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Improving Coastal Urban Flood Risk Management in San Francisco de Campeche, México

Mejorando la Gestión del Riesgo por Inundaciones en Zonas Urbanas Costeras en San Francisco de Campeche, México

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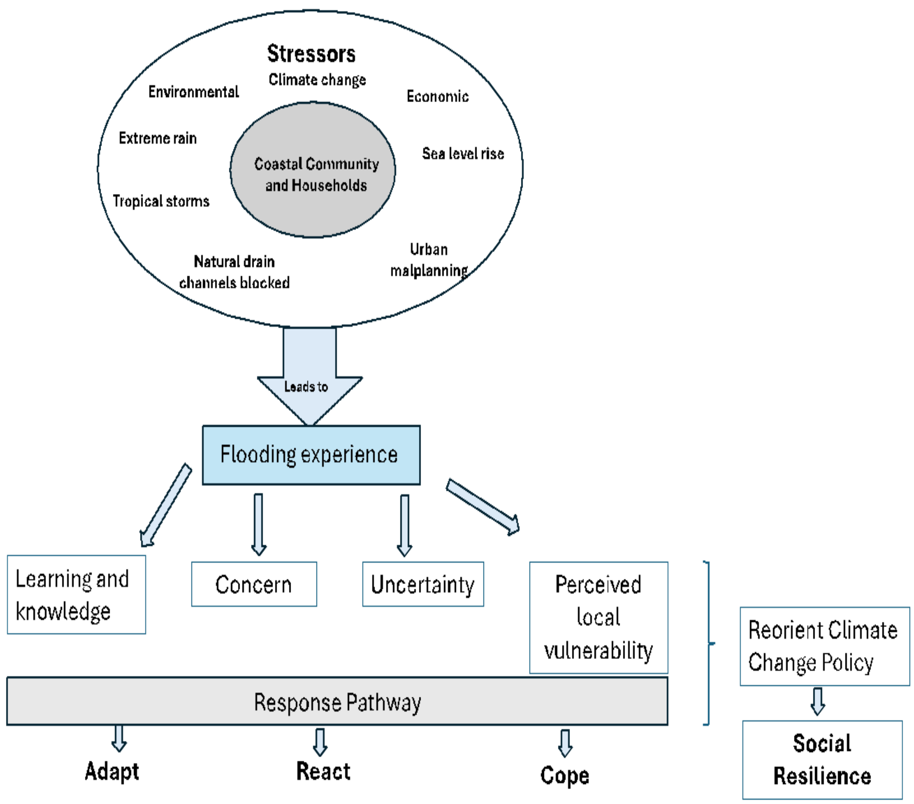
Abstract

The aim of this paper is to address people's perception and conduct facing related climate change effects, and how these will improve education, sensibilization, decision-making, and resilience in coastal zones. As a coastal city, San Francisco de Campeche, México (SFC) is innately vulnerable to the effects of climate change. Given this problem, life experiences, opinions, needs and proposal data collections provide a social diagnosis about how people perceive and act, when faced with climate adverse consequences, to enhance their resilience capacity. Our methodological approach used qualitative and quantitative methods to better understand people, the social systems' nature, and how those integrating factors play key roles in and have decisive influences over constantly changing quotidian life ways to transform those data into public policies and strategies that link environmental changes with social adaptation actions through applying 113 interviews. We also identified the floodable zones of SFC using literature and maps and a field guideline to describe each zone. Derived from those natural and cultural figures information we designed SFC's Action Climate Program (ACP). This agenda directly addresses "Climate Action" sustainable development's objective 13, target 3, by offering environmental education strategies and community collaboration and participation for design public policies and decision-making processes for coastal management resilience. We conclude that correctly implementing this program will improve people's capacity to respond and adapt to climate change effects. Moreover, active participation in decision making processes offers a second corollary to empower people to reduce risks that resolve nagging socio environmental issues in their coastal communities.

Graphical Abstract



1. Introduction

According to Aziz *et al.* (2024) coastal urban flood risk involves complex interactions between climate change, sea level rise and human-induced factors that require different strategies to cope with spatio-temporal evolution patterns. It is urgent to adopt integrated adaptive flood management mechanisms to mitigate evolving vulnerabilities. Rentschler *et al.* (2022) stated that by 2050, flood events will occur twice as frequently as today in 40 % of the world's coastal cities, which are especially vulnerable to flooding caused by the compounded effects of severe rainfall, seawater intrusion, storm surges and rising sea levels.

Moreover, considering the exponential increments in occurrence and severity of these incidents, it is urgent that effective mitigation strategies be implemented to deter losses and damages to society, infrastructure and disruption to the economy (de Koning & Filatova, 2020). Chen *et al.* (2023) considered that in order to accurately estimate and diminish risks, government interventions should consider the complex and dynamic relationship between different flooding drivers, such as climate change, urbanization, societal dynamics, and sea level rise.

Campeche's geographical location, topography, and socioeconomic characteristics enhance vulnerability to climate change (CC) (SEMARNAT & INECC, 2018). These three key features amplify disaster risk and marginalization and heighten hydrometeorological and climatic threats' direct impact on vulnerable populations, who suffer increased social, welfare, and resilience disadvantages from changes in their surroundings.

Target 3 of the "Climate Action" Sustainable Development Objective (SDO) 13 emphasizes improving education, sensitizing, and reinforcing human and institutional capacity to help mitigate and adapt to CC, actions which should lessen effects and early warnings. These findings coincide with Art. 6 of the U. N. Framework on Climate Change Convention (UNFCCC); Art. 12 of the Paris Agreement related to education, training, sensitization, and public participation for climate action; and the Sendai Framework for Reduction of Disasters Risks 2015-2030, Priority 1 "Understanding Disaster Risks". Target 3 SDO13 compliance could foster resilient communities and enable individual and collective action capacities' response to CC effects and other associated risks (Comisión Europea, 2020). This means that fostering a participatory planning framework to promote flood management practices which are socially inclusive and equitable will enhance governance and policy frameworks that are crucial for the successful implementation of coastal urban flood risk management plans (Aziz *et al.,* 2024).

SFC predominant climate is tropical sub-humid with precipitation during Summer with an average temperature of 27.1 ºC that may reach up to 45 ºC (Rivera-Arriaga *et al.*, 2020). Precipitation may reach 1965.9 mm, concentrated between June-September annual rainy season (Rivera-Arriaga, *et al.*, 2020; Mangas, 2018). Weather-related risks include 31 registered hurricanes from 1970 to 2018, whose excessive precipitation levels caused coastal urban area flooding (Cabrera & Audefroy, 2019).

Campeche's geological substrate and geographical location are prime factors affecting flood behavior; geological uplifted sectors create uneven karstic clay residual pocket substrata that inhibit rainwater filtration (Palacio, 2013).

Despite designing both a long-term CC Action Program (2015-2030) and a Natural Hazards Atlas, Campeche's prevention plans still require greater advances in environmental education curricula, training and risk management agendas. Significant individual or collective social change and response schedules also lag current and future climatic scenarios. These trends may result from overly cognitive design rather than a more social participative focus that encourages reflection, appropriation, and motivation (González-Gaudiano & Cartea, 2020).

Extreme rain events regularly inundated SFC city, particularly those associated with torrential seasonal rain and hurricanes (Palacio *et al.*, 2005; Rivera-Arriaga *et al.*, 2020). Floods not only create a socio environmental new normal, but also damage city infrastructure and residential areas. The SDO13 Target 3 proposal's objective is to motivate SFC residents and local governmental agencies to undertake responsible and conscious policies and strategies, according to their possibilities, needs, and priorities, to resolve socio environmental trends and mitigate future CC problems. Therefore, through this investigation we seek to answer the research questions: Do local people are aware of climate change events? Do past flooding experiences have taught them anything? What has changed in their surrounding environment? How are government actions protecting them from climate change events? What can they do to improve their adaptation capacity to vulnerability? The main objective of this paper is to address people's perception and conduct facing related climate change effects, and how these will improve education, sensibilization, and resilience capacity in coastal zones.

2. Theoretical framework

Complex system theory envisions social structures as multidimensional organizations (Sierra, 2003), in which the individual and collective whole are connected in various levels. Any complex system integrates physical, biological, social, economic, and political chaos, uncertainty, and self-determined aspects (Sierra, 2003; García, 2006; Lara-Rosano, 2017).

We considered an interdisciplinary investigation team that incorporates three aspects:

- The source of a complex system's hindrance should avoid a simple situational justification or innate phenomenological juxtaposition.
- The conceptual framework must eschew theoretical baggage to identify, select and organize data.
- Domains incorporated within a complex system should address each part's particular requirements.

Optimum results will incorporate key answers derived from those prerequisites. A flexible, integrated diagnosis provides a roadmap from which to propose actions that evolve and adjust to consequences over time.

Complex system theory guides social diagnoses development of perceived CC, those measures that people take to mitigate flooding, how institutions address socio environmental problems, as well as what equipment, infrastructures, and the effectiveness of these that SFC city requires (Sierra, 2003). A complex system paradigm can discern a problem's diverse distress factors (figure 1).

