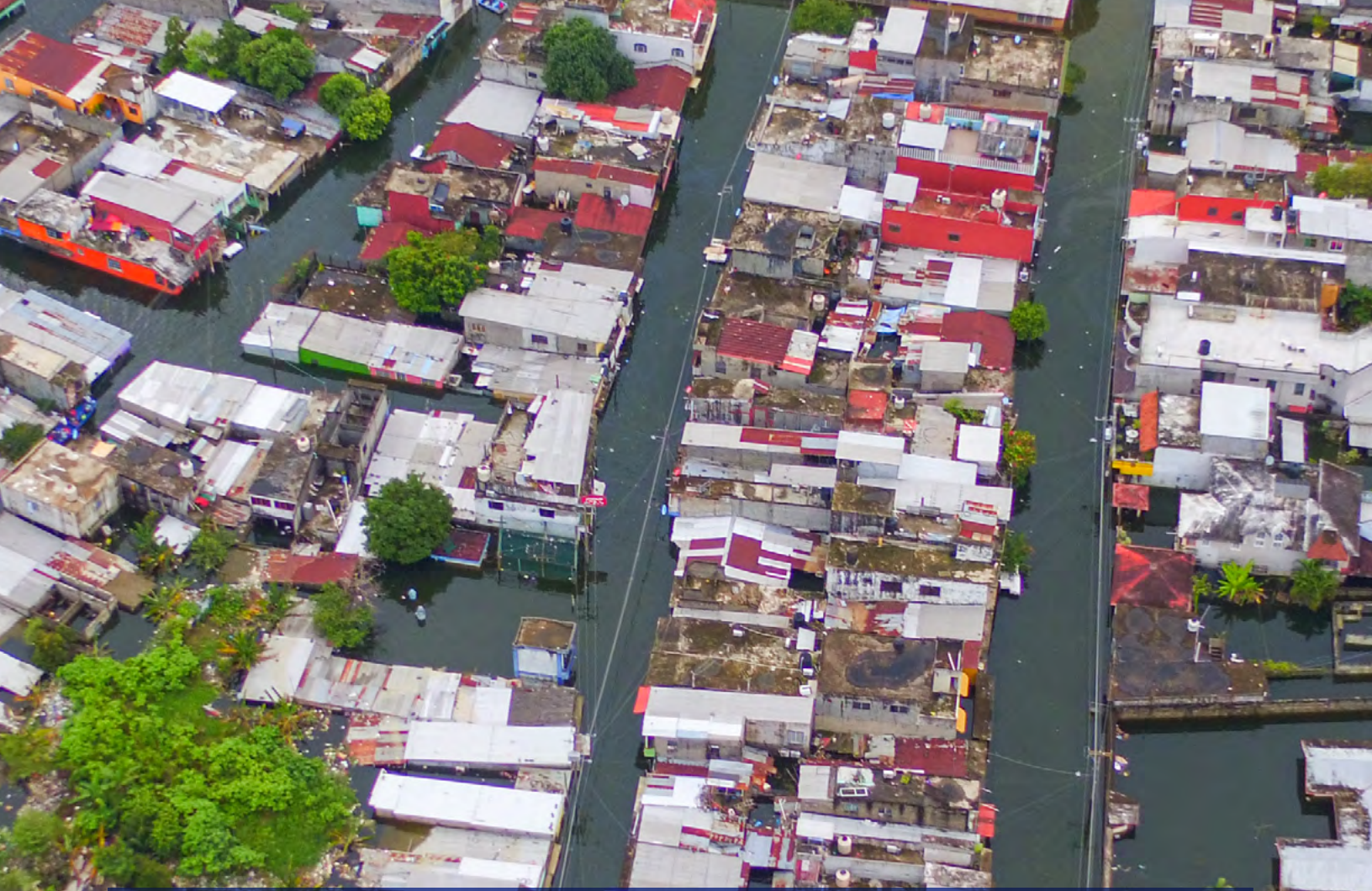
June 2022

2020 Tabasco floods

Learning from the past to prepare for the future

Aerial photo of El Castaño, Macuspana, Tabasco © CENAPRED, 2020



This report is based on the Zurich Flood Resilience Alliance's Post-Event Review Capability (PERC) methodology, which analyzes flooding in Tabasco, Mexico, in 2020. This paper presents the lessons learned on resilience and is based on key informant interviews and desk research. More information on the PERC methodology can be found at: www.floodresilience.net/perc; more information on flood resilience can be found at: www.floodresilience.net

ACKNOWLEDGEMENTS

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Back cover: Delivering humanitarian aid in the 2020 floods in Teapa, Tabasco © By Javier Lara, Head of Training and Disaster Preparedness, Mexican Red Cross, 2020

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Acronyms

CENAPRED	National Centre for the Estimation, Prevention and Reduction of Disaster Risk
CNPC	National Coordination of Civil Protection
CONAGUA	National Water Commission
CRM	Mexican Red Cross
DANAs	Damage and Needs Assessments
DOF	Official Journal of the Federation
ECLAC	Economic Commission for Latin America and the Caribbean
FONDEN	Natural Disaster Fund
FOPREDEN	Fund for the Prevention of Natural Disasters
INAI	National Institute of Transparency, Access to Information and Personal Data Protection
INEGI	National Institute of Statistics and Geography
IOM	International Organization for Migration
IPCET	Institute of Civil Protection of the State of Tabasco
LGPC	General Law of Civil Protection
LOAPF	Organic Law of the Federal Public Administration
LPCET	Civil Protection Law of the State of Tabasco
NGOs	Non-governmental organizations
OECD	Organization for Economic Co-operation and Development
PERC	Post Event Review Capability
PHIT	Integral Water Plan of Tabasco
PICI	Integrated Flood Control Program
PIMAT	Comprehensive Water Management Project
PROHTAB	Hydrological project to the public from flooding and improve water use in the state of Tabasco
SEDATU	Secretariat of Agrarian, Land and Urban Development
SEDENA	Secretariat of National Defense
SEMAR	Secretary of the Navy
SIESA	Health Emergencies Information System
SINAPROC	National Civil Protection System
SMN	National Meteorological Service
SSPC	Secretariat of Security and Citizen Protection
UNDP	United Nations Development Program
UNHCR	The United Nations Refugee Agency

Coordinating health campaigns following the 2020 floods in the community of Santa Rita, Tabasco
© Guadalupe Pérez, Community Technician, Mexican Red Cross

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Preface

The song "Vamos a Tabasco" describes Tabasco as an Eden. The green, rolling, sometimes mountainous landscapes, abundant rivers and waterfalls, and picturesque coastline highlight the idyllic qualities of the region, as well as its important history. The local gastronomy, based on the foods of the ancient Mayans and Chontal people – like *pozol,* a cold chocolate drink dating to Mesoamerican times that I still remember tasting for the first time – and resource management has its roots in this era.

It is this last element – land and water management – combined with the geography of the region and the natural history of flooding that continues to impact *tabasqueños* today.

