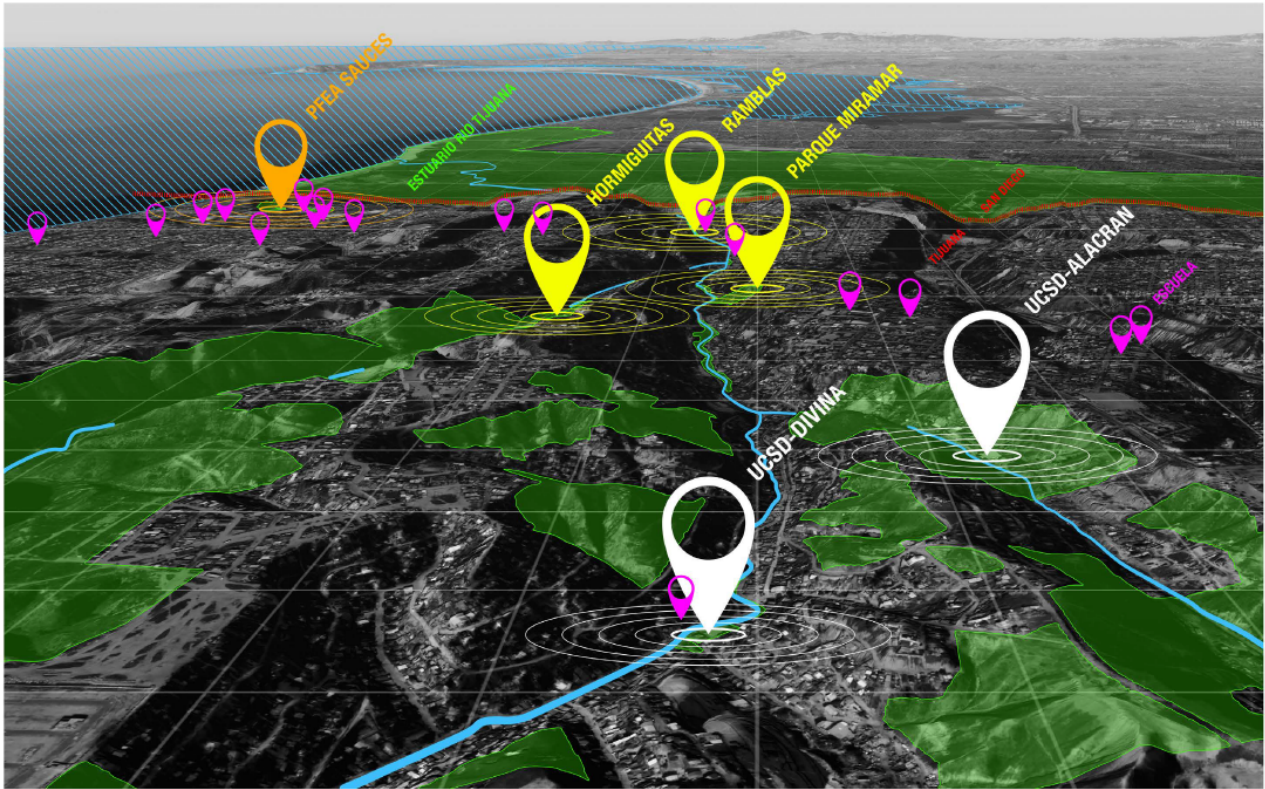
<i>Category</i>	<b>Activity</b>	<b>Information</b>
<i>Social Agency</i>	1. Collaborative Mapping	Create maps noting significant features and understanding what the community perceives as their sense of place and gain insight to the site’s historical ecology
	2. PhotoVoice	Provide cameras to participants to document, reflect, and identify different areas in the community to gain knowledge and develop an awareness of their community.
	3. Climate Storytelling	Engage members in visual stories to increase comprehension and convey information related to climate change, projected impacts, and effects
	4. Diagramming Networks	Participants draft a list of their names, plants, and animals to understand the complexity of social-ecological systems and shared spaces.
<i>Eco-Strategies</i>	5. Sun vs Shade Experiment	Demonstrate the difference in temperature in the sun vs. the shade by setting up temperature gauges for community members to record observation.
	6. Erosion Demonstration	Simulate water erosion with a hands-on activity and emphasize the challenges associated with storm and erosion events.
	7. Trash Management	Engage in a joint waste sorting activity and focus on the deliverable of reducing waste and reusing items for other applications when possible.
	8. Biodiversity	Provide magnifying glasses to younger members of community and investigate the existing biodiversity and specific richness in the environment.
<i>Public Space</i>	9. Clean up and Reforestation	Emphasize the use of native vegetation as a nature-based solution to use as a form of erosion control or to provide shade.
	10. Denuncias Exercise	Jointly file formal complaints to the municipalities concerning issues in the canyon region.
	11. Land Use Walk	Walk together with the community to identify challenges and opportunities present in a site and assess where development is required
	12. Co-Management and Adoption	Filling out space adoption forms which provides insight on performing policy mechanisms for self-management of spaces.