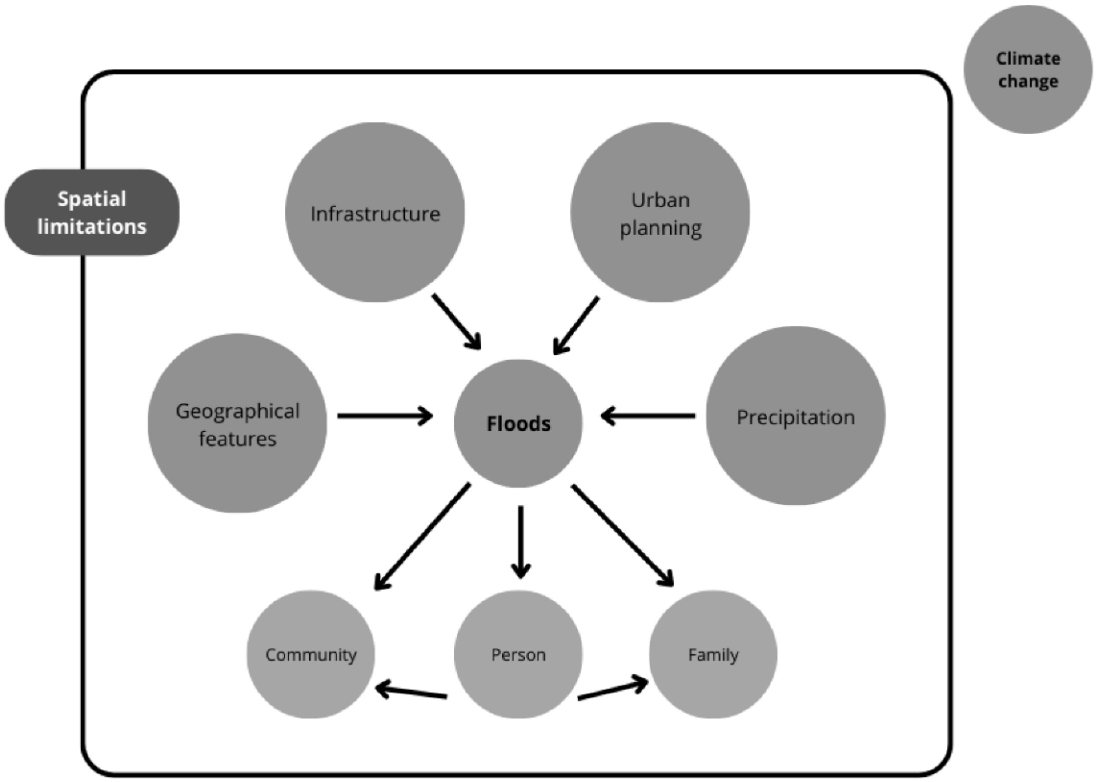


Figure 1. Complex system on flooding problematic.

3. Methodology

Our main research objective is to better understand people, the social systems' nature, and how those integrating factors play key roles in and have decisive influences over constantly changing quotidian life ways to transform those data into public policies and strategies that link environmental changes with social adaptation actions.

First, we made a literature review using Google Scholar with key words. Then, through urban fieldwork we located sixteen severe inundation areas using processed data from the Hydrology Laboratory at EPOMEX Institute. Next, observed damaged environmental situations or phenomena generated by human intervention comprise a social diagnosis, and constitute a research reality (García, 2006). Specific polygons, derived from the 2016 National Housing Inventory (INEGI, 2016), also provided an objective design model to conduct 113 field questionnaires and interviews. In addition to location, we collected data on housing construction types and material characteristics; as well as landscapes yards with vegetation, since these also can condition security and risk thresholds (Mardones & Vidal, 2001; Ferrando, 2002; Sepúlveda *et al.,* 2006 in Lagos, Cisternas and Mardones, 2008; Rouleau *et al.,* 2022). We also collected data about demographics in each polygon and per house, to identify vulnerable people. We analyzed collected data using descriptive statistics and designed a socio-environmental reference system per polygon that offered three different scenarios and systemic interactions. We were able to reconstruct the flood events history of the city from 2017 to 2019 and their cause. Perception analysis and auto-adaptation taken from collected data were key to understanding how people consider climate change, their role and response, and therefore, their decision-making.

Finally, we tailored a plan based on all those results to promote community participation, cohesion and social action strategies; and at the same time, we included strategies to include social information networks, capacity building, and empowerment action programs to mitigate climate change elements and strengthen adaptive capacities by adopting more sustainable options in daily life.

We used the SWOT analysis to obtain information on socio-environmental systems in each polygon. First, we identified the variables that influenced the design and intervention proposal. These variables were grouped into four categories: Strengths, weaknesses, opportunities, and threats. We grant to each variable a value related to the impact probability, where 1 represents low, 2 medium, and 3 high. This was to identify the system conditions, prevent impacts and establish action forecasts (Ramírez, 2009). For the second analysis we compared strengths, opportunities, weaknesses, and threats per influence area. We took the 12 variables of each table as a reference. A media of 6 was established to determine if there was a higher or lower number of variables per category. To facilitate the analysis a map was elaborated that shows if there were a higher or lower number of variables per category in comparison to the 15 influence areas identified earlier (Appendix A).

Study area

Epomex created a map illustrating floodable zones in SFC (Palacio *et al.*, 2005; Mangas, 2018). The chart shows seven flood zone categories: general data, delimited territory, urban services, commercial areas, urban image, public spaces, and floodable streets. Next, we surveyed all exposed residential neighborhoods in this chart.

We identify the floodable zones of SFC using literature and a map (Palacio *et al.*, 2005; Mangas, 2018). An observation guide was designed with seven categories: general data, territorial delimitation, urban services, commerce, urban image, public spaces, and identified floodable streets. It was used while on the route within each neighborhood covering the marked zones in figure 2.

Urban fieldwork located the following sixteen severe inundation areas: Cuatro caminos, Héroes de Nacozari, Infonavit Justo Sierra Méndez, Siglo XXI, Ciudad Concordia, Fraccionamiento El Fénix, Unidad y Trabajo, Solidaridad Nacional, Ah Kim Pech, Centro, Barrio de Guadalupe, Barrio de Santa Ana, Flor de Limón, Las Flores, Fracciorama 2000, and Samulá.

Next, observed damaged environmental situations generated by human intervention comprise a social diagnosis, and constitute a research reality (García, 2006) Ten-step approach guided this diagnosis, which includes flooding events noted in specialized literature, electronic information, and newspaper reports. An extensive, open and closed-inquiry questionnaire format also added general data, response parameters, family background, perception, personal adaptation, mitigation, and active participation aspects.

Specific polygons, derived from the 2016 National Housing Inventory (INEGI, 2016), also provided an objective design model to conduct field questionnaires. Our results supplied ample population data by age, house frequencies, and public services for each polygon. A simple random sample used the following formulas (FCA, s/f):

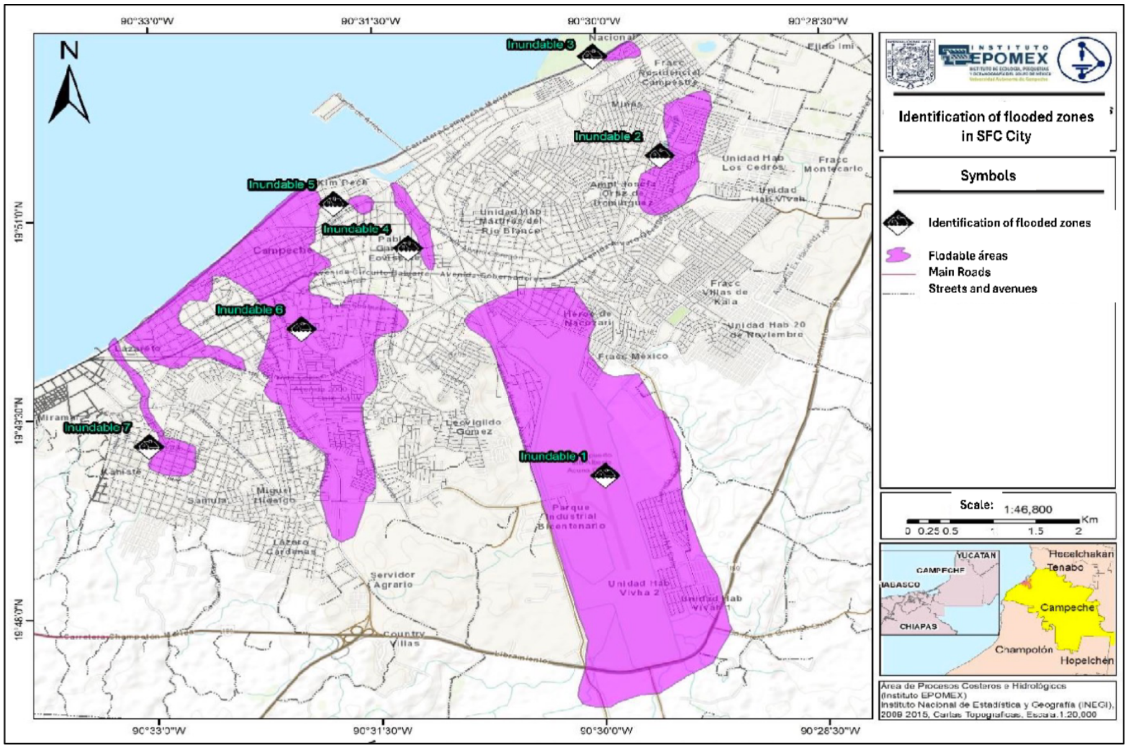


Figure 2. San Francisco de Campeche urban flood zones.
(Source: Coastal and Hydrological Processes Laboratory, EPOMEX Institute).

