Sociedad y Ambiente
ISSN: 2007-6576
sociedadyambiente@ecosur.mx
El Colegio de la Frontera Sur
México

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Sociedad y Ambiente, no. 19, 2019
El Colegio de la Frontera Sur, México
Available in: https://www.redalyc.org/articulo.oa?id=455759501005
DOI: https://doi.org/10.31840/sya.v0i19.1936

Artículos

Living with Risk: Climate Change and Vulnerability. Community Perceptions in Peri-urban Areas of La Paz City, Mexico

Viviendo en riesgo: Cambio climático y vulnerabilidad. Percepciones comunitarias en áreas periurbanas de la ciudad de La Paz, México

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DOI: https://doi.org/10.31840/sya.v0i19.1936
Redalyc: https://www.redalyc.org/articulo.oa?id=455759501005

Received: 27 April 2018
Accepted: 14 December 2018

Abstract:

This study analyzes two peri-urban communities exposed to hurricanes and floods in La Paz, Baja California Sur, Mexico, showing that both are aware of climate variability. People in these communities recognized their vulnerability to climate change and the high frequency of hurricanes in the area. They also identified the economic transformations, and social adaptations these phenomena have caused, and recognize the impacts on health due to the spread of new diseases. Obtaining local information on climate impacts, understanding the social causes of vulnerability and increasing the effectiveness and efficiency to adaptation through local empowerment are key elements in the analysis of climate change. Our research included meteorological/climate data that complement the information obtained from the inhabitants of the region.

Keywords: climate change, community perception, vulnerability, governance, empowerment.

Resumen:

El objetivo de este estudio fue analizar la vulnerabilidad, la capacidad de adaptación y el empoderamiento para enfrentar el cambio climático a través de la percepción de los habitantes en dos comunidades periurbanas expuestas a huracanes e inundaciones en La Paz, Baja California Sur, México. Desarrollamos talleres participativos en cada comunidad para obtener la percepción acerca de su exposición a cambios climáticos y la forma en que los han enfrentado. Ambas comunidades tuvieron la percepción de que ha habido un cambio en las condiciones climáticas a lo largo del año, indicando que ambas son conscientes de la variabilidad climática. La gente reconoció su vulnerabilidad a los cambios en el clima y la alta frecuencia de ciclones en la zona. Además, ellos identificaron las transformaciones económicas y las adaptaciones sociales que estos fenómenos han provocado, y reconocieron los impactos en la salud debidos a la proliferación de nuevas enfermedades. Esto nos permitió confirmar cómo las percepciones de los habitantes son fundamentales, no sólo para detectar la variabilidad climática, sino también para demostrar la importancia del conocimiento local para reducir la vulnerabilidad y mejorar la capacidad de adaptación y empoderamiento. Obtener información local de los impactos del clima para entender las causas sociales de la vulnerabilidad, la adaptación y el empoderamiento es un planeamiento novedoso en el análisis del cambio climático.

Palabras clave: cambio climático, percepción de la comunidad, vulnerabilidad, inundaciones, empoderamiento.

Introduction

In order to design strategies to mitigate the impact of climate change, it is important to study the vulnerability of human communities and natural ecosystems. Analysis of social and natural risks (hazards and exposure) and active practices (resilience and adaptation capabilities) make it possible to devise formal and informal strategies to reduce social and ecological vulnerability. This is particularly relevant in peri-urban areas, which

combine numerous social and ecological characteristics of rural, natural and urban environments, which makes their understanding and management more complex.

For the purposes of this study, we have adopted the definition of peri-urban zones as spaces located in urban peripheries that serve as an interface between urban and rural areas. These spaces have spatial contiguity and are in areas with urban and rural features. These areas can also be analyzed from a position where the modern meets the traditional, hybrid spaces where the social interactions of individuals, groups and/or institutions shape the social landscape, giving it its own characteristics. In operational terms, peri-urban spaces are distinguished from urban and rural areas by having more heterogeneous land uses (Alfie, 2017).

Risk of climate change in peri-urban socio-ecological systems, as a temporal, spatial, progressive and cumulative process, can be explained by the magnitude of the hazards to society, as well as the inhabitants' vulnerability and ability to cope with them, in addition to the tactics and strategies for adaptation. Community adaptation implies the development of a resilient culture, an optimal, autonomous process of participation and deliberation (empowerment), and the possibility of undertaking actions that strengthen individual and community capacities, and reinforce community identity and participation and collective learning. This process means that individuals, the community or social group are endowed with a set of tools to increase their strength, build their capacities and expand their potential, in order to improve their social, political, economic or territorial status.

In this study, we assessed social and cultural perceptions of climate change and the attendant vulnerability. Our case studies were two peri-urban communities with contrasting socio-economic characteristics: Esterito and Chametla, located in La Paz, Baja California Sur, Mexico. The purpose of the study was to analyze the vulnerability, capacity for adaptation, resilience and empowerment of these two communities in facing climate change risk. Accordingly, we developed participatory workshops with the inhabitants of each study area to find out about their perceptions of the climate changes to which they have been exposed and how they have faced them. We also assessed the extent to which these perceptions were related to the data gathered in meteorological stations. This approach is novel because it explores the peri-urban characteristics of each community, in addition to taking up the climate data obtained by the meteorological stations and contrasting these data with what the people who attended the workshops mentioned as part of their perceptions and experiences.

Although hard data contrast with social perceptions, the point of complementing them is to understand how close the perceptions of communities are to data obtained by rigorous methods, in order to devise possible action strategies based on these two matrices with the aim of determining the plans and actions required to achieve adaptive actions to combat climate change (CC). The Oxfam Project and the Earth Net Foundation for Adaptation to Climate Change (2010) in the province of Yasothorn in Thailand launched the combination of these two instruments. On the one hand are the perceptions of rice farmers of climate variability and, on the other the importance of scientific information that allows better and earlier adaptation to CC by the community (Pettengell, 2010).

Some theoretical categories and their use in Social Sciences

The study of CC from the point of view of Social Sciences only emerged recently, since the first approaches to the subject focused on mitigation, essentially in the search for alternative energies and greenhouse gas reduction at the international level. Adaptation, vulnerability, social perceptions and governance are categories on which the design of local policies in highly vulnerable sectors is based. Adaptation to CC entails changes in lifestyles, driven by industrialization, urbanization and population growth. Basically, we are talking about the dialectic relationship between development and environment.