## Application

To achieve our goal of adaptive capacity, we need to research and identify social and ecological conditions and engage directly in a long-term exchange of knowledge. Workshops are currently scheduled to be conducted in three separate community stations in Summer 2022. Long-term partnerships have been maintained in the community stations through other projects. Further engagement will occur by entering and sharing the space over the period of six weeks. It remains essential to maintain positive rapport to promote a collaborative process that is not dominated by experts or facilitators and will advance projects using the community's voice and input.

To promote participation, workshops will focus efforts within an hour time span and direct efforts on the activity and community engagement. The workshops will act as a reciprocal process, information will be delivered to the community during the activities with the facilitators acting as bridging agents and information will be collected to learn more about the community perspective. Facilitators act as bridging agents by creating a safe, open environment for sharing ideas and exchange information by disseminating technical information while collecting information on community perspective to establish a foundation for building bridges to consensus. The tools within a workshop are designed to build off each other since an overarching goal is for this to develop into a resident-driven collaborative planning process for the communities. Workshops and tools will be presented as a consistent, iterative process to work towards building continuity and achieving resilient results in areas that have faced issues of programs being implemented and forgotten. Thus, it is imperative to build successful partnerships and create a safe space for residents to engage in collaboration.

Workshops will be conducted three small, informally developed colonias of the Laureles canyon: Anexa Miramar, Divina Providencia, and Cañón Alacrán, two of which are part of the UCSD community stations network (Figure 11), the other a site of a pedagogical water management park currently in development by the UCSD Center on Global Justice and the Proyecto Fronterizo de Educación Ambiental in Tijuana. Each site contains similar "triggers" or conditions that promote marginality in the area (Table 4). The core tools from the toolkit have been selected from the conditions that are the most prevalent across all three sites, including accumulation of trash, erosion and sediment flow, and absence of green space or canopy for shade. For instance, the prevalence of trash and piles of burnt or burning trash are observed across all locations in the canyon. Given the topography of the canyon and its soil composition, sediment flow is widespread, particularly after storm events. The sediment flow carries trash and other waste down into the lower areas of the canyon, leaving homes susceptible to infiltration or damage. Therefore, the core tools will involve an erosion demonstration, trash sorting activity, and shade vs. sun observations.



**Figure 11.** Diagram illustrating the UCSD Community Station Network south of the border. Source: Figure courtesy of UCSD Center on Global Justice. This is the cross-border commons with the CS sites (D + A) in white. The CS does not = CBC, one is the pedagogic hardware (places to teach) the other is a program for investigation and intervention.

**Table 4.** Social, ecological, and urban conditions are color coded according to level of relevance within Miramar, Divina, and Alacrán. The affluent communities of Playas and La Jolla are included for comparative purposes. As observed in the BSVI, populations are more vulnerable in Tijuana. Key: **high**, **medium**, and **low** level of prominence.

Site	Water	Temp	Soil	Flooding	Erosion	Urban Growth	Roads	Parks	Trash	Marginality
Miramar	High	High	High	High	High	Medium	High	High	High	High
Divina	High	High	Medium	High	Medium	High	High	High	High	High
Alacrán	High	High	Medium	High	High	High	High	High	High	High
Playas	Medium	Low	Low	Low	Medium	Low	Low	Medium	Medium	Medium
La Jolla	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low

## Miramar

Presently, workshops are being conducted in Miramar through Proyecto Fronterizo de Educacion Ambiental AC (PFEA), a community-based organization that looks towards local engagement. Miramar experienced a devastating landslide in 2015, in which many homes were displaced, and residents were left to pick up the pieces. The site is characterized by steep, unvegetated slopes, clandestine dumps, and other hazards such as sewage seeping down roads and into homes (Table 4). Workshops focus on the history of the landslide and recognize the community as a living space that continues to heal and adapt. Participating in walks with community members are essential as they're able to reflect their experiences in different spaces.