$\eta_{\circ}$ = z^2 (pq)/e^2 (1)

Where:

$\eta_{\circ}$ = Sample Size

z^2 = Confidence Level

pq = Variance Proportion

e^2 = Margin Error

An adjusted 25032 sized population sample provided a 95 % degree of confidence.

n' = $\eta_{\circ}$ / 1+ ($\eta_{\circ}$–1) / N (2)

Where:

n' = n adjusted

$\eta_{\circ}$ = size of the sample

N = size of the population

Level of confidence was 95%

1- ∝=95%

Where:

z = 1.96, in a normal distribution table.

A 5% error probability, denoted as e = 5, represents relative values: e = 0.05

A 0.5 assigned *p* value shows the proportion.

pq obtained through the following operation:

Pq = 1

q = 1 – p

q = 1 – 0.5 = 0.5

Random sample result values:

$\eta_{\circ}$=(1.96)^2(0.5)(0.5)/(0.5)^2

$\eta_{\circ}$ = 384

Adjusted population size values:

n' = 384/1 + (384 – 1)/25,032

n' = 379

Snowball-method sampling in ten pilot interview surveys found response similarities. According to Founded Theory in 1960, no data variation promotes a saturation point that deters process feedback and theoretical sampling (Ardila & Rueda, 2013). Therefore, to avoid possible problems with survey interviews, a 30 % sample reduction gave an optimal 113 questionnaires, which were processed in Microsoft Office Excel.

Project proposal design

Influence areas descriptions, illustrate project context, subject, and objective. However, proposal viability required a strengths, opportunities, weaknesses, and threats analysis (SWOT) to assess positive or negative impacts on different plan phases (see Appendix A).

The "Climate Social Action Program for San Francisco de Campeche" Project's objective is to foment the SDO 13, through environmental education and community collaboration strategies (see Appendix B).

Housing and residential area characteristics

Urban spawl has filled in wetland areas, disrupted natural drainage systems, enclosed the principal north – south drainage channel, La Ría, and has paved hillsides. Current extreme rainfall events due to CC have increased the population's vulnerability (Vega *et al.*, 2013; Rivera-Arriaga *et al.*, 2020).

The city's serious flooding events impact houses built in risk zones. In addition to location, housing construction types and material characteristics also can condition security and risk thresholds (Lagos *et al.*, 2008). Residential damage levels covary with maximum flooding depths, built landscapes, and construction types (Lagos *et al.*, 2008).

4. Results

While SFC's historic downtown sector is a popular World Heritage tourism destination, a scenic waterfront makes it vulnerable to recurring meteorological events. Those who reside near the coastal zone, surrounded by karstic hillocks, frequently are inundated. Uneven urban growth sectors, downtown gentrification and depopulation, and concentrated economic hubs create other problematic factors for the city (Cabrera & Audefroy, 2019). The study area presents sixteen neighborhoods (figure 3) with severe flooding problems due to seasonal downpour events.

Social synopsis for diagnosing obstacles

A human-environmental relationship questionnaire provides social parameters to diagnose how to create affordable housing options (Tello, 2008). Results offered three different scenarios and the systemic interactions considered within each one (figure 6).

Social contexts, representation, meaning, personal, group, and community expressions among vulnerable populations are key analytical data to understand, and conceive social systems resilience capacities.

We interviewed mature adults: 50-59 years old (36%), followed by older adults over 70 years old (21%), and 15% between 60-69 years old. Females comprised 72% and males 28%. Education levels include 28% with elementary school, 15% intermediate school, 26% high school; 23% university and only 3% had postgraduate studies.

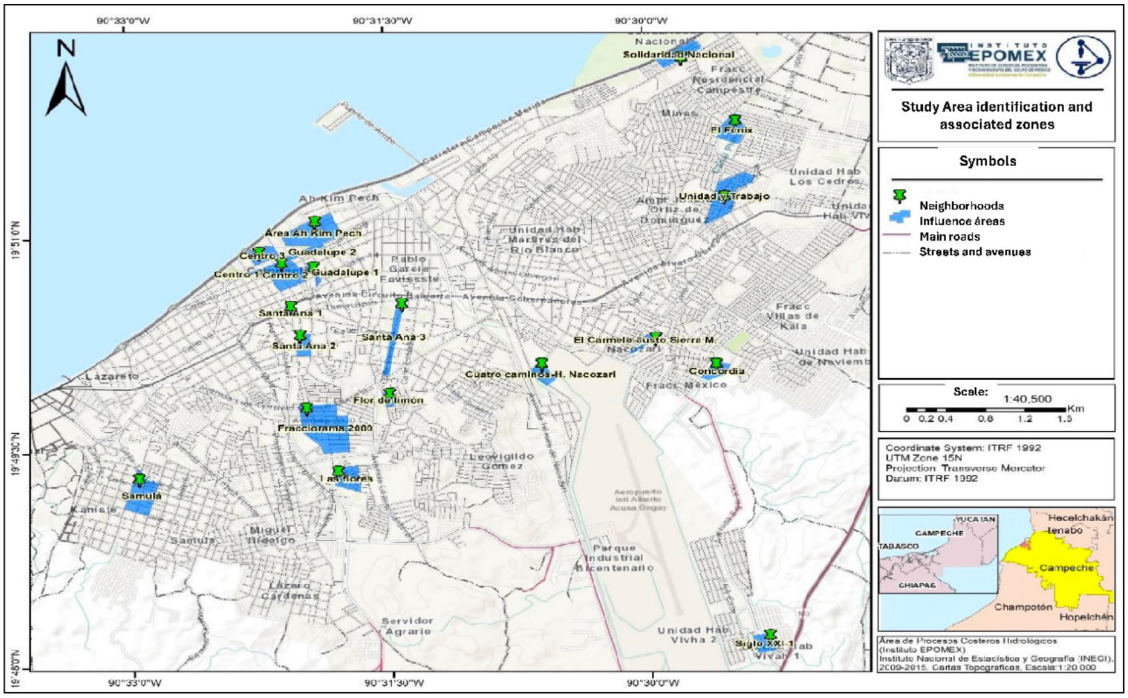


Figure 3. Flood zones and associated areas in SFC.

Social representation on CC

Human perception not only establishes a relationship between objects and events physically removed from us (Day, 1981), but also portrays inner states and self-induced activity (Mejía *et al.*, 2001).

A recent SFC precipitation hydrological analysis found continuous rainy days increments above 40, 50, and 60mm thresholds per year (Rivera-Arriaga *et al.*, 2020). While annual precipitation totals (1043.8 mm/year) have not changed from 1952 to 2015, the number of days with extreme precipitation did. 44% informants observed shifts, 41% did not, and 15% view precipitation quantities as unchanged.

Some have 30 years of memories on the number of times that their houses have been flooded (table 1).

31% of water height inside houses was between 40-59 cm; 28% reached 10-19 cm and 20-39 cm. Among only 6% did flooding reach 80 cm. Flooding lasted about 30 minutes. To assess social and economic impacts from floods, families lost furniture (35%), electrical items (20%), personal documents (7%), photographs (4%), and 18% lost their vehicles.

Risk, or change situations caused by environmental or social factors, trigger diverse behavior or emotions (Páez *et al.*, 2001). Those situations alter daily routine and break one's sense of security due to physical, affective, employment, housing, recreation, and socio-cultural integrity loss. They also form how people perceive CC and channel answers and actions to deal with collateral problems (Cruz Roja Colombiana, 2007). Extreme rainfall events evoke some of the following emotions: (33%) fear that their house will flood (22%); sadness, distress, and a heightened