Because of its unique location on the coast of the Gulf of Mexico and its varied topography, the hydrology of the state is complex. Tabasco is dominated by two rivers, the Usumacinta and Grijalva, which join for 25 km before reaching the Gulf of Mexico; together they form one of the world's largest river systems in terms of volume. In addition, the average rainfall in this location is three times higher than Mexico's average and accounts for almost 40% of the country's freshwater. The abundance of water and the impact of dams on the hydrology of the region, by altering the natural flow of rivers, can cause flash floods and flooding, affecting the drinking water, health, and livelihoods of hundreds of thousands of *tabasqueños* each year.

Therefore, flooding is not unusual in the region; however, in the fall of 2020, several cold fronts, as well as cyclones Eta and Iota – which brought heavy rains to Tabasco – caused the worst flooding in decades. The magnitude of the floods motivated us to investigate the why of the floods, that is, why they manifested themselves in the way they did.

In a thorough analysis of the event, our Post-Event Review Capability (PERC) report shows that key stakeholders in government and civil society have made significant progress in recent years, both to manage the initial response and to support early recovery. In particular, we found examples of lessons learned from past floods on decision making that, when applied, achieved changes in reducing the impacts of the 2020 floods.

However, we also found that much more can and must be done to truly integrate proactive disaster risk management and resilience building into current policies, practices, and budgets. Our key recommendations aim to support a strategic direction that prevents a hazard from becoming a disaster and reiterates the importance of building resilience and living with floods, rather than resisting them. Our key recommendations are focused on early warning systems, land use policy, development of alternative housing models, infrastructure, holistic dam management and investments in social and human capital.

We also note the critical need to increase the resilience of downstream communities to seasonal and extreme flooding. This implies sustained engagement with local, state and national stakeholders to include vulnerability reduction in flood mitigation plans and projects.

Beyond these best practices, the changing nature of flooding demands innovative solutions. One recommendation highlighted in the report is how nature-based solutions and green infrastructure can offer a flood resilience solution that is often more cost-effective than grey infrastructure while also providing additional benefits, such as improved human well-being.

Focusing on the October and November 2020 floods, this PERC report aims to answer questions related to aspects of resilience and flood risk management, along with disaster management. It explores what worked well, as well as opportunities for improvement, resulting in a set of recommendations for the future that we hope stakeholders can implement in their efforts to reduce risk and increase resilience.

This PERC should not be seen as a stand-alone assessment or as having ended with the publication of this report. This main document should be taken as a starting point for further discussion of these key ideas and recommendations. We published a number of additional complementary products, including a series of policy papers on natural capital-focused topics such as nature-based solutions, and the critical role of social capital in flood resilience.

The Mexican Red Cross sees an opportunity to strengthen the foundation of collective action for flood resilience by leveraging existing networks and the diverse roles we play as individuals and community members, within organizations and informal and social networks. We hope that these pieces will form part of future discussions on disaster risk reduction and flood resilience programs, for which we stand ready to participate as an active partner not only in Tabasco, but across the country.

Best regards,

Francisco Ianni

SECTION I
PHYSICAL EVENT

In October and November of 2020, a series of cold fronts and two cyclones caused severe flooding in the states of Chiapas, Tabasco, and Veracruz, Mexico. Tabasco also received significant rainfall in the month of November. Floods, landslides and the discharge of water from the Angel Albino Corzo "Peñitas" hydroelectric dam left the region under water. In total, the storms and resulting floods inundated 14% of the state and affected approximately 800,000 people, damaged close to 200,400 houses and flooded thousands of hectares of crops throughout the state. The floods also damaged 2,000 km of roads, and affected drainage systems and major urban infrastructure, which suffered damage amounting to USD 37 million and USD 93 million respectively (see Box 1).

BOX 1. IMPACTS OF THE 2020 FLOODS

- 17 municipalities affected - 946 communities
- 800,000 people impacted (200,400 families)
- 10,000 people evacuated
- 200,400 homes with some level of damage
- 10 deaths
- 511 schools damaged

Roads

- 21 road closures
- 152 km of federal highway damaged
- 2,059 km of state and municipal roads with damage

Energy

- 31,844 users affected
- 3 distribution transformers, 34 poles, 4 transmission lines damaged

Water

- $764.3 million Mexican pesos in damage to drainage systems in the federal sector
- Drinking water pipelines damaged
- Drinking water treatment plants damaged

Urban Infrastructure

- $1,914 million Mexican pesos in damages
- Macuspana and Centro are the municipalities with the greatest damage.

Agriculture

- 6,263 hectares of crops potentially impacted

Source: National Civil Protection System (2020)

Tabasco 2020 floods in the community of Torno Largo 2nd Section, Jonuta, Tabasco © Paulo Cerino, Community Technician, Mexican Red Cross

Since much of Tabasco lies on a coastal plain, flooding is common in the state. For example, previous floods in 2007 left almost 80% of the state under water and caused losses of up to USD 3 billion; the 2020 floods caused losses of USD 677,802 (see Table 1). Combined with the impacts of climate change and ongoing land use change – including unplanned urban sprawl, the oil industry, and deforestation – it suggests that the region is likely to experience flooding of a similar, if not greater, magnitude in the future.

TABLE 1
Socioeconomic impacts of the 2007 and 2020 floods

	2007	2020
Damage and losses	$31.8 billion Mexican pesos USD 3.1 billion (2007)	$13,508,600 million Mexican pesos USD 677,802 (2020)
Emergency response	$510 million Mexican pesos USD 46,703,296 (2007)	$226 million Mexican pesos USD 11,339,688 (2020)
People affected	1.5 million (75% of the population)	800,000 (33% of the population)
Houses with some level of damage	123,000	200,400

Prepared with data from CENAPRED, 2021a; 2021b; CNPC, 2020.

TABLE 2
The 2020 Storms

Start Date	End Date	Phenomenon
29 September	5 October	Cold Front #4, #5 and Tropical Storm Gamma
29 October	7 November	Cold Front #9, #11 and Tropical Cyclone Eta
15 November	19 November	Cold Front #13 and Tropical Cyclone Iota

Source: Institute of Civil Protection of the State of Tabasco, 2021.

The storms

Between October and November 2020, the southern region of Mexico was affected by a series of cold fronts (#4, #5, #9, #11, and #13), as well as Tropical Storm Gamma and Tropical Cyclones Eta and Iota. The combination of cold fronts and tropical storms dumped large amounts of rain in the region, causing significant flooding. Over the course of October and November, the state received 1051.7 millimeters (mm) - 550.4 mm in October and 501.3 mm in November - of rainfall, more than one-third of its average annual rainfall (see Figure 1).

Cold fronts #4 and #5 and Tropical Storm Gamma brought torrential rains in early October. Tropical Storm Gamma made landfall on October 3, 2020 near the town of Tulum, along the northeastern side of the Yucatan Peninsula, bringing with it heavy rains and maximum sustained winds of 112 kph. Landslides and flooding resulted. Emergency declarations were issued in the states of Chiapas, Tabasco, and Veracruz. Some localities in the states of Chiapas and Tabasco recorded more than 200 mm of rain in a 24-hour period since the first of October.