The adaptation concept developed in 2014 by the Intergovernmental Panel on Climate Change (IPCC) is, "the process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks

to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects" (IPCC, 2014). Mitigation is a generic action, whereas adaptation is a local action, specific to a context: "adapt to it and detect the consequences" (Meinke *et al.* 2006).

Adaptation is usually associated with vulnerability and resilience and includes development trajectories, as well as elements that range from effectiveness, efficiency and legitimacy to equity (Adger *et al.* 2005, Gallopín, 2006). Adaptation involves both exogenous and endogenous elements and, therefore, decision-making processes about the planning of a territory, response to risk and resource management, among others. Adaptation involves a core set of CC policies that make it possible to address local impacts in the most vulnerable sectors of society. This logic is part of the school known as Adaptation Based on Communities, which gained momentum in Latin America in the late 1990s. According to Hebe González (2017), these visions sought to create CC approaches linked to the development of communities by incorporating bottom-up decisions at the political level.

As we mentioned earlier, adaptation involves vulnerability, a concept defined in relation to a natural or anthropogenic hazard. In this respect, this concept refers to the characteristics of a person or group and their situation, influencing their ability to anticipate, cope, resist, and recover from the impact of a threat. However, in most cases, the population lacks the capacity to anticipate and prevent disasters, yet has the capacity to cope, resist, and recover from the impact (Wisner *et al*., 2004).

The concept of vulnerability is used in various disciplines, such as engineering, physical geography, and more recently sociology. Several authors define vulnerability and ways of measuring or understanding it (Lampis, 2013). Some authors recognize it as the consequence of a natural phenomenon and stress the fact that it depends on the location and physical conditions of the population. Others relate it to cultural or ideological issues, beyond the location or its physical characteristics. The first contributions to vulnerability studies in Latin America have been the great influence of the group known as "La Red" (The Network: Network of Social Studies and Disaster Prevention in Latin America). From their perspective, disasters are the result of socio-historical accumulation that creates certain conditions of socio-environmental vulnerability, which, when combined with natural or anthropogenic threats, enable risk and disaster.

From Lavell's point of view (1996), vulnerability is essentially a human condition, a characteristic of social structure and a product of historical social processes. This perspective attempts to emphasize the social components of vulnerability and denies that it is merely a problem of people being located in dangerous terrains, or a cause of changes in nature. "The great contribution of this approach was, without a doubt, to incorporate society as an active element, opposed to the dominant vision that placed only the physical-natural factor at the center of studies ...vulnerability is inherent to the development of society. Its evolution and accumulation are therefore indicative of the styles of growth and of the existing forms of social organization" (Mansilla, 2000: 19). In this respect, authors such as Cardona (2001) refine the concept when he points out that vulnerability is the predisposition or physical, economic, political or social susceptibility of a community to be affected or to suffer damage in the event of a destabilizing phenomenon, of either a natural or anthropic origin.

Our research concerns community perceptions of CC, in which adaptation and vulnerability are two important concepts that can show us how communities deal with climate variability. As proposed by Adger (2003) individuals, social groups, organizations and governments make adaptation decisions, framed in a social, economic, political and cultural structure. Accordingly, the study of the perceptions and beliefs that guide the action of individuals and groups acquires special relevance, making it possible to find the motivation underpinning everyday practices and thereby proposing alternative programs and projects that better meet the needs and expectations of local populations.

Authors such as Berkes, *et al.* (2000), Heyd (2010) and VanderMolen (2011) state that perceptions attribute qualitative characteristics to environmental assets through references that are based on specific

cultural and ideological systems, constructed and reconstructed by the social group, making it possible to obtain evidence of conservation practices in their territory. In Mexico, there are very few studies on CC perceptions. By way of an example, we found the Sandoval *et al.* (2014) researched a community in Yucatán, where respondents perceived that climate change negatively affects their crops and health while in Guanajuato, Vélez *et al.* (2016) also found that rural and peri-urban communities perceive more heat and less rain.

In official studies, local and vulnerable populations are not taken into account in the debate on climate change, so all the knowledge accumulated by generations is not incorporated into the design of policies and programs designed to reduce vulnerability to climate change (ITDG, 2008). According to Giraldo and Wilches-Chaux (2005), the perceptions, knowledge and strategies of local social actors in peri-urban areas, must occupy a place in establishing diagnoses on the different expressions of vulnerability and the concerted responses to the impact of climate change. The responses or agency strategies of these social groups in the face of risks can mediate, sharpen or redefine the impact of disasters.

In this respect, governance plays an important role in giving a say to communities in the decision-making process. It involves strengthening adaptation on the basis of communities, taking into account their perceptions and their local knowledge, in order to strengthen local policies in the most vulnerable sectors. It is a fact that all levels, including the local and regional, must participate in the search for solutions to global problems (Cash *et al*. 2006). A concrete example of this aspect is multilevel governance, in which members of institutions engage in horizontal interactions with their peers, and vertical interactions with the various hierarchies of organizations (Young *et al*. 2008). The interconnection in social systems must be effective at all levels: horizontal and vertical links are equally important. These links provide the flow of information and knowledge, which increases the capacity for learning and facilitates participatory processes and more democratic decision-making.

For Heyd (2010), the importance of governance regarding environmental issues emerged with renewed vigor due to the success of these new forms of social coordination between different social and political actors. Governance can achieve significant changes that lead to new institutions (such as watchers for environmental friendliness). It can also be a means to disseminate information, opportunities and actions to enrich the organization itself. The concept of "governance for community-based adaptation" is central, which can be defined as "a process guided by communities according to their priorities, needs, knowledge and ability to empower people to plan and face the impacts of climate change" (INECC-SEMARNAT, 2012). Community perceptions are key to implementing adaptation, containing vulnerability and beginning to put environmental governance into practice. This paper seeks to find out about the perceptions of two communities of CC and to visualize the possibilities of change from a socio-political point of view.