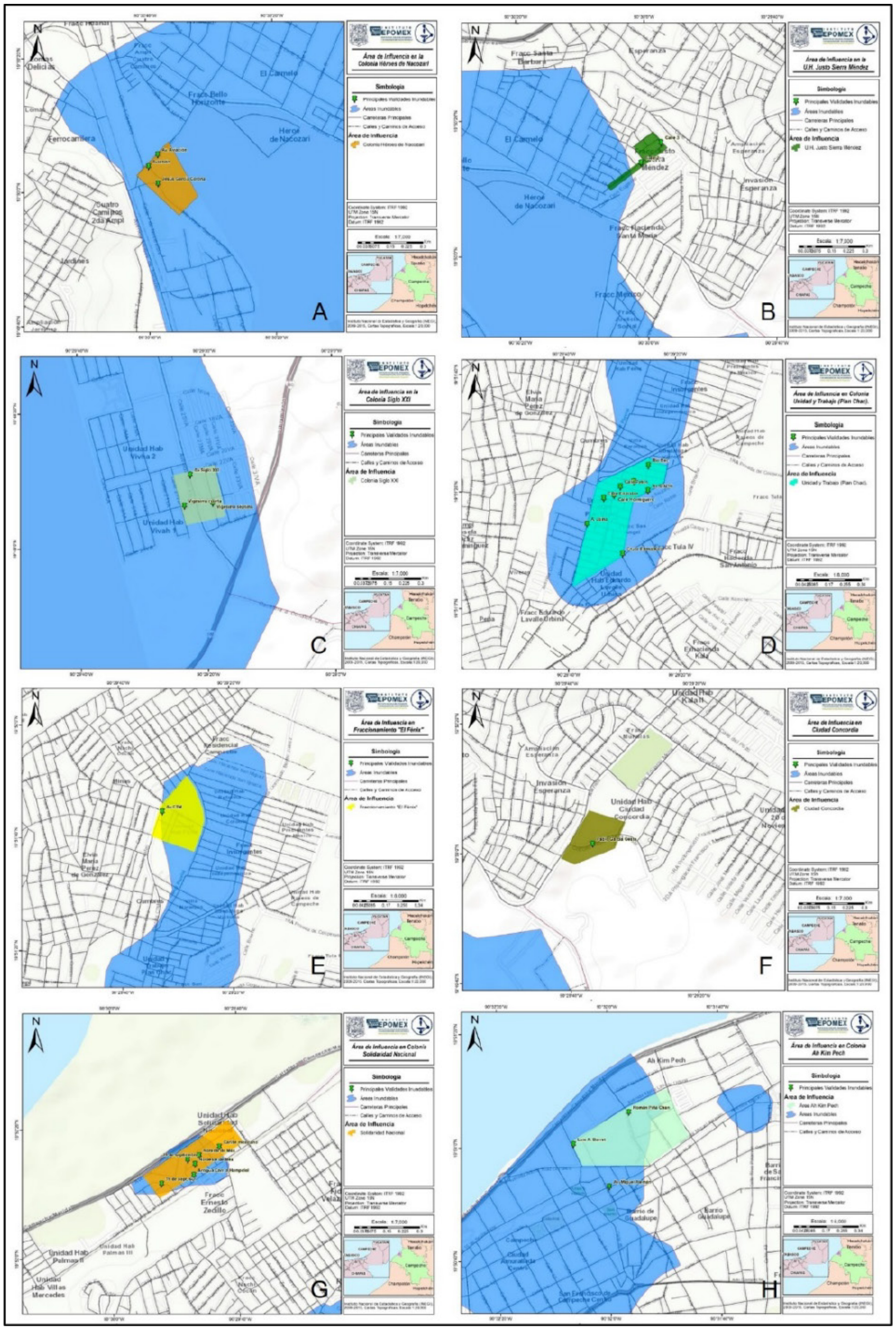


Figure 4. A) Flooded zone at Héroes de Nacozari. B) Flooded zone at Justo Sierra Méndez. C) Flooded zone at Siglo XXI. D) Flooded zone at Ciudad Concordia. E) Flooded zone at El Fenix. F) Flooded zone at Plan Chac. Map 9. Flooded zone at Solidaridad Nacional. Map 10. Flooded zone at Ah Kim Pech.

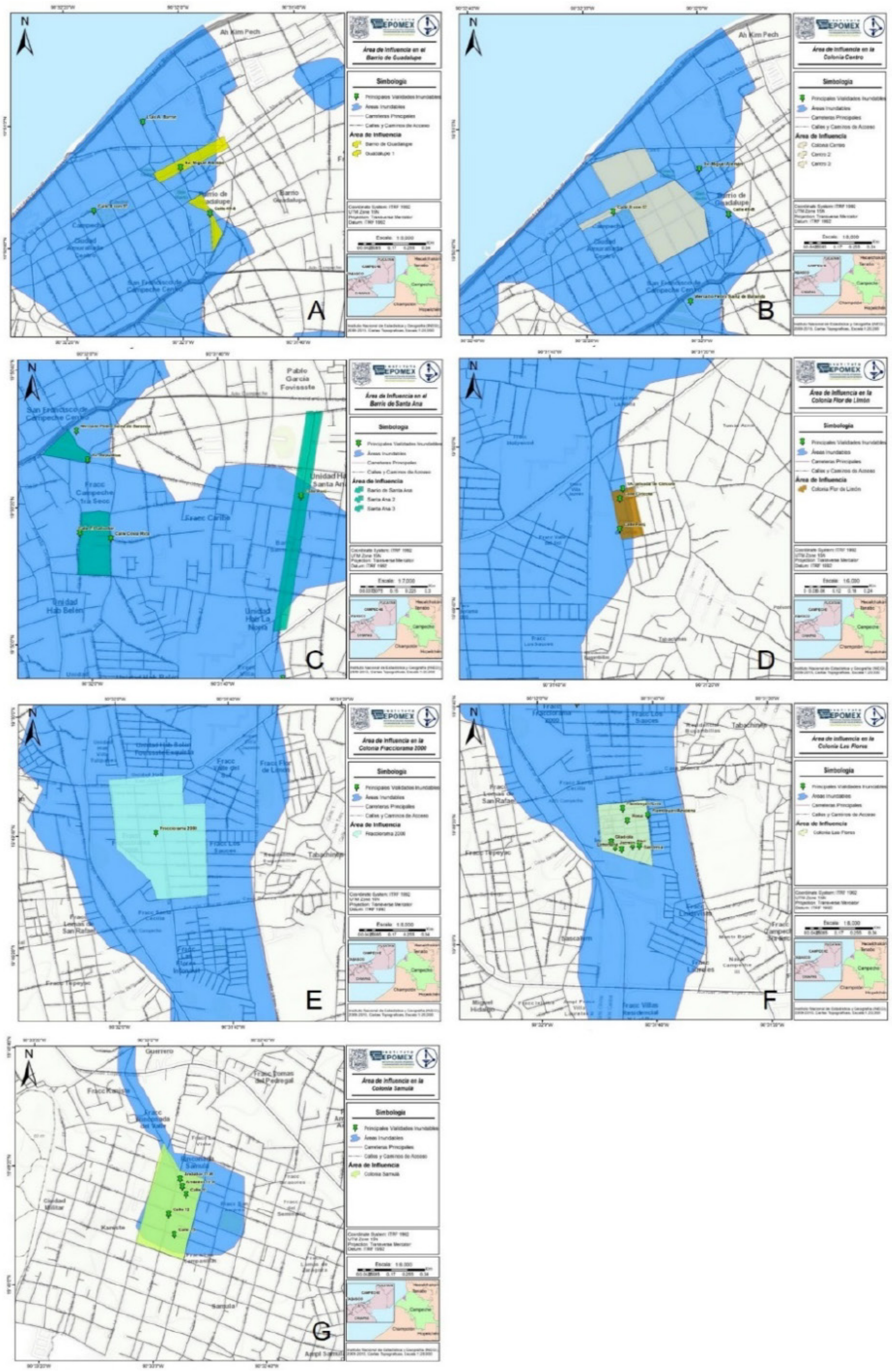


Figure 5. A) Flooded zone at Barrio de Guadalupe. B) Flooded zone at Historic Downtown. C) Flooded zone at Barrio Santa Ana. D). Flooded zone at Flor de Limón. E) Flooded zone at Fracciorama 2000. F) Flooded zone at Las Flores. G) Flooded zone at Samulá.

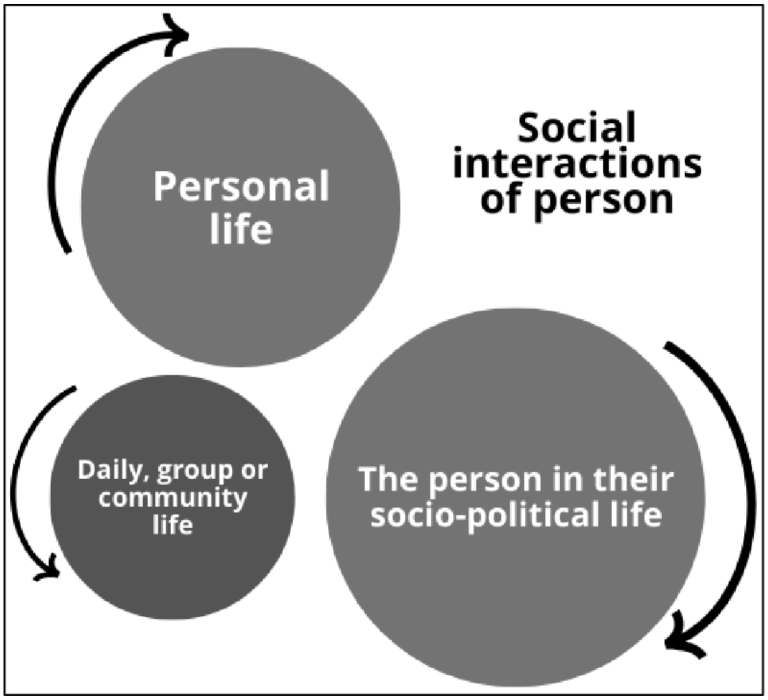


Figure 6. Systemic interactions analyzed in the social diagnosis that result in three different scenarios and systemic interactions (Source: Modified from Tello (2008)).

Table 1. Climatic event that flooded houses in the period 2017-2019: 41% of houses flooded more than six times, 21% from three to five times; 15% one or two times, and 13% never flooded.