Here, it is imperative to ensure that their voices are heard. From the collaborative activities, residents consider the dimensions of their emotions, apply them to different situations, and recognize that there is a healing process. While this process does not bring immediate change to the community, it allows the residents to recognize issues, and recollect on the features of community cohesion and resilience. It reinforces the aim of working together to identify challenges and find community solutions to address them. Future workshops in Miramar will focus on refining community solutions towards the site's innate conditions. For instance, we plan to implement tools related to erosion control, native plant reforestation, and waste sorting.



**Figure 12.** Photo displaying community members in Miramar actively participating in a collaborative mapping exercise. Here, residents were asked to share their experiences and recollections of the landslide that occurred in the area in 2015. Facilitators gained a sense of the community-wide support that was present that day and the weeks that followed. Source: Photo taken by Natalia Rangel.

## Divina

The community station located in Divina is marked by a main, paved road that goes through the community and contains some of the few remaining green spaces. Although these two characteristics set Divina apart, the area is subject to illegal waste dumping and waste run-off concerns during storm events. Trash and sediment flow from ravines flow down into private homes and one of the two elementary schools in Los Laureles Canyon, Primaria Basilio Badillo. The community station is located across the street from the primary school, known to be overcrowded and underfunded. Specifically, the children of the community are placed directly in the path of polluted water and sediment. This serves as a visual demonstration of why members of the community believe issues, such as trash collection, should be priorities to the city. Table 4 further depicts the prevalence of the issues with reduced water quality, increased temperatures, presence of marginality, and rapid urban growth afflicting the area. Thus, tools will be deployed with relevancy to trash, water quality issues, and shade demonstrations.



**Figure 13.** Photo of Divina showing informal development on steep slopes where erodible soil is visible and comprise the foundation of many homes. Source: Photo courtesy of UCSD Center on Global Justice.

## Alacrán

Alacrán is comparable as it is also afflicted by various conditions such as water run-off, waste quality issues, and access to basic amenities. The space is unique as it has become an informal settlement for migrant refugees that receive no institutional support from the city. The shared cultural, social, and ecological issues in Alacrán in comparison to other canyon communities calls for educational programming to respond to a multitude of migration challenges. Here, the site focuses on emergency housing, acting as a receiver and transient location site for refugees, and strategies for social and economic inclusion. Since the site faces major water issues, tools will be deployed to distribute information related to erosion, sediment flow, and how contact with trash contributes to pollution and water quality issues. Piles of burnt or burning trash are also prevalent in this site. Therefore, tools related to waste sorting will prove useful to the community.



**Figure 14.** Photo of Alacrán showcasing prevalence of trash in the canyon, deep erosion cuts, and other signs of informal development. Source: Photo courtesy of UCSD Center on Global Justice.

The development of the tools is important to create engagement between researchers and residents. Researchers are expected to develop a greater understanding of the issues afflicting these areas and how residents perceive these issues and their urgency or priority. Below are four of the core tools to be deployed this summer: erosion demonstration, trash management, shade vs sun experiment, and climate storytelling.



The erosion demonstration is an example of how the tools will be utilized to address the critical conditions that residents face and will provide them with information on how to cohesively work together to reach common goals. The erosion demonstration will allow residents to observe several clear containers filled with soil side-by-side. The containers will be fitted with washers to allow for water to flow out. In addition to the soil, the containers will have different conditions, including native plants, no plants, gravel, and trash. Residents will be asked to describe what they observe whether it's clear water or murky water. From the observations, residents will understand that native plants act to filter water while other substrates contribute to pollution.

The trash sorting activity will be comprised of jointly sorting through waste with a focus on reducing waste and reusing items for other applications when possible. The shade vs sun experiments will be interesting as participants will be able to instantly observe the difference in temperature. The three zones are predicted to experience increased temperatures from project climate impacts. This observation emphasizes the use of tree canopy and other natural forms of shade to combat the heat. Climate storytelling will be deployed where residents will be encouraged to share stories or personal recollections which will provide insight to the historical ecology of a site, prior to the increase in informal development.