Methods

Case studies

Two peri-urban communities in the municipality of La Paz, in the Mexican state of Baja California Sur, comprised the study area. These communities were Esterito, dominated by urban development with high population density and a full range of urban services, located on the border, with natural vegetation, and Chametla, which has a mixture of natural vegetation, agriculture and scattered urban settlements with low population density (Figure 1). Both localities belong to an area identified by CENAPRED (the Mexican government's National Center for the Prevention of Disasters) as being at a high risk for hurricanes (Ivanova and Bermúdez, 2013). This designation was made on the basis of the hurricane frequency from 1949 to 2010. In fact, between 2000 and 2015, this area has received either a Disaster Declaration or an Emergency Declaration [1]. These declarations are financial instruments the Mexican federal government delivers to states and municipalities to contribute to the reconstruction of damaged infrastructure and the reestablishment

of the normal function of the society facing natural disturbances (Secretaría de Hacienda y Crédito Público, 2010).

The city of La Paz is the state capital, with a population of 215,078 inhabitants, most of which (93.6%) are located on the coast. The main economic activities are maritime trade, fishing, tourism and services, and some agricultural activities in the valley area relatively far from the coast (INEGI, 2013a). From 1950 to 2010, the population of La Paz rose steadily (by an average of 4.5% per year), which denotes a community in movement, due to continuous migration attracted by its relatively high development. The rapid population increase has led to a regional environmental change, primarily characterized by waste generation, vehicle fleet growth and the increase in deforested areas. Likewise, disorganized urban growth has caused several problems such as pollution and a rise in greenhouse gas emissions (Ivanova and Bermúdez, 2013).

Temperatures in La Paz and the surrounding areas vary, from high temperatures in the summer of between 40 and 44 °C to low temperatures in the winter oscillating between 14 and 16 °C. Due to its rainfall of less than 200 mm / year (Gobierno de Baja California Sur, 2018), it is generally considered a typical desert climate. Most of the rainfall comes from hurricanes which historically, at least every two years, have caused disasters in the region (Steinitz *et al.*, 2005). An increase of approximately 1 °C in average sea temperatures has been recorded, together with the extension of warm weather in summer (with an average temperature of 27 °C) to the months of October and November. These phenomena contribute to the intensification of the cyclones, their extension and duration with the attendant consequences (Ivanova and Bermúdez, 2014). The most representative crops are tomato and chili, accounting for approximately 65% of the total volume of agricultural production, followed by alfalfa and pasture. The total value of agricultural production was 769.2 million Mexican pesos in 2013-2014. In the case of the fisheries, the most important species in terms of volume are scale fish, shark, clams, squid and stingray. The total value of fishery production was 71.2 million Mexican pesos in 2014 (Gobierno de Baja California Sur, 2015).

The community of Esterito comprises 3,381 inhabitants with an average of nearly nine years of education. Only 23% have medical services and almost 77% of homes have dirt floors (INEGI, 2013a). The community is exposed to floods, torrential rains, debris and garbage discharged into waterbodies (DesInventar, 2017). In our typification of peri-urban spaces, it has mostly urban characteristics combined with fishing activities due to its proximity to the sea. Houses are surrounded by natural vegetation comprising scrubland and grassland, with no agriculture nearby. The dominant soils are leptosols (thin soils) and fluvisols (sediment) (INEGI 2013b). In the case of Chametla, it comprises 2,178 inhabitants with an average of almost nine and a half years of education. Only 29% have medical services and nearly 1.5% of the houses have dirt floors (INEGI, 2013a). The community is exposed to floods, torrential rains and hailstorms (DesInventar, 2017). This peri-urban space presents a combination of urban, agriculture and natural spaces, far from the city center (Figure 1). Natural vegetation and agriculture surround the houses in the Chametla case (scrubland and grassland). The dominant soils are solonchaks, fluvisols, leptosols, regosols and vertisols (INEGI 2013b).

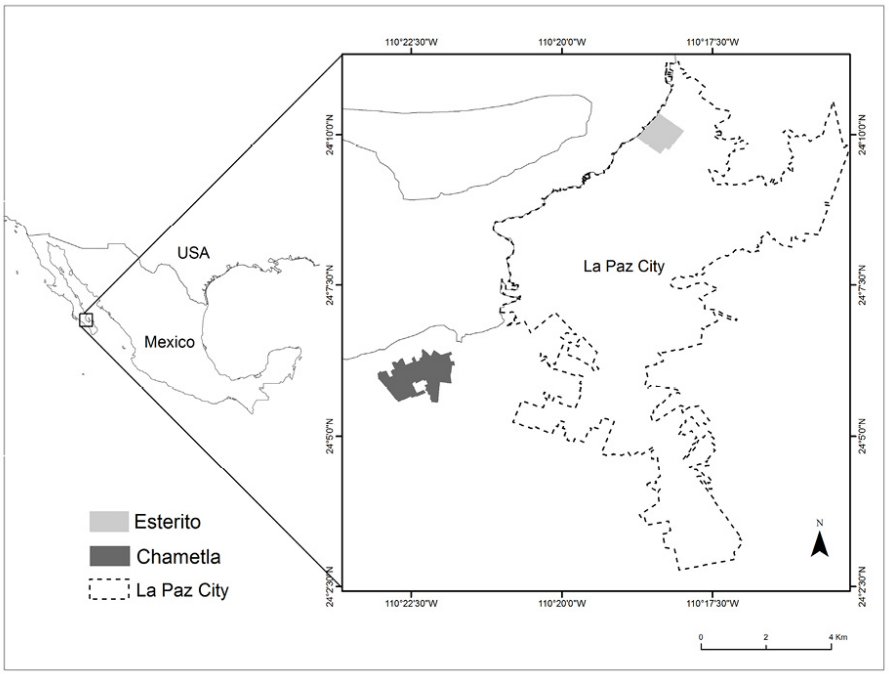

FIGURE 1.
Study cases. Chametla and Esterito, BCS, Mexico
Source: Laboratorio de Análisis Socioterritorial, UAMC.

Vulnerability analysis

The analysis of vulnerability was undertaken through participatory workshops, using a modification of the methodology developed by the National Commission of Protected Areas in Mexico and the Deutche Gessellschaft fur Internationale Zusammenarbeit (CONANP-GIZ, 2014). Five dimensions of community vulnerability were described: life strategies, welfare conditions (house, water, education, among others), the adaptive capacity of individuals and households, community and collective adaptive capacity and governance (Ulrichs *et al*., 2015).