Year	Month	Climatic Event	Affected Neighborhood
2017	June	Tropical depression Calvin	Flor de Limón, Solidaridad Nacional, Unidad y Trabajo
2017	August	Tropical storm Franklin	Unidad y Trabajo, Flor de Limón, Solidaridad Nacional, Las Flores, U.H. Justo Sierra Méndez, Cuatro Caminos
2018	June	Tropical Wave No.5	Unidad y Trabajo, Flor de Limón, Las Flores, U.H. Justo Sierra Méndez
2018	July	Tropical Wave No.13	Solidaridad Nacional, Unidad y Trabajo
2018	August	Tropical Wave No. 28	Flor de Limón, Solidaridad Nacional, U.H. Justo Sierra Méndez, Cuatro Caminos
2019	May	Strong Rains	Cuatro Caminos, Flor de Limón
2019	August	Tropical Wave No.39	Flor de Limón, Las Flores, Solidaridad Nacional, U.H. Justo Sierra Méndez, Cuatro Caminos
2019	October	Tropical Wave No. 44	U.H. Justo Sierra Méndez, Cuatro Caminos
2019	November	Strong Rains	Flor de Limón, U.H. Justo Sierra Méndez

sense of alert (14%); anger and stress (8%). When standing water begins to appear in their street, some people place items on tables, chairs, or on the top of anything 50 cm or higher (stoves, refrigerators, cupboards, etc.) to prevent damage and loss. These emotions should require governments to develop psychosocial intervention models to assist people before and after extreme weather events (Cruz Roja Colombiana, 2007; Ortiz y García, without date).

Flooding collateral damage also provokes illness (IPCC 2007). Morbidity and mortality rise as do floodings provoke behavioral changes to vector transmitted illness. These specifically affect vulnerable populations (figure 7) (COFEPRIS, 2017).

Informants (23%) stated that during the floods they suffered from diarrhea, flu, cough, allergies, headaches, fainting and rash.

SFC's Civil Protection Agency provides adequate temporary shelters for people due to floods. However, most individuals tend to stay home (69%) to protect their belongings, and 18% sheltered with family in another part of the city.

People create value, those values also express beliefs, interests, feelings, convictions, attitudes, judgments, and actions, thus, each one constructs "reality" (Fragoso, 2006). Therefore, individual perception produces value and an importance level from 0 to 5, where 0 is the lowest value, and 5 the highest. 85% gave a 5, and 15% a 0.

Interactions between natural or anthropogenic threat and social vulnerability conditions create flood risk perceptions (Smith, 2007; Sierra, 2003). Nevertheless, these authors said that this risk concept is also modulated by social perception that exists about

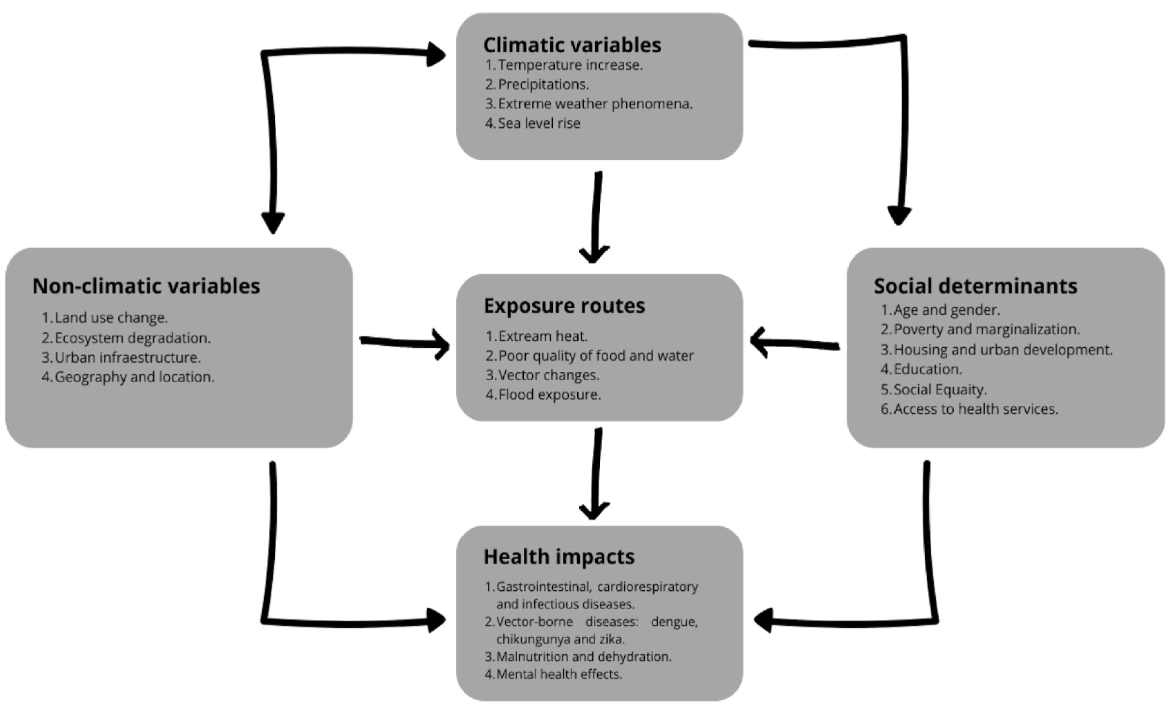


Figure 7. Climatic variables, exposure paths, and social determinants that might influence health within a climate change scenario for SFC.

it. This notion is forged by intuitive judgements that individuals or groups make, using limited or ambiguous information from prior experience, knowledge, emotions, culture, mass media, and political and social contexts (Lara San Martín, 2013; SSPC & CENAPRED, 2019). SFC vulnerable zone inhabitants relate risk causes with inefficient drainage and sewage as the main causes of neighborhood flooding (29%); street trash and blocked drainage systems are the second perceived cause (25%); and poor urban planning when building residential units with insufficient drainage systems (11%).

Table 2 summarizes scenarios with perceptions. These perceptions do not reflect cause and effect between flooding and CC, are mainly because the population have not related yet floodings with CC as part of their current and future context, do not conceive one's own responsibility in the problem, or just assume the causes to be administrative, political, social, or cultural factors. Apparently, understanding the city's geographic setting also fails to play a role in this problem. Finally, while CC is not the sole causal factor, it continues to influence natural risk increments.

Auto adaptation measures for CC

In SFC individuals and families auto adapt as a survival concept that comes from different measures and actions that everyone adopts to become more resilient to CC and its effects. In Concordia and Flor de Limón, 50% residents have built barriers in their houses' doorways to prevent water filtration, and heights vary from 40cm to 1.10m. But in Samulá, Fracciorama 2000 and Guadalupe, modified house designs by elevating driveways and floors by 50 cm to 1 m (14%), others built a second story, and 51% will not modify their house or move. Reasons revolve around a sense of belonging, becoming accustomed to risk, having had special moments there, and special histories with people or their things. However, 49% of informants said that they would like to move to a higher area in the city or even to somewhere else.

Table 2. San Francisco de Campeche flooding risk scenarios: 56% thought it would be worse, 21% considered it will continue the same, and 18% said the situation will improve.

Worse scenario	Better scenario	As usual scenario
Precipitation increases	Government will improve pluvial drainage systems	Floodings are part of the neighborhood and our life
Greater numbers of extreme weather events (hurricanes and severe rainstorms)	Authorities will provide positive solutions	When it rains, we will continue to flood
Insufficient/inefficient drainage systems.		Authorities' inattention will not resolve the problem
Population increases		

5. Discussion

In poor coastal states in Mexico, such as Campeche climate change, old settlements, rapid and unplanned urban growth, poor institutional capacity, funding issues worsen the risk of floods; therefore, it is imperative to address the necessity for tailoring an urban flood risk management plan and the strengthening of societal and institutional capacities to mitigate flooding risks (Satour *et al.,* 2021). Moreover, it is urgent to fully understand the consequences of future climate change on urban coastal zones. It is also key to address risk management through a transdisciplinary and integrated adaptation strategy in coastal cities to manage the growing risk of flooding (Cioffi *et al.,* 2022, Hirabayashi *et al.,* 2013, Kumar *et al.,* 2022).

Results from this research showed that people perceived that insufficient provision of flood mitigation infrastructure, government lack of attention, and the continued growth of urban areas exacerbate the hazards of flooding, particularly in certain polygons within SFC (Iqbal *et al.,* 2023, Safabakhshpachehkenari and Tonooka, 2024). The front coastline in SFC is reclaimed land, which is highly susceptible to storm surges and rising sea levels, making it necessary to employ a combination of engineering structures and nature-based solutions to enhance resilience in their socio-economic systems (Loizidou *et al.,* 2024).

Risks associated with climate change increase if they are combined with vulnerability and social inequality conditions. However, these risks can be reduced with adequate efforts, such as those oriented to education, training, sensitization and participation to strengthen population adaptation capacities, the social fabric and governance conditions (Comisión Europea, 2020).