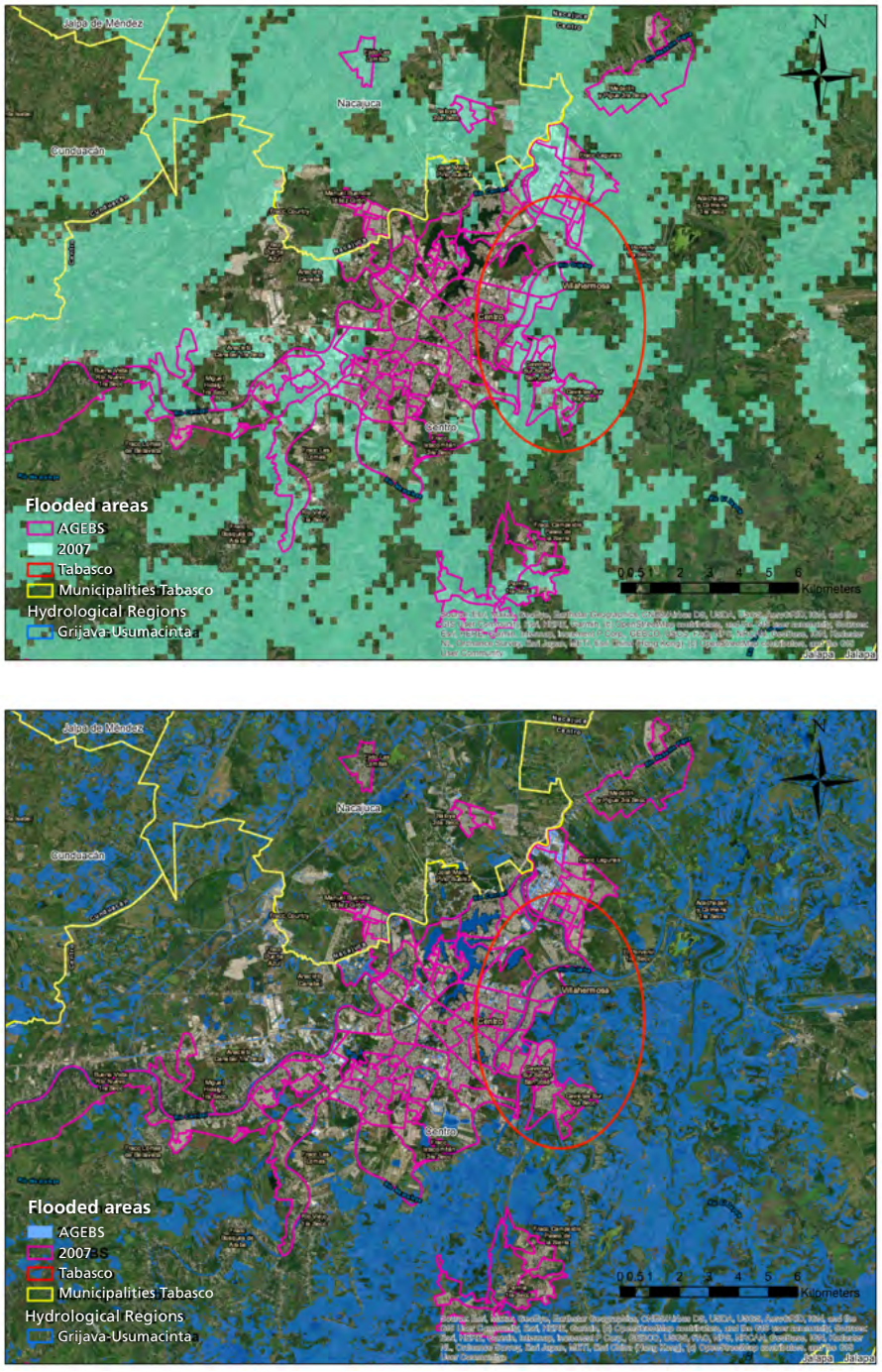
In addition to triggering major flooding, the volume of rain forced the release of water from the "Peñitas" dam on October 9, 2020 into the Grijalva River and its tributaries (the Mezcalapa, Samaria and Carrizal Rivers). While water was released from the dam to prevent it from overflowing, the released water entered rain-swollen rivers, leading to new floods that caused two deaths in Tabasco and affected 800,000 people in 14 municipalities, while also leaving parts of the capital, Villahermosa, under up to a meter of water.

The rains continued during October, culminating on the 30th with a record rainfall of 450 mm of rain in 24 hours. Soils saturated by water from earlier in the month meant that there was nowhere for additional water to go, contributing to river overflows by the week of November 10 due to cold fronts #9 and #11 and Cyclone Eta, as well as flash flooding that inundated communities throughout the region. Of note was the impact of Cyclone Eta, which made landfall on the northeast coast of Nicaragua on November 3 before heading north through Central America. Although Eta eventually moved away from Mexico and out to sea, it caused torrential rains

in the southern region of the country: 315 mm of rain fell in Oxolotán, Tabasco in a 24-hour period on November 6.

Continuing rains in November flooded nearby villages. Residents in some communities experienced water levels that covered the ground floors of homes, forcing them to evacuate via boat. Approximately 12,000 people were evacuated to shelters, while others remained in areas of higher elevation or on the roofs of their houses for fear of looting and the spread of COVID-19. The extraordinary rains caused the "Peñitas" dam to again approach its capacity, forcing emergency releases and flooding downstream in areas where there had previously been little rainfall. Additionally, flood protection infrastructure diverted water out of Villahermosa to minimize flooding in the center of the city, which had a disproportionate impact on disadvantaged communities on the outskirts of Villahermosa and in the municipality of Nacajuca where many indigenous Chontals live (see Figure 1).

FIGURE 1
The 2007 and 2020 Floods



Source: Geophysics RT, 2021

SECTION II
DISASTER RISK REDUCTION

> *Tabasco is going to flood.*
>
> – PERC Interview

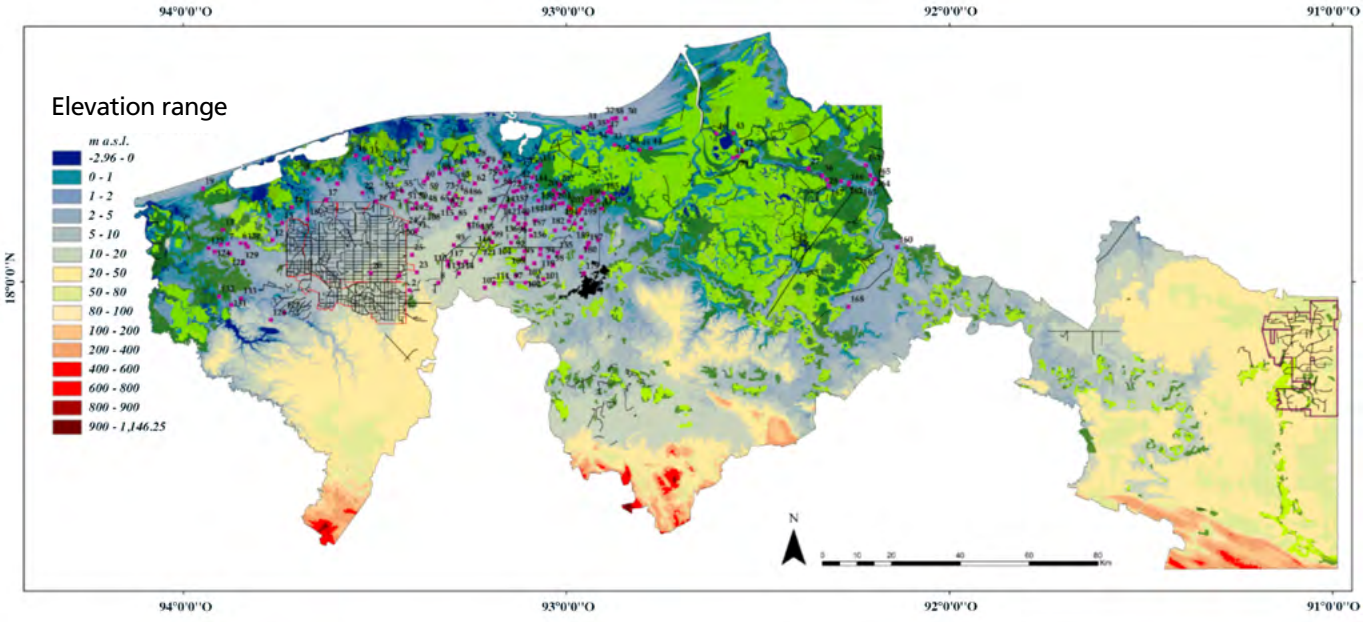
Floods are not unexpected in Tabasco. The topography and geography of the region make it susceptible to recurrent flooding (see Figure 2). Yet, while flood risk management – with varying levels of success – exists, along with robust national and state infrastructure to support emergency preparedness, response, and recovery, changes in land use and unplanned development are increasing the risk of flooding for communities throughout the region. Coupled with the impacts of climate change, the region is likely to continue to experience flooding of a similar magnitude, if not worse than that which was experienced in 2020.