Additionally, technical information related to climate change or social risk will be relayed to residents increase understanding of conditions in the area and how they may be enhanced in the future without the necessary interventions. The community stations present in the canyon provide a consistent setting for this type of deployment, assessment, and for the sharing of best practices for underserved communities across the region. In the summer, students, researchers, community leaders, non-profits, and residents will engage in collaborative research and advocacy to address urgent social and environmental challenges.

While each of the geographically close sites experiences similar conditions, the severity ranges and this important to consider, as tools will continue to be developed and refined for each site. Additionally, the execution of tools in different settings will provide comparative perspectives on the community's culture and active participation in the area. Some sites may require a greater emphasis in capacity building activities to achieve shared goals. Along with the tools mentioned, other tools and activities will be implemented in the summer to gauge interest and efficacy. Photo voice will be deployed across the sites and involves participants taking a series of photographs that reflect upon their own emotions and experiences on locations in their community. This is a community engagement activity where participants will be introduced to the concept and will be asked to reflect upon and explore the reasons behind their selection of images.

## Reflection

Site field visits to the community stations were conducted within the last few months where connections were initiated with a variety of community partners, including residents and colleagues from other organizations and academic institutions. Worsening conditions afflicting communities were observed, but the positive effects of long-term partnerships between the Center and residents were clear. Residents throughout the canyon have an underlying mistrust for their governing institutions. This is due to previous inaction on formal complaints and disastrous effects from storm events where residents have felt pushed aside. However, as devastating as storm events have been in the area, residents have come together as a community and have supported each other. Taking advantage of the sources of cohesion present in these communities will be integral when implementing collaborative strategies and tools to build capacity to reduce social risk reduction and increase ecological resilience.

As mentioned, educational pilot workshops will be conducted in three community stations. Experienced facilitators, researchers, student volunteers, along with others will be present and prepared to assist with the execution. While we have generated a theoretical framework, it is important to consider that implementing the tools in-situ may produce unexpected results. Therefore, it will be key to be flexible in changing situations and emphasize adaptive, learning mechanisms in the program. Properly designed for this evaluative goal, the lessons learned can be vital to advancing progress in these marginalized communities.

Some potential next steps should include fortifying existing relationships with residents by embedding essential actors, such as researchers, non-profit partners, and governing officials in the community processes, learning from implementation, and creating a compendium of best management practices to replicate in future engagements. Future work may also include the construction of a policy document to illustrate the vulnerabilities that marginalized residents face and detail possible interventions. This would increase awareness of important issues and serve as guide for policy makers and planners in the region.

## Conclusion

As the effects of climate change are presently measurable and anticipated increased severity of climate change driven impacts are foreseeable, the scale of impacts within a region are likely to afflict those areas where population densities are increased, and degraded ecosystems compounded by lack of infrastructure. The marginalized populations within the San Diego-Tijuana region have been in peril in previous extreme weather events and worsening conditions elevate the potential hazards for the at-risk Canyon communities. Accordingly, climate change driven adaptation strategies are potentially an important mechanism for societal intervention.

As the complexity of difficulties within the Canyons are confounded by the interweaved marginal living conditions, food insecurity, and augmented social risk, projected impacts will predictably exacerbate the already difficult conditions within the presently vulnerable border communities. A collaborative planning approach will invite community engagement leading to the achievement of shared, common goals in the space. Effective execution will not only rely on bottom-up efforts as effective collaborative efforts will be most productive when accountability and reliable lateral and vertical engagement with governing institutions becomes predictive.

If effective, the climate adaptation strategy "toolkits" may be expanded beyond the proximate treatment within the Canyon communities and scaled to address environmental insecurity and promote sustainable and resilient communities. The execution of the workshops will introduce the collaborative planning instruments or tools for effectively managing, identifying, and gaining access over space, prompting an increase in community capacity for residents to hold governing institutions accountable by creating an understanding of issues produced from informal development.

The tools compiled into climate adaptation strategy 'toolkits' have been used to execute educational workshops to develop community-wide ecological fluency and forge social-ecological resilience. The toolkits are designed to promote engagement between the community and researchers to establish horizontal information exchanges. In turn, this begins the process of collaborative planning on equal and just terms to build community capacity in the most vulnerable areas. Future work will involve further research to evaluate community responses and incorporate refinements to ensure subsequent deployments incite productive and meaningful change.

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