According to the World Bank, in 2023 most of the planet experienced more intense rainfall and catastrophic flooding and damage. A quarter of the world's population (1.8 billion people) is directly exposed to substantial flood risk: 90% live in low and middle-income countries and 40% are poor or extremely poor. The municipality of Campeche where SFC is located has 32.5% people in poverty, 27.8% in moderated poverty, and 4.7% in extreme poverty, being very vulnerable to floods (CONEVAL 2020). Coastal communities, particularly in Campeche, face increased risks due to socio-economic vulnerabilities such as poor infrastructure, low economic resilience and high dependence on natural resources for livelihoods (Kirezci *et al.,* 2023). To Aziz *et al.* (2024) equity and social justice considerations in flood risk management are crucial to ensuring that vulnerable groups such as low-income households, impaired people, and the elderly population are adequately considered, protected and supported.

In SFC unplanned urbanization and population growth, along with climate change, exacerbate the risk of urban flooding in several neighborhoods of the city. Underlining this point, it is the fact that populations in flood prone polygons, such as in SFC-is predicted to increase by 25% by 2050 (Aziz *et al.,* 2024). SFC is growing without considering the natural watersheds and low lands within the city, resulting in significant impacts on the hydrological cycle and exacerbating flooding in those zones. Impermeable surfaces like highways, streets and avenues, malls, and parking lots reduce natural infiltration, leading to higher peak flood flows and increased runoff volumes. Aziz *et al.* (2024) considered that this issue is especially problematic in coastal cities, "*where the ability of natural drainage systems to function properly is already impacted due to low-lying terrain, submerged outfalls, rising sea levels and climate-related catastrophes such as cyclones and hurricanes*".

A very important challenge in SFC is the land use development policy that does not consider to control urbanization in low-lying coastal areas, and there are also illegal settlements that cause social pressure on local governments to provide them with public services. Both issues rise to inadequate drainage systems and further exacerbates flood risk (Sangsefidi *et al.,* 2023). Socio-economic development scenarios ought to consider

inequalities, since flood impacts are often unevenly distributed and disproportionately affect poor neighborhoods in SFC that have fewer resources for recovery and adaptation.

In Latin America, there are a number of colonial coastal cities that lack water and sewage pipelines. These coastal cities -such as SFC- have aging flood mitigation infrastructure that was not designed to mitigate the projected flood risks caused by climate change and rising sea levels. From 2010 to 2015 the state government built part of a rain water pipeline system to enhance the capacity of older drainage systems within the city to increase water flow. Unfortunately this measure was not enough for present and future flood scenarios.

An advantage of the State of Campeche is the climate change public policy instruments, such as the State Action Program of Climate Change: 2015-2030, the State Law of Environmental Education (2020), and the State Law of Climate Change (2020). The presence of these instruments grants legal certainty to actions facing the climatic crisis, and the continuous generation of scientific knowledge from the state research institutions related to risks assessment, and vulnerability analysis to hydrometeorological events, that contribute to decision making in reducing climate change effects.

Despite the fact of legal instruments and scientific research, a large part of the population has not been sensitized nor informed about the causes and consequences of climate change. This represents a problem, because if the aim is to achieve significant changes in impact reductions, the population should commit to undertake actions that increase their resilience capabilities, participate in generating solutions and participate in the decision-making processes. Getirana et al. (2023) considered that an effective management of the flood risks caused by rising sea levels, extreme rains, and more intense storm events in coastal cities requires the combination of scientific knowledge, technical progress, actualized legal framework, institutional capacities, and participative and proactive planning.

Cabrera Sánchez & Audefroy (2019) mention that the population's response and resilience installed capacity depend on the economic and social circumstances but the way people respond to risk situations would also depend on knowledge, experiences, and climatic individual histories. It is through the collective memory that communities can respond to events that damage their environment. The design of the social intervention proposal also derived from the SFC's population experiences that have lived through several hydrometeorological events.

It is important to highlight that in the social diagnosis, the interviewed population did not mention climate change as the cause of floodings, but they perceived a rise in precipitations and temperature, hence the concept appropriation of climate change, causes, effects, and individual's responsibility to the problem is a fundamental topic that should be address. Climate change is a complex topic, and to transmit it to the public requires methods that encourage critical thinking, comprehension, and change of conduct. Therefore, foment environmental education in the State of Campeche will be the beginning of the climatic transition path, sustainable, and respectful with the environment. The importance of public perception and awareness in managing risks and learning adaptation strategies is important, as it is influenced by prior experiences, satisfaction with infrastructure services, and getting used to those events as part of their lives; all these factors impact community readiness and trust in authorities (Xu *et al.,* 2024).

Community intervention proposed plan, seek to unchained changing processes, recover population's knowledge, link theory with action and convert knowledge in transformative actions (Jara 2018). Transformative actions derived from education, training, sensitization, and social participation would mean a fundamental input for climatic governance, since the construction of climatic solutions is a complex process at global scale that involves all levels and social sectors. This requires policies that prioritize vulnerable populations and allocate resources to address existing inequities. Participatory flood risk management plan requires a holistic and integrated strategy that joins local people's knowledge and experiences, decision-makers and academia, and uses innovative modeling techniques to develop flexible, context-specific flood risk measures and adaptation strategies (Awah *et al.,* 2024). Moon *et al.* (2017) considered that *community engagement through open dialogue, transparent decision-making, and collaborative planning is crucial to promote inclusive governance*, *ensuring flood risk management measures are scientifically robust, widely embraced, and ultimately more resilient and sustainable.*

In accordance with Gutiérrez-Barba *et al.* (2010), in any climate change scenario it is necessary to acquire knowledge, attitudes, abilities, and proper conduct for early preparation and adaptation to climate change effects. Education is key for a resilient, sustainable, and respectful future for the environment. In addition, a lack of public participation and commitment to force decision-makers to design participative opportunities and new risk management and adaptation management plans, can lead to delays and failures in implementing flood vulnerability management and resilience-building initiatives (Aziz *et al.,* 2024). The absence of a link among community-decision-makers-science can significantly hinder progress, leaving vulnerable communities exposed to the increasing risks of flooding (Takin *et al.,* 2023). Without strong societal backing, political efforts to address flood risks often disappear or have prolonged delays, conveying inadequate preparedness and response to flooding events.

In SFC, community empowerment would represent an opportunity to increase inhabitant's resilience facing risks that impact their welfare. Since more than a decade ago, there have been efforts to improve the city's vulnerability to climate change effects. This is the first research based in the people's knowledge and perception that grants a proposal of social intervention to solve the current socio environmental problems and increment capacities and responses for future changes.

Results reveal greater opportunities for public interest in generating CC mitigation initiatives and favor people's capacity for adaptation in addition to reducing local disaster risks, this suggests that intervention proposal program development can generate greater positive factors (Ramírez, 2009).

We found that though people did not equate CC with major flood causation, their perception, cause, effect, and individual responsibility are fundamental topics to address. Environmental educational programs promise a new path to a more sustainable CC transition through enhanced awareness that will unlock CC processes through people's collective history to transform that shared memory into transformative action (Jara, 2018). In order to effectively communicate complex scientific findings and risk assessments to society and policymakers implies a significant challenge. We need to address this issue involving educational ministers, communication experts and social media experts to be able to simplify data presentations and improve people's and policy makers' engagement in order to enhance understanding and drive informed decision-making (Aziz *et al.,* 2024).

Community empowerment in SFC would enhance inhabitants' resilience to menaces that impact social well-being. Research to improve vulnerability to CC effects over the last decade had yet to consider knowledge and perception in a proposal to resolve current socio environmental problems, and increment people's ability to respond to those consequences. However, the government should be included in the decision-making process. Aziz *et al.* (2024) recommends that to bridge this communication gap between people with the government, it is key *to develop clear, accessible, and actionable communication strategies such as participatory planning approaches that convey the equity, urgency and importance of risk management and resilience*.

Efficient and effective actions foster participation processes, and climate decision-making policies are highly sensitive to vulnerable peoples' interest, perception, and basic human rights (UNFCCC). Our research is a big step forward to bridging SFC's environmental, social, physical, and community vulnerability. Personal experiences and local lessons learned aid in predicting future CC consequences, to reorient public policy for greater social wellbeing. It is important to create a more inclusive preventative culture to foment citizen participation in local government strategic planning and infrastructure projects (Gutiérrez-Barba *et al.*, 2010). Aziz *et al.* (2024) stated that participatory risk management strategy *entails actively including local communities*, policy makers, and diverse sectors in the planning, decision-making and implementation stages of adaptation management plan. This research's results found that applying local expertise, promoting cooperation and guaranteeing that risk mitigation is both socially equitable and operational, it will be embraced and appropriated by people. Studies have discovered that public participation in risk management plans is more valuable when planners use participatory procedures that facilitate a two-way conversation between the public and authorities (Aziz *et al.,* 2024).

SFC is in urgent need of an urban development plan that considers socio-economic development scenarios under climate change effects; this plan must be considered to develop adaptive measures that can mitigate the exacerbated flood risks due to ongoing urbanization and climate change (Giannakidou *et al.,* 2019).

6. Conclusions

Understanding individual and community risk hazard perception and response provide key points of departure not only for dealing with CC consequences, but also for reducing vulnerability indices and to enhance social well being. Historic climate events permeate life histories for those affected who for many years have suffered debilitating aftermaths that provoke social systemic changes among SFC's residents.