Social vulnerability and exposure to floods

In the last 70 years, the state of Tabasco has experienced rapid population growth and increasing urbanization mainly due to changes in economic activities and production. Originally a primarily agricultural state, in recent years economic activities have focused on the extractive industry – in particular, the hydrocarbons sector – and trade and services, triggering significant population growth in Villahermosa: between 1950 and 2020, its population increased from 33,578 to 340,060 inhabitants (Capdepont-Ballina and Marín-Olán, 2014; INEGI 2021). This population growth has contributed to issues of urban development such as irregular settlements that occupy spaces that are not suitable for habitation, such as reservoirs, and water pollution due to greater amounts of untreated waste. The city has also spread to the lowlands of the coastal plain, which are characterized by low permeability and susceptibility to flooding (Capdepont-Ballina and Marín Olán, 2014; Pérez et. al., 2011).

FIGURE 2

The topography and geography of Tabasco



Source: Adapted from Peraza-Villarreal, H et al. 2019.

Another consequence of this population boom is that Villahermosa has merged with the municipality of Nacajuca. At present, there is uncontrolled expansion in the urban center. The growth of urban corridors and dispersion of human settlements has resulted in decreasing vegetation cover while also contributing to an increase in the risk of flooding (Palomeque et al., 2021).

As a result, Tabasco is seeing an increase in social vulnerability: 53.6% of the state's population lives in poverty and approximately a third has limited access to key socio-economic resources. At the same time, the expansion of settlements in flood-prone areas is creating new risks.

As highlighted in other PERC research reports, the populations living in these higher risk areas tend to be lower income and have higher levels of vulnerability. The populations affected by the 2020 floods – especially due to the release of the "Peñitas" dam – illustrate this phenomenon, as the floodwaters disproportionately affected the poorest and primarily indigenous-populated areas of the region surrounding the state capital.

Environmental context

Due to its location on a narrow strip of coastal floodplain, the state of Tabasco – bounded by the Gulf of Mexico to the north and the Sierra Madre de Chiapas to the south – is susceptible to natural flooding. Approximately one-third of all surface water resources in Mexico flow through Tabasco (Gama et. al, 2010); consequently, floods are a part of the natural history of the basin. However, they have increased in intensity and frequency due to climate change and development.

Lying at the foot of the Chiapas mountains, the Tabasco plain's flat terrain slows the rivers down, favoring the generation of slow-moving streams. However, when there is an increase in flow due to rainfall runoff or dam releases, the rivers quickly overflow. This is further complicated by flood protection infrastructure, which prioritizes the protection of certain areas by diverting water elsewhere. This contributes to the siltation of some rivers, while modifying their natural course and resulting in the deposition of sediment in places where the rivers would not naturally flow. In particular, the Mezcalapa and Carrizal Rivers, which surround the city of Villahermosa, have been modified, causing them to overflow more rapidly than they would have in their natural state.

At the same time, the landscape has been transformed to favor agriculture and cattle ranching in the region. Ninety per cent of the original rainforest has been lost, mainly due to agricultural activities, cattle ranching and inadequate livestock management. Road infrastructure, unplanned urban growth and oil extraction infrastructure have changed the way water moves through the state, especially in coastal areas. In addition, the construction of extensive dams for hydropower production has created both benefits and problems: they generate most of the electrical power used in southern Mexico, but have also significantly modified river flows, leaving downstream populations exposed to planned and unplanned water releases.

The transformation of the natural and hydrological environment in Tabasco was facilitated by the creation of two plans:

- The Chontalpa Plan (1963) was created with the intention of controlling excess water and making the land productive in the area known as the Chontalpa (PERC Interview; ECLAC, 1976; Pacho and Rivera, 1996; Márquez, 2008). This project focused on the development of basic infrastructure, agricultural rehabilitation and social improvement. Part of the infrastructure development included the construction of a 2,000 km drainage system, as well as the 35 km long Huimanguillo-Samaria embankment, to protect the land from Grijalva River flooding.
- The Balancán-Tenosique Plan (1972), primarily focused on encouraging cattle ranching, and triggered an accelerated population increase due to the establishment of new population centers (PERC interview; ECLAC, 1976; Pacho and Rivera, 1996; Márquez, 2008).