This methodology allowed us to evaluate vulnerability to climate change including three important aspects: local information on climate impacts, social causes of vulnerability, and increasing the effectiveness and efficiency of adaptation proposals aimed at local appropriation. Vulnerability analysis focused on the social and cultural perceptions of these communities about climate change, the way they conceive the associated risks, their vulnerability and the ways in which they deal with these problems, as well as their adaptation strategies (Table 1).

TABLE 1
Phases of participatory workshops

Identification of hazards and risks
Identification of hazards and risks (cause - effect) due to the impacts of climate change on the community. Monthly calendar of risks and impacts to understand their seasonality
Identification of areas and populations at risk (development of spoken map - parallel exercise)
Mapping of community infrastructure (water sources, schools, clinics, dairies and soup kitchens) Recognition of areas with forest or rivers, areas with flooding, landslides Location of social groups living in risk areas
Productive activities and risks
Identification of impacts in productive activities in the community (month, sex, location) Detection of level of impact in a specific month, impact and persistence percentage, tolerance limits
Adaptation mechanisms and governance
Enumeration of mechanisms of adaptation to risk situations that families or the community recognize. Their relationship with productive activity and tolerance limits Inventory of support mechanisms for families andcommunity (organization, institutions, programs, family and social networks)

Source: Compiled by the authors using data from CONANP-GIZ (2014).

We chose participatory methodologies to obtain the social actors' perceptions before and after the presence of a climate hazard situation (tropical cyclones). Even though we issued several invitations to participate in the workshops in both cases, we only had acceptable assistance, which is regarded as sufficient by Nielsen (2012). The Nielsen study recognizes that testing five people makes it possible to find almost as many usability problems as one would obtain using many more test participants. Moreover, the Manual of Participatory Techniques in Sucre Bolivia (2003) of the Green Resources Agency of Japan states that there are better results when working with small groups. What matters is the potential those people have for the community and the relationships they have established with the local authorities.

Several authors, such as Gerger Swartling (2007), Kreuger and Casey (2009) and Shensul and LeCompte (2013) highlight how working with small groups has significant advantages, such as the amount of data obtained in a short time. In addition, in these workshops (focus groups), it is possible to discover social norms, behaviors, opinions and attitudes, as well as perceptions, cultural patterns and beliefs. Together with other sources of information, these workshops can contribute to obtaining a complete view of an entire population and their behavior in response to the introduction, promotion and support of possible social changes. The number of participants required in these workshops may vary. These authors recommend between six to twelve people, but a typical group would have seven actors that interact with each other, since larger groups require a greater effort to moderate discussions, as well as strict rules to ensure fair participation. The five of them agree in pointing out how the relevance and meaning of the answers obtained by the focus group can increase the feasibility and acceptance of a research project.

For the Esterito workshop, we had eight attendees and in the case of Chametla, we had nine participants. People who attended the workshops in both cases were residents from nearby settlements, so their responses focused on local issues. They had a diverse profile. In Esterito, all the attendees were women including housewives, business owners and students, whereas in Chametla six of the participants were women and three were men, including professionals in various fields, students and housewives. In both cases, one of the attendees was the neighborhood leader and ages ranged from 20 to 60.

Small group workshops give rise to an active learning process by members, who may be organized in various ways to exchange opinions, reflect in a group and convey the message to the community. According to Pichón Rivière (2014), a group is a restricted party of people linked to each other by constants of time and space, and by their mutual internal representation, which proposes an explicit or implicit task. In both of our cases, community leaders whose interrelationships with the community and local authorities were permanent and constant accepted our invitation to participate. We should note that our research was a qualitative study, designed to collect insights to drive our design. Our findings in the workshops confirm the community's knowledge of climate variability, its ability to adapt, its aim of transmitting the knowledge acquired to their community, and the commitment to talk to local authorities to reach agreements.

The case studies tried to work with the potential of participatory methodologies and created interrelationships between science and popular knowledge. Our aim was to give the community an active role, in order to encourage its participation in the diagnosis and resolution of its needs. Contreras (2002) considers that this type of methodology is a tool that enables the creation of reflection-dialog-action-learning links between people and external agents. It is interesting that this instrument makes it possible to delimit, attend, analyze and propose solutions from those who are directly affected. For Soliz and Maldonado (2006), this methodology allow empowerment and the construction of sovereignty, contributing to the transformation of marginalized groups. It involves knowing how to understand and understanding in order to transform. On the other hand, Villasante (2011) states that participatory methodologies provide innovative ways of finding out about complex phenomena such as collective action and social and political participation.

We conducted four participatory workshops in total, two in each community. The first two workshops were developed on April 2017, the 21st in Esterito and the 22nd in Chametla. In these two workshops,

we wanted to find out about community perceptions about climate variability and climate change and the associated vulnerability as well as the adaptation actions adopted by the community to address them. The last two workshops were held in November 2017, the 17th in Esterito and the 18th in Chametla. The main goal of these last workshops was to recapitulate the work done in the April workshops and give the communities the results and conclusions of the vulnerability analysis. A group of students from a local university who helped with the project opened the invitation to the first workshops to all community members by placing announcements in convenience stores and by direct invitation in some houses. The invitation to the last workshops focused on the participants in the first workshops.

Climate analysis

In order to evaluate the climate trends in both study areas, we used the Eric III database, available from CONAGUA (the Mexican National Water Commission), which has information on climatological stations around the country. For both communities, we selected the closest weather station with a data series from 1970 to 2015. We obtained the daily precipitation and the maximum and minimum temperatures of the months indicating the start of the seasons (March, June, September, and December). In order to analyze the trends, we used the Clic-MD 2.0 software. This climate database management and analysis system allowed us to assess data quality through homogeneity and normalization tests and evaluate climate change trends through the Mann Kendall statistical test (Bautista *et al.*, 2014).

Results and Discussion

Main climate impacts and implications for vulnerability

In both communities, climate was perceived as 'something' that depends on the interaction of factors such as radiation or pressure. In both communities, there was a perception of a change in climate conditions throughout the year. These included higher temperatures and the presence of extraordinary events such as storms or hail, an alteration in climate episodes, or the loss of regular climate events, such as morning and evening winter drizzle.

Heat and temperature variation

Both communities agreed that there has been an increase in heat all year around. For them, it has been more evident in the winter, with temperatures reaching up to 30 °C at noon, with low temperatures at night. Accordingly, the winter season is now considered "warm" with substantial variations throughout the day. In addition, unusual events such as frost and hail have been taking place. Between May and July, temperatures have increased causing considerable droughts that threatened both communities.