The perception of CC is still not conceived as a relevant current problem. This may provoke a sense of forbearance among community members, who view positive future change as an unattainable goal.

Despite information availability and communication media and individual socio political ideas, the perception of climate change is still not conceived as a relevant current problem. Therefore, individual and collective responsibility in adopting significant changes to increase their adaptation capacity is attributed only to administrative and political actors, establishing a resignation point because the problems-situations will remain or will not change positively in the future.

This is key since the social communication strategies for climate change information in the city are not effective and to this day local policies and instruments did not improve adaptation capacities nor neither increased mitigation actions. It is worth mentioning that the most successful outcome for adapting to CC risks and effects remains nuclear families' obligations to carry out within their economic means, social standing, individual needs, and personal priorities to reduce material losses and direct impacts to their health.

CC increases marginalization in addition to social, political, and administrative problems that defy quick solutions. Here, environmental education strategies will be key to coopt greater knowledge, create a social consciousness, and empower a community to demand and adopt change.

A resigned society accustomed to suffering natural disasters, represents the biggest challenge to change. Thus, to shake human subjectivity, raise an urgent warning that we are in front of an "invisible" problem that impacts the social welfare and development, natural resources, as well as the meanings and appropriations for everyone, that it will be fundamental in order to rebuild society-environment relationships.

Community coastal management and action related to increased adaptation capacity and reduction of accelerated changes in climate is an opportunity for the city of SFC's advances and promotes climatic transitions' experiences. Moreover, it would represent changes in public policies to the end of integrating international instruments' dispositions for climate change and sustainable development. In addition, local governments would attend the commitments made with the public to solve still pending environmental and climate related problems.

For greater climatic consciousness and participation, mitigation, resilience, and adaptive policy designs should focus on reducing natural and social risk factors that affect all involved in the coastal zone.

7. References

Ardila, E., y Rueda, J. (2013). La saturación teórica en la teoría fundamentada: su delimitación en el análisis de trayectorias de vida de víctimas del desplazamiento forzado en Colombia. *Revista Colombiana de Sociología*, *36*(2), 93–114.

Awah, L.S., Belle, J.A., Nyam, Y.S., Orimoloye, I.R. (2024). A participatory systems dynamic modelling approach to understanding flood systems in a coastal community in Cameroon, *Int. J. Disaster Risk Reduct.,* 101: 104236, 10.1016/j.ijdrr.2023.104236

Aziz, F., Wang, X., Mahmood, M.Q.,Awais, M.,Trenouth, B. (2024). Coastal urban flood risk management: Challenges and opportunities – A systematic review, *Jour. Hydrology*, 645: 132271, https://doi.org/10.1016/j.jhydrol.2024.132271

Cabrera Sánchez, B., Audefroy, J. F. (2019). Vulnerable areas in tourist cities of coastal zones: Campeche, Mexico. *Coastal Cities and Their Sustainable Future III*, *188*: 83–94. https://doi.org/10.2495/CC190081

Cazau, P. (2006). Introducción a la investigación en Ciencias Sociales (Rundinuskín, Ed.; 3ra ed.).

Chen, H., Xu, Z., Chen, J., Liu, Y., Li, P. (2023). Joint risk analysis of extreme rainfall and high tide level based on extreme value theory in coastal area, *Int. J. Environ. Res. Public Health*, 20: 3605. 10.3390/ijerph20043605

Cioffi, F., De Bonis Trapella, A., Giannini, M., Lall, U. (2022). A flood risk management model to identify optimal defence policies in coastal areas considering uncertainties in climate projections, *Water* (Basel), 14: 1481. 10.3390/w14091481

COFEPRIS. (2017). Impactos Del Cambio Climático a La Salud; https://www.gob.mx/cofepris/acciones-y-programas/impactos-del-cambio-climatico-en-la-salud

Comisión Europea. (2020). La Acción Para El Empoderamiento Climático y Su Potencial Transformador En América Latina. Programa EUROCLIMA+. https://www.fiiapp.org/wp-content/uploads/2020/03/Estudio_Tematico_Euroclima.pdf

CONEVAL. (2020). Estadísticas de pobreza en Campeche. https://www.coneval.org.mx/coordinacion/entidades/Campeche/Paginas/principal.aspx (accessed 13 March 2024)

Cruz Roja Colombiana, Dirección General de salud. (2007). Salud mental en desastres. https://www.minsalud.gov.co/Documents/Salud%20P%C3%BAblica/Ola%20invernal/gu%C3%ADa%20salud%20mental15%20julio%20-.pdf

Day, R. (1981). Psicología de la percepción humana (Limusa-Wiley, Ed.) 228 p.

de Koning, K., Filatova, T. (2020). Repetitive floods intensify outmigration and climate gentrification in coastal cities. *Environ. Res. Lett.,* 15: 034008, 10.1088/1748-9326/ab6668

Fragoso Fernández, E. (2006). ¿Son los valores subjetivos u objetivos? Diferenciación entre lo que es un valor en sí y el proceso de valoración. Dialnet. https://dialnet.unirioja.es/descarga/artículo/4953730.pdf. https://doi.org/10.37646/xihmai.v1i2.59

García, R. (2006). Sistemas Complejos: Conceptos, método, y fundamentación Epistemológica de la investigación interdisciplinaria (Gedisa SA, Ed.).

Getirana, A.S., Kumar, G., Konapala, W., Nie, K., Locke, B., Loomis, C., Birkett, M., Ricko, M., Simard, M. (2023). Climate and human impacts on hydrological processes and flood risk in southern Louisiana, *Water Resour. Res.*, 59, 10.1029/2022WR033238

Giannakidou, C., Diakoulaki, D. Memos, C.D. (2019). Implementing a flood vulnerability index in urban coastal areas with industrial activity, *Nat. Hazards,* 97: 99-120, 10.1007/s11069-019-03629-w

González-Gaudiano, E.J., Cartea Meira, P. (2020). Educación para el cambio climático ¿Educar sobre el clima o para el cambio? *Perfiles Educativos*, *42*(168): 157–174. https://doi.org/10.22201/IISUE.24486167E.2020.168.59464

Gutiérrez-Barba, B., Rivera-Arriaga E., Alpuche L, Reyes F, Torres F, Azuz I. (2010). Educación ambiental en situación de cambio climático. p. 823-845. In: Rivera-Arriaga, E., Azuz I, Alpuche L, Villalobos G, (editors). Cambio climático en México un enfoque costero marino. UAC, CETYS-Universidad, Gobierno del Estado de Campeche. pp 823–845. http://etzna.uacam.mx/epomex/publicaciones/Cambio_Climatico/CCMexico1B.pdf

Heras Hernández, F. (2016). La Educación en Tiempos de Cambio Climático: Facilitar el Aprendizaje para Construir una Cultura de Cuidado del Clima. *Revista de Difusión de la Investigación*, No. 85. https://www.miteco.gob.es/content/dam/miteco/es/ceneam/articulos-de-opinion/2016-04-heras-hernandez_tcm30-70525.pdf

Hirabayashi, Y., Mahendran, R., Koirala, S., Konoshima, L., Yamazaki, D., Watanabe, S., Kim, H., Kanae, S. (2013). Global flood risk under climate change. *Nat. Clim. Chang.*, 3: 816-821, 10.1038/nclimate1911

INEGI. (2016). Inventario Nacional de Viviendas: información general. https://www.inegi.org.mx/rnm/index.php/catalog/80, (accessed 16 March 2024)

IPCC. (2007). Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the intergovernmental Panel on Climate Change M.L. https://www.ipcc.ch/site/assets/uploads/2018/03/ar4_wg2_full_report.pdf

Iqbal, U., Riaz, M.Z.B., Zhao, J., Barthelemy, J., Perez, P. (2023). Drones for flood monitoring, mapping and detection: a bibliometric review, *Drones*, 7, p. 32, 10.3390/drones7010032

Jara, O. (2018). La Sistematización de Experiencias: Práctica y Teoría Para Otros Mundos Políticos, 1st ed.; CINDE, Ed.; https://cepalforja.org/sistem/bvirtual/wp-content/uploads/2019/09/La-Sistematizaci%C3%B3n-de-Experiencias-pr%C3%A1ctica-y-teor%C3%ADa-para-otros-mundos-posibles.pdf

Kirezci, E., Young, I.R., Ranasinghe, R., Lincke, D., Hinkel, J. (2023). Global-scale analysis of socioeconomic impacts of coastal flooding over the 21st century, Front. Mar. Sci., 9, 10.3389/fmars.2022.1024111

Kumar, M.D., Tandon, S., Bassi, N., Mohanty, P.K., Kumar, S., Mohandas, M. (2022). A framework for risk-based assessment of urban floods in coastal cities. *Nat. Hazards*, 110, pp. 2035-2057, 10.1007/s11069-021-05024-w

Lagos, M., Cisternas, M., Mardones, M. (2008). Construcción de Viviendas Sociales En Áreas de Riesgo de Tsunami. *Revista de la Construcción*, 7(2): 4–16. http://www.redalyc.org/articulo.oa?id=127612584001

Lara San Martín, A. (2013). Percepción Social En La Gestión del Riesgo de Inundación En Un Área Mediterránea; Universidad de Girona, Ed.; Costa Brava, España, Tésis Doctorado, https://www.tdx.cat/bitstream/handle/10803/98249/talsm.pdf

Lara-Rosano, F. (2017). Fundamentos para el Diagnóstico e intervención en sistemas complejos: Metodología para el análisis de la Complejidad social (Editorial Académica Española, Ed.).