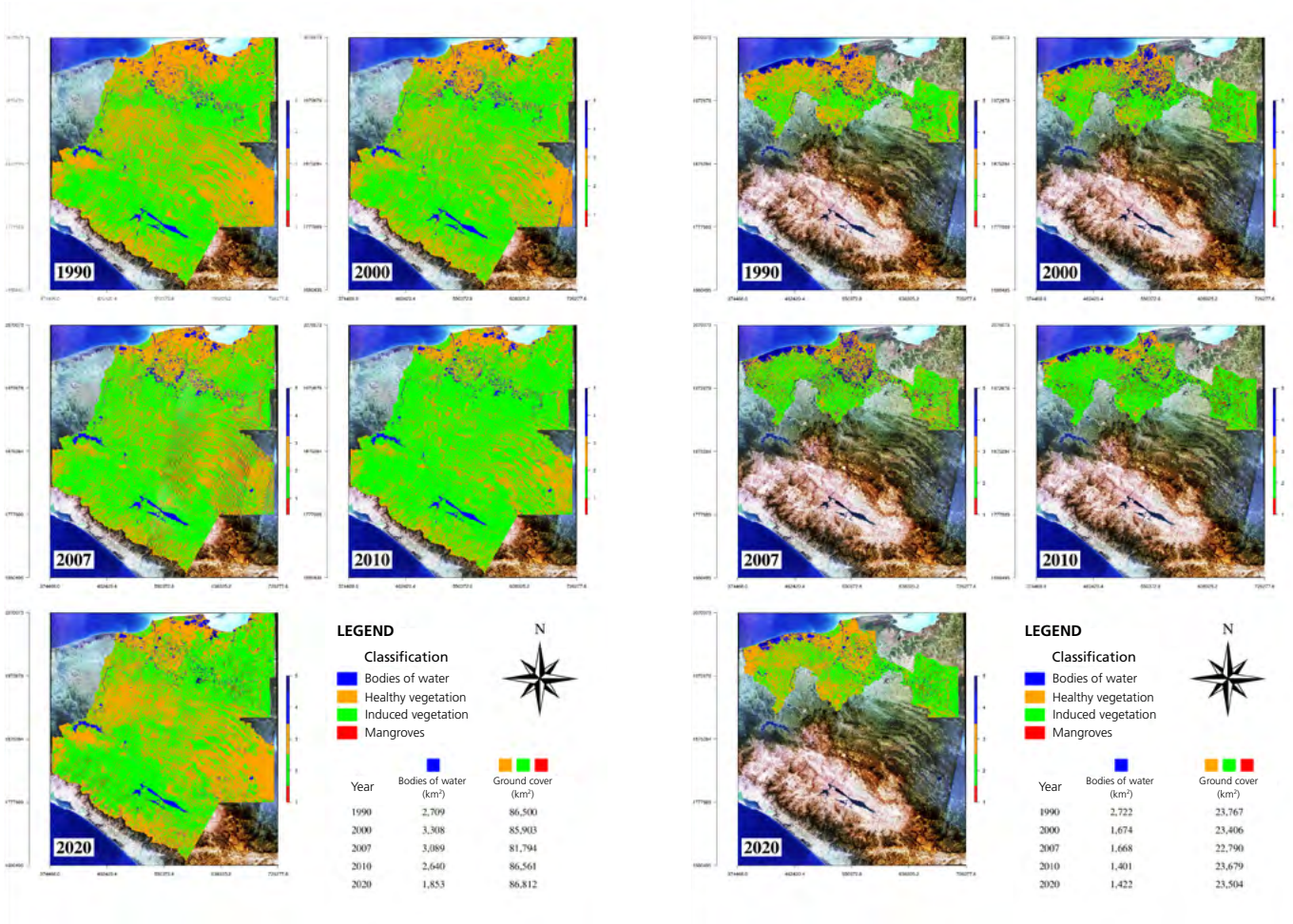
The deforestation and land use changes as a result of these plans have led to increased erosion and sedimentation in rivers. The accumulation of sediment increases the impact of flooding because less water is needed to push the river over its banks. In turn, overflowing rivers can cause the banks to collapse, adding more sediment to the river, or it can lead to the creation of new river channels. In short, these changes can create negative feedback loops which continue until the river reaches a new equilibrium.

Additionally, activities related to oil extraction often generate alterations in the ecosystem due to the contamination of farmland and bodies of water by oil spills. They also transform the landscape and natural environment by modifying or blocking natural drainage with facilities, accesses or wells. As a result, the water, not finding natural outlets, floods the surrounding areas (Aranda, 2014).

Climate change impacts in Tabasco

Climate change is further magnifying the impacts of land use change and increasing community exposure

FIGURE 3
Deforestation



Source: Geophysics RT, 2021

to flooding, with cascading impacts on agricultural livelihoods. Located just above sea level, Tabasco is vulnerable to the impacts of sea level rise, which includes the increase in the frequency and severity of coastal flooding (Society of Bangladesh Red Crescent Society et al, 2021). At the same time, climate change impacts on seasonal weather patterns are likely to exacerbate droughts, rainfall intensity and tropical cyclone intensity in the region. With changes in land use and shifts in demographic patterns towards urbanization and land transformation, existing vulnerabilities are also likely to increase.

Tabasco Floods

Both the population and public officials characterized the Tabasco floods of 2007 and 2020 as "historic"; however, floods in other years were triggered by similar factors.

Tabasco Flood Timeline

1999 Three floods in the rivers of the Sierra in 1999, triggered by the conjunction of Tropical Waves #26 to #30, Tropical Depression #11 and cold fronts #4 and #7, which flooded the city of Villahermosa. The floods led to the construction of flood walls in Villahermosa and along the banks of urban rivers.

2007 This year's floods were triggered by cold fronts #4 and #7 and Tropical Cyclone Noel, which mainly affected the "Peñitas" dam due to the accumulation of precipitation. In addition to the above, on November 4, the "Peñitas" dam was blocked by a landslide. Villahermosa was severely affected, highlighting the need for the development of the new Integral Water Program of Tabasco.

2008 In this year, rainfall was concentrated in the months of September and October. The floods were triggered by rains from Tropical Waves #32 and #33, due to cold front #4 and the remnants of Tropical Depression #16. The use of embankments worked in some river areas, but in others, overflows were unavoidable.

2010 Flooding in this year was triggered by the passage of Hurricane Frank, Tropical Wave #25, Tropical Depression #11-E, and Tropical Storm Matthew. Although disaster declarations were issued for flooding, there was effective coordination in the management of upstream basins, in infrastructure, and civil protection actions in the lower basin (IPCET, 2021; Arreguín-Cortés et. al, 2014).

2020 In this year, there were cold fronts, low pressure systems and tropical cyclones which, due to the excess of water, saturated soils throughout the state. In addition, 2020 was a "la Niña" year, after a period of three years of little rainfall dominated by "El Niño". According to official figures, in 2020 annual rainfall reached 3,406 mm.