Although the hurricane season officially starts in May, people report that they "actually" come in August and September, and sometimes in October. The perception was that hurricanes are now more frequent and more intense when they make landfall. They said that in 2016, unusually early rain was recorded in June, although the rainy season usually starts in August, and that a phenomenon like that had not been seen in forty years. Most participants stated that the rainy season has been reduced and begins earlier in the year. In short, in the area of study, the perception was that temperature and droughts have increased throughout the year, intense hurricanes are more frequent, and there is an absence of mornings and evening winter drizzle.

These perceptions are consistent with statements by INECC and SEMARNAT (2012) -the Mexican environmental agencies-, which reported that hurricanes, floods and droughts in the country have doubled

their frequency, and increased their intensity in the past two decades due to climate change. In addition, they reported that 96% of economic losses were the result of the disasters caused by those events.

According to Martínez-Gutiérrez and Mayer (2004), the record of tropical storms and hurricanes in the eastern North Pacific basin from 1949 to 2001, shows that the frequency of storms is higher in July, August, and September, with the highest frequency being in September, as stated by the workshop attendees, given that, this month has the highest likelihood of a hurricane-continuing north towards the Baja California Peninsula, mainly between September 1 and 10. In fact, these authors reported that between 12 and 16% of hurricanes formed in the eastern basin of the North Pacific directly affect the peninsula of Baja California.

Impact on activities

Both Esterito and Chametla are peri-urban communities, located in a transition area between the rural and urban sectors. Accordingly, they work as farmers and fishermen, but also in formal and informal trade (sale of food and merchandise in street stalls, rather than in an established business). The people working in the primary sector who attended the workshops expressed serious concern about how the climate and its variation have affected their jobs. For example, the frost that occurred in 2015 caused crop losses in the agricultural fields surrounding the city, whereas in the spring the heat increase burns crops and causes a price increase, but also a drop in consumption. Many of these activities were abandoned and informal trade began to grow, as adaptive measures involving economic changes in both communities.

In relation to fishing, catch volumes have decreased due to temperature changes that limit the amount of fish. The workshop participants mentioned a temperature increase in the last decade "... summers are hotter and fish do not grow..." From May to July is the red tide, whereas in November and December, sea algae grow and the fish that feed on them decompose sooner (after they are caught they must reach the market quickly and be consumed the same day). The presence of hurricanes affects those engaged in fishing along the riverside; their effects can be long-term whenever capital, boats or nets are lost. They therefore have to supplement their livelihood with sporadic tourism, by offering tours of the surroundings from time to time.

Workshop attendees indicated that hurricanes also affect tourist services (tours), and even informal trade, especially the sale of meals, which are an alternative source of income for the fishermen of Esterito. When floods occur, tours cannot be offered and businesses must close, or their sales decrease. However, businesses recover faster after a hurricane, and only remain affected when floods continue and isolate communities for several weeks. One benefit of hurricanes is that sometimes people sell food to the employees of companies that come to repair the area.

The impacts of climate variation on primary activities, is a warning because they directly affect the food security of communities that depend on them. In both Esterito and Chametla, climate variation is recognized as a factor that affects crops, reduces fishing, with hurricanes particularly affecting tourism.

In both communities, people had learned how to locally deal with floods, so they have created household solutions to their problems, such as building walls around houses to prevent the entry of water, raising the sidewalks, or buying generators. Their response capabilities and adaptation strategies in households or communities involve social, political, economic, and ecological factors. The increase in heat and the temperature variations that prevail in these communities, as well as the impacts associated with hurricanes or droughts require a series of actions and adaptation strategies by people and groups.

Vulnerable groups

In Esterito and Chametla, there is high vulnerability, especially in sectors living in conditions of poverty (with low income and economic precariousness) as well as those who build their own homes, and those engaged

in primary activities. Territorial location is a key factor in relation to hazards. The villagers stated that the residents most exposed to cyclones and floods were those who live near rivers or the sea. From their responses, we can determine that most of them have a passive attitude (low participation and interest in the matter) towards environmental hazards, although they recognize the risks in different parts of the territory of their community, since they were able to identify the sites of landslides and floods.

Even though they know their territory, they have not identified the places of risk, potential shelters, what to do in the event of danger or what precautionary measures to take against risk. There is little or no environmental education and only incipient social organization. There is a generalized idea that the government should take responsibility before and after the disaster. Some of the problems mentioned by the people of Esterito and Chametla in relation to hurricanes and their vulnerability to those events are the impacts of strong winds such as the loss of roofs and the flooding of precarious houses, falling electricity poles, the interruption of communication services and water distribution.

The most recent antecedent of the social construction of this perception was Hurricane Odile, in September of 2014. Downpours causes floods in drainage zones. People describe them as events where a significant amount of rain falls in a relatively short period causing the level of streams to rise: "... two rainy hours in which all the water that has not fallen in the year is deposited..."

Residents of Chametla and Esterito said that the impacts of downpours in their communities are due to the low permeability of the soils that prevent infiltration, producing streams that reach high speeds and drag materials and objects along with them. In both communities, people agreed that drainage pipes that cross under the roads or streets are insufficient or small so they get clogged with objects dragged by the water. They also agreed that floods are associated with waste deposited on the streets or not properly disposed of, so it is dragged by rainwater, blocking the drainage systems and producing floods. The impact of floods is magnified because water enters homes and destroys personal property.

It is important to point out that due to its location in the foothills in the north of La Paz, Esterito can be isolated from the rest of the city for hours or days. The situation is exacerbated when roads, electricity and drinking water services are affected. The most vulnerable people are those in a situation of poverty, which makes their recovery from hydro-meteorological impacts disorganized and slow. Precarious housing, deficient services, land use changes, poor infrastructure and lack of environmental education are key elements that define population vulnerability in the two communities. Both also understand that the degree of vulnerability of the population is expressed in direct relation to their level of development, which is influenced by inadequate construction techniques; spatial exposure of the population to physical hazards; low income levels; national economic weakness; a deficient degree of social organization; the presence of passive ideologies regarding the relationship between man and his environment and the control over it; as well as inadequate environmental education and high levels of population mortality.