Loizidou, X.I., Orthodoxou, L.D., Loizides, M.I., Petsa, D., Anzidei, M. (2024). Adapting to sea level rise: participatory, solution-oriented policy tools in vulnerable Mediterranean areas. *Environ. Syst. Decis.*, 44: 126-144, 10.1007/s10669-023-09910-5

López-Morales, L. (2019). La educación climática como una medida de adaptación al cambio climático. In Cambio climático y Gobernanza: una visión transdiciplinaria (1st ed.).

Mangas, E. (2018). Evaluación del Sistema de Drenaje Pluvial de la Ciudad de San Francisco de Campeche. Tesis Maestría, UAC-EPOMEX.

McPherson, E. Nowak, G., Heisler, G. (1995). Quantifying urban forest structure, function, and value: The Chicago urban forest climate project. *Urban Ecosystems*. https://www.researchgate.net/publication/255946320

Mejía Ricci, S., Mendoza Puccini, R., Amarís, M., Obregón, R. (2001). Percepción social que tienen de sus connacionales los inmigrantes colombianos residentes en Kendall (Miami, USA). *Investigación y Desarrollo*, 9(1), 464–487, https://www.redalyc.org/pdf/268/26890106.pdf

Moon, J., Flannery, W., Revez, A. (2017). Discourse and practice of participatory flood risk management in Belfast, UK. *Land Use Policy*, 63: 408-417, 10.1016/j.landusepol.2017.01.037

Ortiz, G., García, B. (n.d.). Preparación psicológica para situaciones de emergencia. Gobierno de México. Retrieved June 26, 2024, from https://www.proteccioncivil.gob.mx/work/models/sismos/Resource/68/1/images/atencion.pdf

Ortiz-Lozano, L., Granados-Barba, A., Solís-Weiss, V., García-Salgado, M. A. (2005). Environmental Evaluation and Development Problems of the Mexican Coastal Zone. *Ocean Coast. Manag.* 48: 161–176. https://doi.org/http://dx.doi.org/10.1016/ j.ocecoaman.2005.03.001.

Oxfam-Québec. (2014). Manual para la elaboración de un plan de acción local en adaptación al cambio climático y reducción del riesgo de desastres.

Páez, D., Fernández, I., y Beristain, C. (2001). Catástrofes, traumas y conductas colectivas: procesos y efectos culturales. In Catástrofes y ayuda en emergencia: estrategias de evaluación prevención y tratamiento (pp. 85–148). Icaria. https://www.researchgate.net/publication/286439420_Paez_D_Fernandez_I_Martin_Beristain_C_2001_Catastrofes_traumas_y_conductas_colectivas_procesos_y_efectos_culturales_In_C_SanJuan_Ed_Catastrofes_y_ayuda_en_emergencia_Estrategias_de_evaluacion_prevenci

Palacio Aponte, G. (2013). Identificación y Caracterización de los bajos inundables. p. 125–136). In: PPalacio Aponte, G., Salles, P., Silva, R., Bautista, E., Posada, G., y Val, R. Peligros naturales en el Estado de Campeche: cuantificación y protección civil. UAC, CENECAM-Gob. del Campeche, y CENAPRED.

Ramírez, J. (2009). Procedimiento para la elaboración de un análisis FODA como una herramienta de planeación estratégica de las empresas. Instituto de Investigaciones y Estudios Superiores de las Ciencias Administrativas de la Universidad Veracruzana. https://www.uv.mx/iiesca/files/2012/12/herramienta2009-2.pdf

Rentschler, J., Salhab, M., Jafino, B.A. 2022. Flood exposure and poverty in 188 countries, *Nat. Commun.*, 13: 3527, 10.1038/s41467-022-30727-4

Rivera-Arriaga, E., Vega Serratos, B. E., Posada Vanegas, G., y Mangas Che, E. A. (2020). Building adaptation to extreme rain effects in San Francisco de Campeche, Mexico. *Atmosfera,* 33(2). 159–174. https://doi.org/10.20937/ATM.52650

Rivera-Arriaga, E.; Espejel-Carbajal, I.; Gutiérrez- Mendieta, F., Vidal-Hernández, L. E., Espinoza-Tenorio, A., Nava Fuentes, J. C., García-Chavarría, M., Sosa-López, A. 2020. Global Review of ICZM in Mexico. *Revista Costas vol especial* 1: 179–200. https://doi.org/10.26359/costas.e109.

Rouleau, T., Stuart, J., Call, M., Yozell, S., Yoshioka, N., Maekawa, M., Fiertz, N. (2022). The climate and ocean risk vulnerability index: Measuring coastal city resilience to inform action. *Front. Sustain. Cities*, 4, https://doi.org/10.3389/frsc.2022.884212

Safabakhshpachehkenari, M., Tonooka, H. (2024). Modeling land use transformations and flood hazard on Ibaraki's coastal in 2030: A scenario-based approach amid population fluctuations. *Remote Sens.* (Basel), 16, p. 898, 10.3390/rs16050898

Sangsefidi, Y., Bagheri, K., Davani, H., Merrifield, M. (2023). Data analysis and integrated modeling of compound flooding impacts on coastal drainage infrastructure under a changing climate. *J Hydrol (Amst)*, 616: 128823, 10.1016/j.jhydrol.2022.128823

Satour, N., Raji, O., El Moçayd, N., Kacimi, I., Kassou, N. (2021). Spatialized flood resilience measurement in rapidly urbanized coastal areas with a complex semi-arid environment in northern Morocco. *Nat. Hazards Earth Syst. Sci.,* 21: 1101-1118, 10.5194/nhess-21-1101-2021

SEMARNAT and INECC. (2018). Sexta comunicación nacional y segundo informe bienal de actualización ante la convención marco de las naciones unidas sobre el cambio climático. https://cambioclimatico.gob.mx/sexta-comunicacion/ (accessed 10 February 2024)

Sierra, J. (2003). La investigación social y el dato complejo: una primera aproximación. Universidad de Alicante.

Smith, K., Petley, D. N. (2007). Environmental Hazards: Assessing Risk and Reducing Disaster, 4th ed.; Routledge, Ed.; https://spada.uns.ac.id/pluginfile.php/591800/mod_resource/content/1/Environmental%20hazards%20assessing%20risk%20and%20reducing%20disaster%20by%20Keith%20Smith%20%28z-lib.org%29%20%281%29.pdf

SSPC, CENAPRED. (2019). Diagnósticos sobre la percepción local del riesgo de desastres. https://www.cenapred.unam.mx/es/Publicaciones/archivos/428-INFORMEDEACTIVIDADES2019.PDF, (accessed 10 April 2024)

Takin, M., Cilliers, E.J., Ghosh, S. (2023). Advancing flood resilience: the nexus between flood risk management, green infrastructure, and resilience. *Front. Sustainable Cities*, 5, 10.3389/frsc.2023.1186885

Tello, N. (2008). Apuntes de Trabajo social (Estudios de Opinión y Participación social AC, Ed.; 1ra ed.).

The World Bank. (2023). Climate Action Game Changers: Adaptation to Climate Shocks.https://www.worldbank.org/en/news/immersive-story/2023/11/14/climate-action-game-changers-adaptation-to-climate-shocks?cid=ECR_E_NewsletterWeekly_EN_EXT&deliveryName=DM201264, (accessed 10 February 2024)

Turnbull, M.. Sterrett, C.L.. .Hilleboe, A. (2014). Toward Resilience, A Guide to Disaster Risk Reduction and Climate Change Adaptation. Practical Action Publishing Ltd. https://oxfamilibrary.openrepository.com/bitstream/handle/10546/297422/bk-ecb-toward-resilience-drr-climate-change-adaptation-guide-030113-en.pdf;jsessionid=A8B3756390710CF4DBDDB144AAE8B2B9?sequence=1

UNFCCC. (n.d.). What do adaptation to climate change and climate resilience mean? U.N. Climate Change. Retrieved June 26, 2024, https://unfccc.int/topics/adaptation-and-resilience/the-big-picture/what-do-adaptation-to-climate-change-and-climate-resilience-mean, (accessed 10 February 2024)

Vega, E., Posada, G., Domínguez, R., Esquivel, G., Martínez, A., Ramírez, D., Kuk, A., y Ruiz, G. (2013). Inundaciones por desbordamiento de Ríos. (pp. 21–62) In: Peligros Naturales en el Estado de Campeche Cuantificación y Protección Civil. UAC, CENECAM-Gobierno del Estado de Campeche, y CENAPRED.

Xu, P., Wang, D., Wang, Y., Singh, V.P., Zhang, Z., Shang, X., Fang, H., Xie, Y., Zhang, G., Liu, S., Fu, X. (2024). A dynamic von mises-based model to evaluate the impact of urbanization and climate change on flood timing in Yangtze and Huaihe river Basins China. *J. Hydrol (Amst)*, 634: 131120, 10.1016/j.jhydrol.2024.131120