Institutional structure and risk management

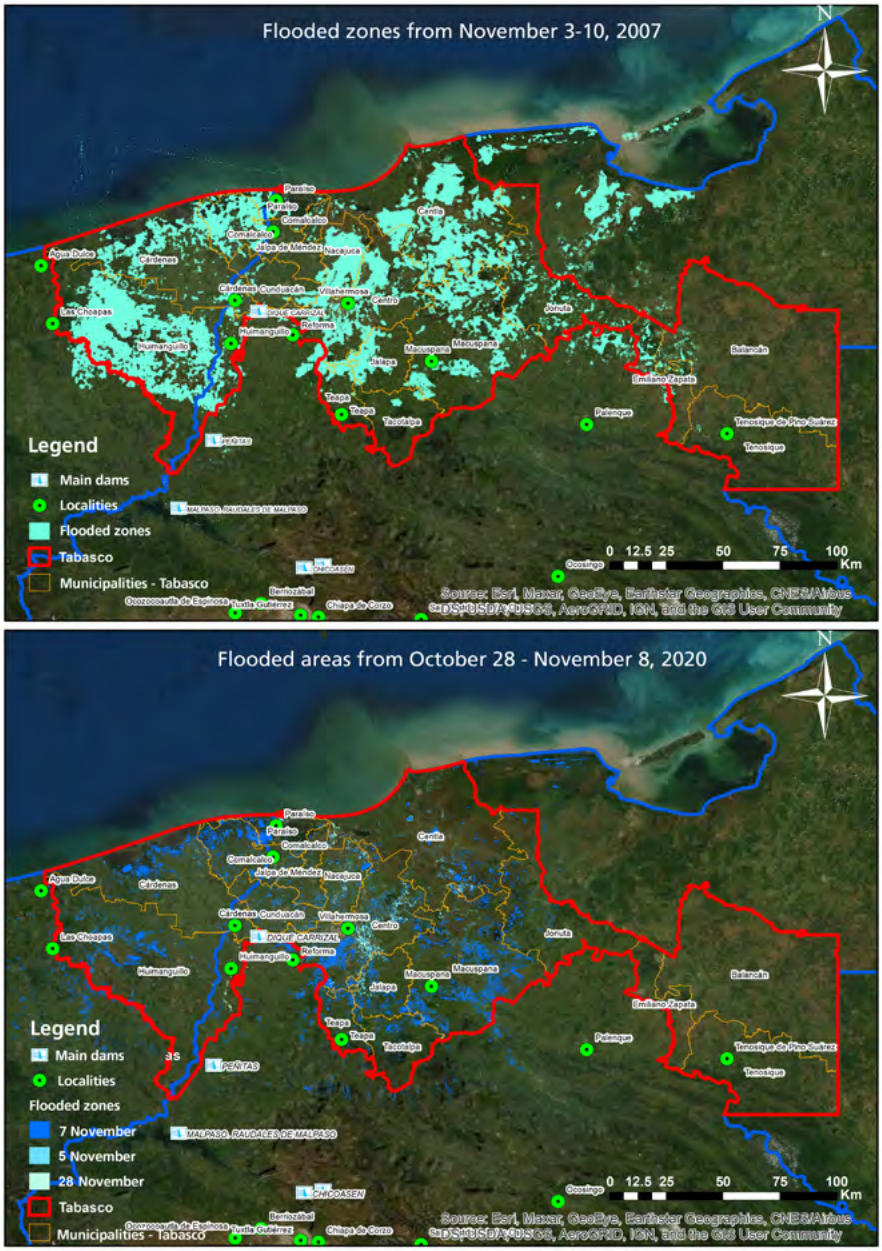
Since 1986, disaster risk management in Mexico has been the responsibility of the National Civil Protection System (SINAPROC). SINAPROC is made up of organizations from the public sector, with representatives from the three levels of government (Federal, State and Municipal), and the private and social sectors. In the past 35 years, SINAPROC has evolved from being a reactive system to one that contemplates the different stages of disaster risk management, based on a legal and regulatory framework that has been integrating risk prevention, early warning and forecasting.

National Civil Protection System (SINAPROC)

In 2000, the General Law of Civil Protection provided legal support to SINAPROC. In 2012, a new General Law of Civil Protection using a preventive approach came into force. The law recognizes integrated risk management as a guiding principle, considering both risk mitigation and prevention in order to increase the population's resilience to disasters (Hernández; Castillo, S/F).

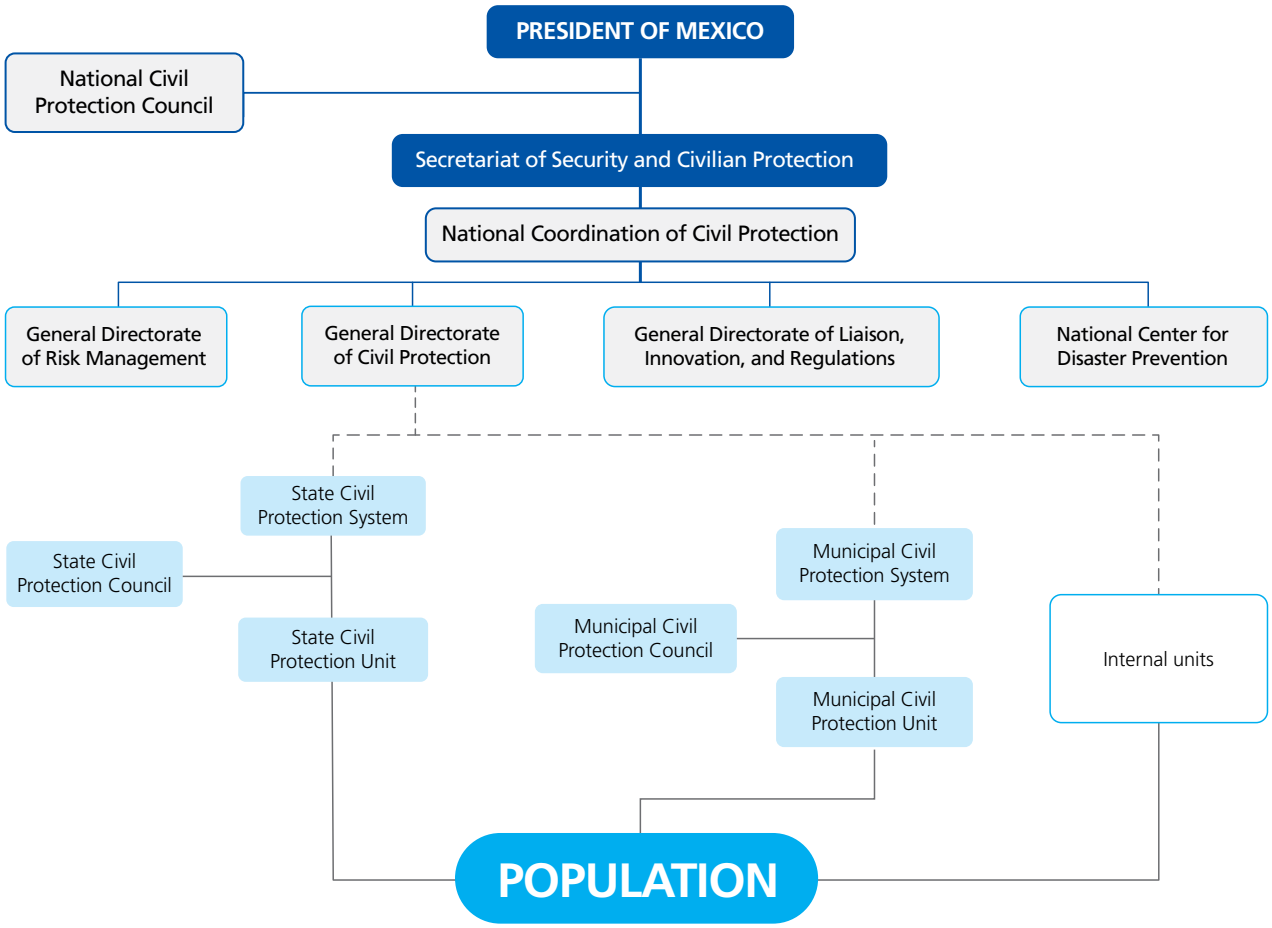
FIGURE 4

Comparison of maps of the 2007 and 2020 floods



Source: Geophysics RT, 2021

FIGURE 5
Structure of SINAPROC



SINAPROC 2021

Currently, the executive coordination of SINAPROC is the responsibility of the National Coordination of Civil Protection (CNPC), which reports to the Secretariat of Security and Citizen Protection (SSPC). This coordination is hierarchical, headed by the President of the Republic, with civil servants in the middle and the public at the bottom (see Figure 5).

The National Civil Protection Council is made up of the heads of the Ministries of State, the governors of the 32 states of the Republic and the board of directors of the Civil Protection Commission of the Chamber of Senators and Deputies. The head of the SSPC serves as executive secretary of the National Civil Protection Council and presides over it in the absence of the president. The head of the CNPC serves as technical secretary of the National Civil Protection Council (LGPC, 2012; LOAPF: DOF 20-10-2021).