In general, we can say that the communities studied have adapted to climate risk on the basis of their own culture, knowledge and experience. On many occasions, it is a case of trial and error, which has given them the ability to resist rather than preventing risk. Hurricane Odile generated a process of building an emerging culture of disaster prevention, in which authorities have an important role: warning about the presence of hurricanes, so that people close their businesses and take some measures in their homes.

Those who attended the workshops recognized serious infrastructure deficiencies due to the lack of paving, inefficient drainage, large amounts of waste and the lack of public services, all of which intensified the emergency. In Chametla, it was very clear that in the event of disaster, the lack of nearby hospitals, ambulances and health clinics could negatively affect the community. They are isolated and it is difficult to come to their aid. There are few access routes to reach the neighborhood and they may have no electricity and water for several days.

Accordingly, actions carried out by the communities to deal with impacts of climate change mainly focus on keeping their homes in their original place, firstly, by modifying them or building structures that help

prevent a greater impact from floods and torrential rains, even with temporary structures that act as barriers. The fact of "resisting" or "enduring" impacts in place is not diminished since their land and homes are their most important assets. The risk of living in vulnerable places is worth it (according to our respondents), given the difficulties of obtaining housing and the lack of resources.

Health

Within a precautionary and equity principle (WHO 2014), there is a strong link between environmental conditions and human health. In this regard, the United Nations Environment Program highlights aspects of vulnerability, risks to the health of human groups, and food security in relation to the phenomenon of environmental change (UNEP, 2011).

In the workshops in Esterito and Chametla, an additional concern of the attendees was the increase in disease related to climate variability, with children and the elderly being the most vulnerable, particularly respiratory and gastrointestinal diseases. Inhabitants of both communities mentioned vector-borne diseases: particularly dengue, followed by chikungunya, Zika (transmitted by *Aedes aegypti*, from mosquito bytes) and Lyme disease (transmitted by Ixodoidea, from tick bites). This type of diseases is growing due to the changes in the land use, the low infiltration capacity of the soil and the lack of paving that leads to the formation of puddles where mosquitoes can easily breed. The shortage of water due to hot temperatures causes inhabitants to store it in containers for several days, which leads to the expansion and growth of mosquitoes.

On the other hand, people associated the presence of respiratory diseases, such as cold or flu, with drastic temperature fluctuations. This situation creates additional family expenses, since they have to pay for medical consultation and medication. During the hot months, cases of dehydration and heat strokes occur, food decomposes rapidly, particularly seafood, and at times of drought there is a lack of water supply for basic health needs. All these factors cause an increase in gastrointestinal diseases. However, the greatest concern of the communities was the significant increase in dengue hemorrhagic fever, Zika, chikungunya and tick bites. After Hurricane Odile, more than 4,500 cases of dengue were recorded in the state of Baja California Sur (BCS). The government has invested between 15 and 20 million mexican pesos in campaigns to prevent vector diseases, based on prevention brigade policies and sprays, as well as collecting containers where water is stored (BCS Noticias, 2018).

These numbers are related to the research of Pisanty-Baruch (2006). She states that a third effect of climate change is expected. Different levels of ecological complexity may had led to a population imbalance, with the resulting presence of pests and diseases in natural systems, whose effects can be devastating. There are reports of 143 total species (animals and plants) that have already shown morphological changes, as well as alterations in their abundance, which coincide with what was predicted by the models of physiological responses to climate change (Schellnhuber, 2006). Moreover, many of the population behaviors pose a risk to human health, since they imply an expansion in the range of distribution and an increase in the number of insects that transmit diseases. This is the case of mosquitoes, which are dengue and malaria vectors (Union of Concerned Scientist, 2018). Many of those mosquitoes are the same as those present in BCS.

Adaptive strategies and skills

As Bidegain *et al*. (2013) explain, climate variability in less developed countries such as Mexico, with low diversification in terms of production and high dependence on their natural resources poses, enormous challenges in the adaptation and transformation of their socio-ecological systems (SES) in the immediate future

This approach has developed concrete and successful strategies in relation to increasing the resilience of SES. The most successful strategies in this field include: (i) learning to live with change and uncertainty, (ii) increasing the diversity of all the components of the SES (economic objectives and natural resources used, among others), (iii) combining different types of knowledge and learning, (iv) creating opportunities for self-organization and links between different levels, such as between the national and departmental levels (Folke *et al.* 2003 and 2005).

Each culture has its own conceptions, relationships, and perceptions about nature and its territories, as well as about the history of environmental changes, including climate changes that have occurred since before the history of the human species (Heyd, 2011). In this context, adaptation to these changes is not unprecedented for societies, since the different ways of understanding, perceiving and acting in the face of climatic phenomena have made it possible to transform and maintain social practices of environmental and productive management over time.

From this perspective, it is interesting to note that, in the face of complex climatic phenomena, the residents of Esterito and Chametla have implemented direct actions to address them, which have not been imposed by models, institutions or external actors, but have arisen empirically as a result of their own knowledge and experience in the environmental management of ecological systems in the region, which is why measures of "spontaneous adaptation" to the changing climate are considered. It is also important to highlight the role of certain traditions that represent an important cultural heritage that has enabled communities to compensate for the effects of flows and the increase in temperature, as well as new diseases.

For example, health authorities use pesticides to combat the proliferation of vector-borne diseases caused by the increase in temperature and the availability of favorable habitats. Both communities recognized the need for more information on disease prevention, for example, in the management of water deposits to stop mosquitoes from breeding. In Chametla there is a perception that a tire dump, near the neighborhood, accumulates material without any type of control, which allows the accumulation of water and the proliferation of mosquitoes.

The residents of Esterito built a cement canal, behind some houses, to channel the flow of water into the sea. Although this canal reduced the entry of water into nearby houses, floods still occur in the area. Every year, before the hurricane season, people in certain areas of Esterito raise the level of the sidewalks by placing construction debris around their houses to prevent flooding. In both communities, it was recognized that the weather information and announcements made by the government about the arrival of hurricanes has allowed them to be prepared before the cyclone hits, by buying food, water, candles, radios, batteries and generators.

In Esterito, people recognize the shelters, hospital locations and evacuation routes. Shelters are important when the community is isolated due to flooding and water stagnation. Conversely, Chametla is a relatively new community that has no nearby hospitals or fire stations and people can be isolated for several days. According to Heyd (2010), rural communities, have been more vulnerable in their everyday lives to complex climate events and, in this respect, they locate the consequences of such changes in their realities. This can be applied in both of our study cases.

Governance

Both communities recognize the reluctance of residents to organize and form a robust citizenry. They still rely on traditional forms of lobbying. In Esterito, there are representatives from each city block who meet with public officials to address community problems. However, the meeting results are not conveyed to all inhabitants. One of the key points for empowering the population is knowledge about climate variations and the possibility of organizing to implement joint actions where participation and deliberation are the basis of the decision-making process. The interest of people in sharing their experiences offers the possibility of

consolidating common interests and improve the living conditions of people and their families, as well as establishing links within the neighborhood.

The people and groups in these communities have limited intervention in concrete actions against climate change due to the lack of information and training, while the City Council and the public institution in charge of water and sewerage focus their actions on controlling damage. Communication has begun between people and civil organizations since hurricane Odile. NGOs have done important job in the communities, trying to create social action networks that provide information, and are also willing to engage in integrated, planned work to achieve greater effectiveness in the prevention of risks and an increase in the resilience to climate change. Important actions among neighbors include community assistance when Hurricane Odile struck, and the intervention of certain religious groups which provided support and distributed food and materials for reconstruction. People perceive that government support is insufficient or inappropriate for this type of emergencies, and there is a lack of promotion of civil protection.

From our point of view, in both cases, communities should turn to local organization as a means of dealing with their vulnerability. This element can be reinforced through social networks, the exchange of information and joint work among neighbors, NGOs and local governments. If the ties of solidarity are reinforced and joint action is taken, the risk of disasters can be reduced. Strengthening the deliberation and participation of various actors and stakeholders favors the empowerment of localities and contributes to addressing the problem of climate change from a local perspective, where culture, heritage and ways of life are key factors for the success of adaptation processes. Governance becomes a tool that can enrich collective decision-making.

Climate analysis

We found an increase in minimum temperatures from April to August, coupled with a a significant decrease in maximum temperatures for April, July and August. No significant changes were found in precipitation (Table 2).

TABLE 2.
Summary of changing trends in precipitation and maximum and minimum temperature in the El Cajoncito climatological station

Month	Max temperature (°C)	Z	Mean temperature (°C)	Z	Min temperature (°C)	Z	Precipitation (mm)	Z
Jan.	23.85	-1.41	17.84	-1.56	11.82	-0.1	11.82	-0.76
Feb.	24.69	-1.5	18.29	-1.17	11.88	-0.43	6.59	0.22
Mar.	27.32	-1.8	19.89	-0.76	12.46	1.43	2.41	0.11
Apr.	29.91	-1.99	21.8	-0.95	13.68	3	0.22	0.69
May	33.02	-1.73	24.43	-0.13	15.84	4.72	0.99	0.04
June	35.4	-1.78	26.97	0	18.53	3.79	1.2	0.51
July	35.99	-2.7	28.57	-1.08	21.15	2.91	24.21	0.61
Aug.	35.97	-2.81	29.02	-1.77	22.07	2.32	60.51	1.01
Sept.	35.35	-1.9	28.47	-1.56	21.59	0.43	87.93	0.74
Oct.	32.85	-1.25	25.62	-0.3	18.41	0.25	24.86	0.48
Nov.	28.3	-1.34	21.57	0.14	14.84	0.86	6.6	-1.74
Dec.	24.73	-1.02	18.5	-0.56	12.28	-0.95	11.23	-1.64

Source: Laboratorio de Análisis Socioterritorial, UAMC.

According to the Normalization Pettit test, the inflection point in the minimum temperature happened at the end of the 1990's, whereas the maximum temperature occurred at the beginning of the 2000s (Figures 2 and 3).

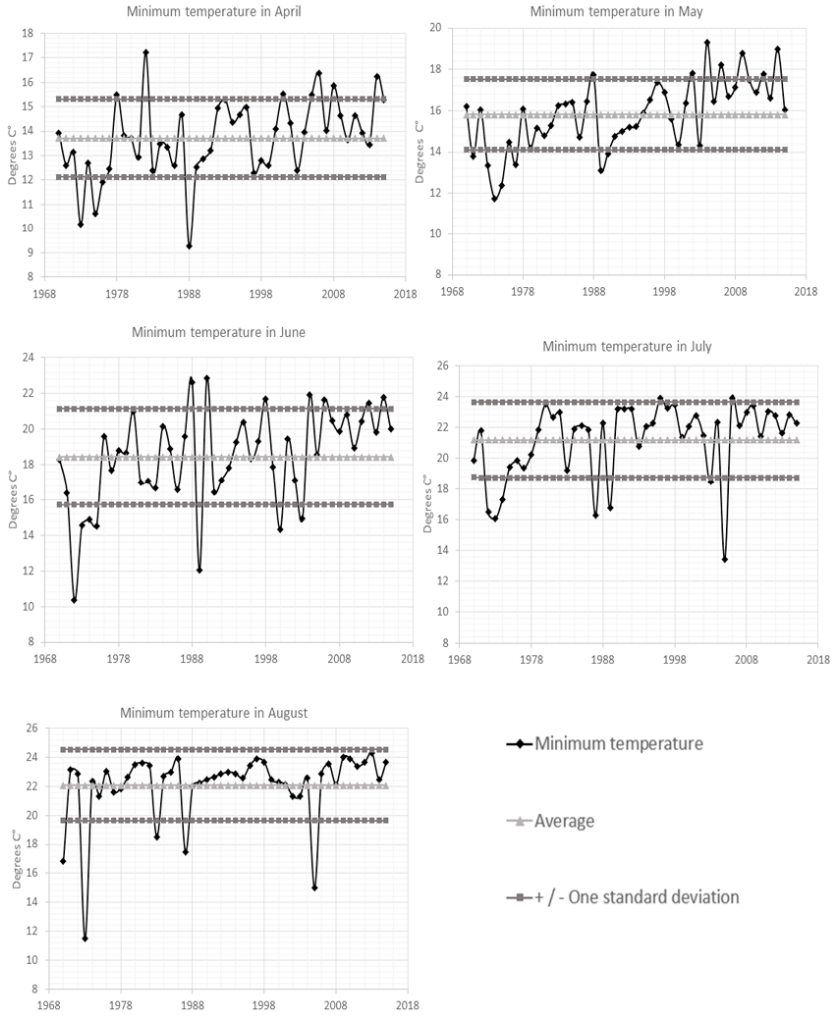

FIGURE 2.
Normalization of minimum temperature from April to August
Source: Laboratorio de Análisis Socioterritorial, UAMC.

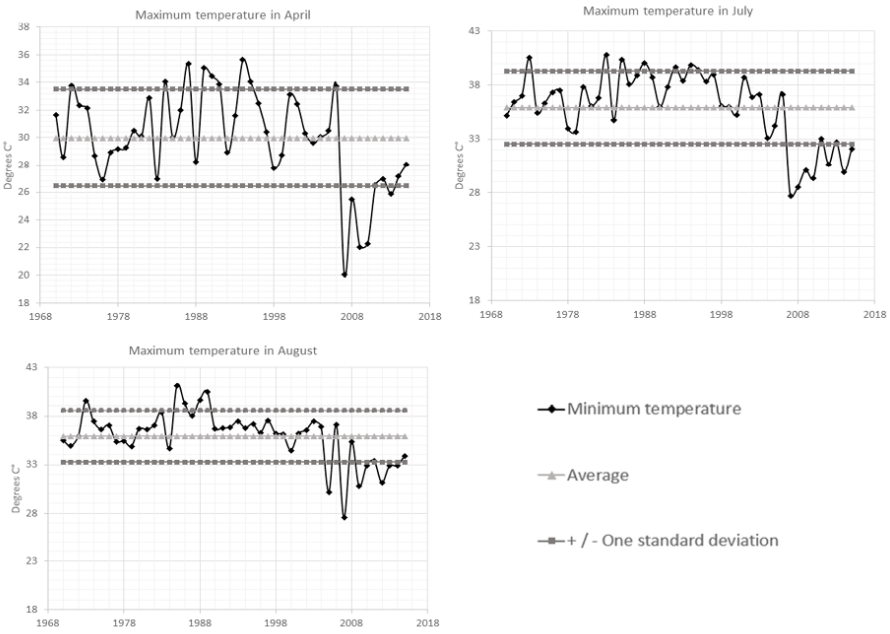

FIGURE 3.
Normalization of maximum temperature for April, July and August
Source: Laboratorio de Análisis Socioterritorial, UAMC.

These results show a partial coincidence between people's perception and climate data. In particular, the increase in minimum temperatures agrees with people's perception of a hotter climate. In our study it was important to analyze the vulnerability of the population to the impacts of climate change. That is why we tried to understand how people deal with hurricane risk, which was the nature of the event, its dynamic and the interrelation between various climate threats and their interaction with means of support. Moreover, it was important to point out the socio-demographic characteristics of inhabitants, their levels of marginalization and economic and social exclusion, as well as the perceptions of people themselves regarding this phenomenon.

Secondly, taking up the perceptions of the population regarding hydro-meteorological phenomena was an empirical tool to reflect on the construction of policies focused on the recovery and strengthening of traditional and local knowledge to cope with climate change. Our two workshops showed the importance of people's perceptions of climate change every month of the year and the way they deal with the consequences. It allowed us to observe the depth of knowledge and ability to deal with the danger of hurricanes. Situations of risk encourage the participation of the community in their neighborhood problems.

As in our case studies, the analysis of community perceptions about climate change showed us the meaning of making judgments about the physical and social environment in which learning, memory and symbolization intervene. Moreover, those perceptions revealed the qualitative characteristics of the objects or circumstances of the surroundings appreciated by the community, and the specific cultural and ideological systems, constructed and reconstructed by the social group that produced evidence based on reality.

Conclusions

This study shows the community's perception of climate variability. Likewise, there is a variety of sensitivity (vulnerability and exposure to hurricanes and floods) on the changes in the climate in both communities, and the forms of adaptation have been put into practice from the experience of the disaster and their cultural heritage. Both communities detect direct effects on health due to climate change, resulting in an increase in respiratory and vector diseases, a novel phenomenon related to floods and garbage.

The absence of the state in the solution once the catastrophe occurs is mentioned by both localities. Immediate answers do not solve the problem of a disorganized territory, lack of services and places that are not conducive to human settlements. However, after Odile and the lessons they have learned, the government began a series of preventive measures against hurricanes that have elicited positive reactions at the individual and community levels.

Both communities defend their property and their houses and adapt "spontaneous" solutions in the face of disaster. It is significant to note that communities' adaptation to climate change has to do with the knowledge they have acquired from the disaster, improvised measures designed to mitigate the damage. There is local recognition of the location of risk areas, but at the same time the lack of health services places them in a situation of high vulnerability.

The lack of social organization is a key factor when disaster strikes. In Esterito it was said that after the Odile hurricane, looting and violence occurred, whereas in Chametla there was a neighborhood organization that was able to create a series of practices to meet the needs of the community. In that respect, reinforcing governance implies the knowledge of social actors about their own resources that allow them to have local information to exercise deliberation processes in decision-making. A key point should be the promotion of cooperation between actors, negotiations between local governments and community actors to cope with the new risks posed by climate variability .

This study made it possible to recognize the perception of climate variability in two peri-urban communities exposed to constant hurricanes and floods, and paved the way to think about possible adaptation and mitigation solutions, where one of the main factors are the promotion of environmental governance and community empowerment. In this respect, our study shows how the combination of perceptions and hard data can not only establish community recognition of CC, how they cope with it and their adaptation capacities, but also the verification through data of the way climatic variability in the region is presented. This analysis opens up a range of possibilities, in which research-action plays a central role in the processes of adaptation. We should further explore local knowledge and community culture in the adaptation process as an important means of achieving results to deal with CC, and also to try new methodologies to improve best practices.

Acknowledgements

This research was financed by the SEMARNAT-2015-01-263102 (CONACYT/SEMARNAT) grant, for the project entitled "Análisis de la Vulnerabilidad y Resiliencia al Cambio Climático en Sistemas Socio-ecológicos Periurbanos". We are extremely appreciative of the time and consideration given to us by the residents of Esteritos and Chametla. Thanks are also due to Roberto Muñoz and Gabriela Cárdenas who conducted the workshops, to Antonina Ivanova, Yuma and Ian from the Universidad Autónoma de Baja California Sur, and the students who participated in the data collection.

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Notes

1 In Mexico a Declaration has legal status, because it is a federal government instrument.

Additional information

Dolores Molina Rosales: Editora Asociada