The CNPC is responsible for coordinating civil protection actions among the three levels of government, which are vertically integrated under the principle of subsidiarity. Municipalities and states provide the immediate response to emergencies. However, if the municipality is overwhelmed in its response capacities it can request assistance from the state; in turn, the state can request federal resources when their capacity is surpassed (CONAGUA-federal interview, 2021; Escamilla, 2017; OECD, 2013).

Until December 2020, a state or federal agency could access federal support through the Natural Disaster Fund (FONDEN) in two ways:

1. "**Declaration of Emergency**" for relief and immediate attention to the population.
2. "**Declaration of Natural Disaster**" for damage to infrastructure.

Upon receiving the funds, the federative entity is responsible for its administration, as well as for attending to and supporting its population.

The public is part of SINAPROC. Although it is the main group to be protected, it is located in the lower part of the system (see Figure 5). In recent years, the participation of the public has been promoted throughout the disaster risk management cycle. However, prevention and resilience-building actions are still isolated, although reflected in community brigades, neighborhood groups and civil society organizations. The participation of the public is usually emergent during the response to emergencies.

State Civil Protection System in Tabasco

Civil protection systems were created following the SINAPROC structure. In the state of Tabasco, the first Civil Protection Law of the State of Tabasco was enacted in 1998, which established that among the functions to be fulfilled by the Civil Protection Coordination was the "coordination and execution of prevention, relief and recovery actions to face the consequences of a risk, emergency or disaster, ensuring the maintenance or prompt reestablishment of priority public services in the affected areas" (LPCET, 1998).

After the floods of 2007, and in accordance with the Civil Protection Law of the State of Tabasco, in 2011 it was agreed that the Civil Protection Master Plan of the State would serve as a guiding document

DECLARATION OF NATURAL DISASTER

Act by which it is recognized that, in the presence of a natural hazard, the state requesting [this declaration] has exceeded its local, financial, and operational capacity to *deal with the damage*.

DECLARATION OF EMERGENCY

Act by which it is recognized that one or more municipalities or municipalities of a state of the Republic are facing the imminent, high probability or presence of an abnormal situation generated by a natural hazard, and therefore it is required to provide *immediate assistance to the population* whose safety and integrity are at risk.

(DOF: 16/08/2021)

for public policies on civil protection aimed at promoting a culture of prevention and self-protection.

In 2015, the new Civil Protection Law of the State of Tabasco (LPCET) came into force. In addition, a decentralized public agency of the State Government, named the Civil Protection Institute of the State of Tabasco, was instituted, with administrative, budgetary, technical, managerial, operational and executory autonomy for the proper development of its functions (LPCET, 2015).

IPCET promotes proactive civil protection with a disaster risk management approach. Among its objectives are:

- Improve the Early Warning System;
- Expand and create Civil Protection services in the Tabasco State Risk Atlas Platform; and
- Open the National School of Civil Protection Tabasco campus (Master Program of the Civil Protection Institute of the State of Tabasco, 2019-2024).

Financial mechanisms for disaster relief in Mexico

In Mexico, financial mechanisms for emergency and disaster response have been available since the late 1990s. Until 2020, the federal fund for natural disasters (FONDEN) was financed under general branch 23 of the federal budget, which did not require allocations to correspond to direct spending by agencies and entities. Under FONDEN, it was possible to collect budgetary resources from year to year, without returning them to the federation even if they were not used in the corresponding fiscal year. In this way, it was possible to maintain the fund while not needing to manage an extra budget for emergency and natural disaster declarations. In 2021, FONDEN was replaced by the newly created Program for the Attention of Emergencies caused by Natural Hazards, with the purpose of responding to emergency declarations, financed by the current federal budget. If its resources are insufficient, the National Coordination of Civil Protection must manage an extension of the budget. And, on the

BOX 2. THE FOPREDEN

In 2003, the Fund for the Prevention of Natural Disasters (FOPREDEN) was created with the objective of providing economic resources for preventive actions including:

1. Risk identification;
2. Risk mitigation or reduction; and
3. Promotion of the culture of prevention and self-protection.

FOPREDEN, which is currently in force, is financed by the 23rd branch of the Federal Expenditure Budget, through which resources are earmarked for projects focused on preventive measures for risk reduction. Federal and state public agencies, public bodies and institutions, as well as academic and research institutions, can apply for support for the development of preventative projects. These include carrying out studies, analysis and research on issues related to risk management; studies and research to transfer knowledge, promote training and formulation of public policies and social programs on risk management to the competent authorities; as well as projects that contribute to greater effectiveness and usefulness of FOPREDEN, its financial instruments and its regulatory framework (DOF 6, 2010; GFDRR, 2012).

other hand, Declarations of Natural Disaster must be supported by the *Response to Damage caused by Natural Phenoma Program*, using funds from the 23rd general branch of the federal budget.

Flood risk management in Tabasco

In the Grijalva-Usumacinta basin, flood protection infrastructure and programs have been in place since the 1960s. Dams have been built in Chiapas, which generate electricity and mitigate flooding in both Chiapas and Tabasco.

According to the National Water Commission (CONAGUA), the dams located on the Grijalva River (Angostura, Chicoasén, Malpaso and Peñitas), constitute the main protection against floods in the Tabasco plain (Government of Tabasco, 2020). However, during the 2020 floods, when water was released from the "Peñitas" dam and diverted through the El Macayo floodgate to reduce the amount of water passing through Villahermosa and the industrial zone of Nacajuca, the water was directed instead towards the agricultural and livestock areas of Nacajuca.

Since the 1999 floods, the need to develop specific programs to mitigate the risk of flooding in the state was highlighted. The Federal Government, through CONAGUA together with the State Government, have been in charge of these programs.

The main infrastructure works that have been built in the state of Tabasco are:

1. Embankments to protect cities, neighborhoods, or rancherías.
2. Retaining walls to protect the population.
3. Marginal protections, including rockfill, gabions, sheet piling etc. as heavy rains and large river runoffs deteriorate riverbanks.

The construction of the El Macayo floodgate was completed in 2013. Closing this floodgate prevents flooding in Villahermosa and the industrial area as it controls the passage of excess water through the state capital (see Figure 1). The floodgate was used for the first time during the 2020 floods, protecting 80,000 people who would otherwise have been affected. However, although these infrastructure projects have been successful in reducing damage, PERC research highlighted two related issues:

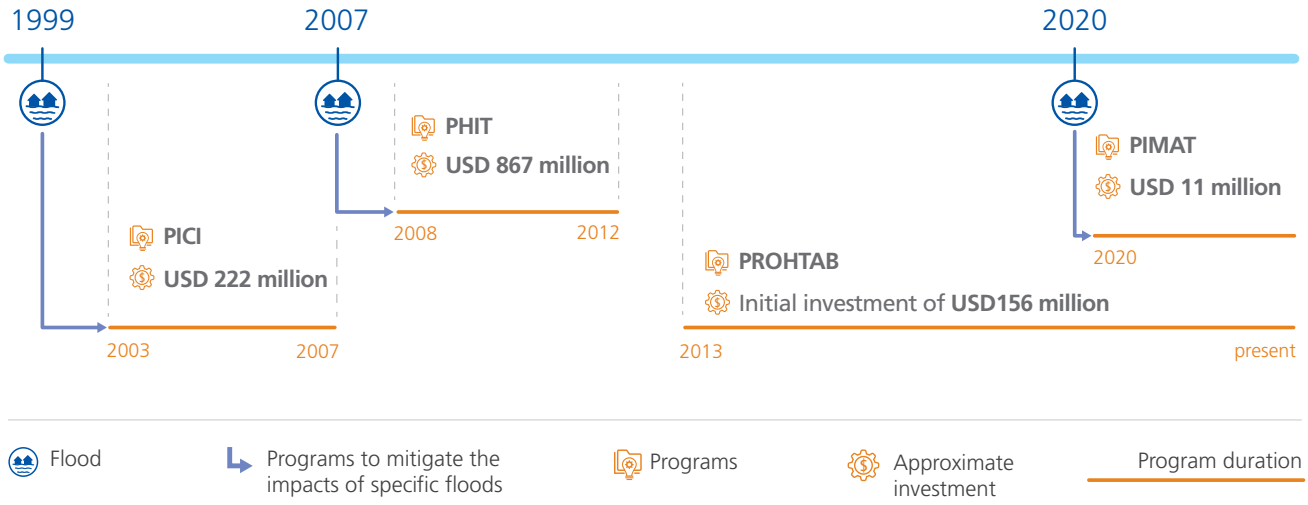
TABLE 3
Dams in Chiapas and Tabasco

Construction period	Dam
1960-1964	Malpaso
1969-1974	Angostura
1974-1980	Chicoasén
1979-1987	Peñitas

BOX 3. SUMMARY OF THE DISCHARGE OF THE "PEÑITAS" DAM

- Water was released to avoid a possible catastrophic overflow of the dam.
- The discharge of the dam caused the flooding of rivers and communities that had not been affected by the previous heavy rains/floods, and disproportionately affected the most vulnerable communities.
- It was necessary to release the water from the dam because the hydroelectric companies were keeping the water levels high in the dam and had not released the water in anticipation of the rains.

FIGURE 6
Infrastructure programs to mitigate the risk of flooding



Prepared with information from CONAGUA, 2012, 2015; Miranda, 2021.

> *2020 saw the results of these infrastructure works. In 2007, the historic part of Villahermosa was completely underwater, but in 2020, as a result of the works, the city, which is practically an island bounded by the Grijalva, Carrizal and Mezcalapa rivers, was only surrounded by water. It was seen that the works did work.*
>
> – PERC Interview

1) most of the work that was done in 2008 was not adequately maintained and 2) community members do not carry out flood prevention and preparedness actions because they rely heavily on existing infrastructure.

Some parts of the protective embankments, for example, were in poor condition. Especially in the suburb of Gaviotas – which was the most critical in Villahermosa – embankments they had constructed to protect the suburb broke allowing overflow from the Sierra River into the suburb. As evident in this example, hard infrastructure projects do not always work and they mitigate only part of the risk, which is problematic for communities unprepared for such an eventuality.

Tabasco's abundant natural capital is conducive to developing nature-based solutions, maintaining natural drainage, and leaving space for rivers, which presents a risk reduction opportunity for communities.

TABLE 4
Flood programs

Integrated Flood Control Program **PICI**	Integral Water Plan of Tabasco **PHIT**	Hydrological project to the public from flooding and improve water use in the state of Tabasco **PROHTAB**	Comprehensive Water Management Project **PIMAT**
2003-2007	2008-2012	2013-present	2021
Objective Protect the lowland areas of the state's plains, in particular Villahermosa and its surrounding area, from flooding due to the overflow of rivers. **Project** Construction of banks, canals and other works, including hydraulic systems in the Mezcalapa Samaría, Ríos de La Sierra, and Carrizal Medellín Systems.	**Objectives** 1. Reduce the conditions of risk and vulnerability of the population, including to economic activities and ecosystems in the face of extreme hydrometeorological events and possible effects of climate change. 2. Establish medium- and long-term strategic guidelines in order to plan structural and non-structural actions for the management, utilization and conservation of the state's water resources and associated natural resources. PHIT is considered to be an extension of the PICI, taking into account socio-economic and environmental aspects.	PROHTAB was established in 2013 as an agreement between the government of the state of Tabasco and CONAGUA, to give continuity to PHIT. **Project** 185 works and actions in the Mezcalapa Saloya, Chilapa-Usumacinta, Carrizal-Viejo Mezcalapa, Ríos de la Sierra-Bajo Grijalva, and Mezcalapa Samaria river systems.	The Agency of the Southern Border Basin of the CONAGUA Directorate in Tabasco presented the PIMAT technical sheet. CONAGUA-allocated budget to carry out scoping studies for the construction and rehabilitation of infrastructure to protect against the overflow of dams, rivers and streams. This project will be complementary to PROHTAB, since the scope of activities and work are independent.

Prepared with information from CONAGUA, 2012, 2015; Miranda, 2021.

SECTION III
WHAT HAPPENED

Early warning system and dams

During October and November, the National Meteorological Service (SMN), in coordination with CONAGUA, issued warning bulletins for states where rivers had overflowed their banks and heavy rains had occurred. Meetings were also held with Civil Protection entities to provide information to communities without internet access so that they could evacuate; house-to-house visits were made if necessary. In some communities, community brigades facilitated the dissemination of early warnings through bulletins and megaphones, and implemented protective measures. They also monitored rivers using hydrometric scales painted on wooden stakes or trees (Mexican Red Cross, 2021).

While warning messages were successfully disseminated and received in some areas, interviewees and PERC research highlight that gaps remain in the early warning system. While technical components of the early warning system exist, communication and education in risk management needs to be improved, especially in order to reach the most remote communities.

In addition, while there are early warning systems for potential river flooding based on rainfall, there is no such warning system for dam overflows, a critical gap that has the potential to influence the impact of flooding in Tabasco. In particular, this gap is understood to have impacted the 2020 floods, since 28% of the rivers that run through the Tabasco region are controlled by dams (La Jornada 2020).

Emergency response and early recovery

Mexico's strong institutional structure for emergencies and recovery was reinforced by international assistance and from assistance from across the country, resulting in immediate and significant response to the floods. Federal, state and local actions were coordinated to respond to the emerging needs of the affected population, contributing to what key stakeholders considered to be a historic emergency response to the 2020 floods, especially because it took place in parallel to the global health response triggered by COVID-19.

Due to the severity of the crisis, the National Coordination of Civil Protection issued several Declarations of Emergency for immediate attention (see Table 5), as well as to deal with the damage from disasters (see Table 8).

TABLE 5
Declarations of Emergency

Date	Municipalities
14 October 2020	Cunduacán Jalpa de Méndez Nacajuca Centro Balancán Jalapa Tacotalpa Teapa
20 October 2020	Macuspana
9 November 2020	Cárdenas Centro Comalcalco Cunduacán Jalapa Jalpa de Méndez Macuspana Nacajuca

Source: DOF 3, 4, 5, 2020

Initial emergency response actions focused on: 1) evacuation and clean-up; 2) shelter management; and 3) humanitarian aid.

Evacuation and clean-up

Support by government actors during and immediately after the floods included evacuation, relocation of household possessions, assessment flights to identify needs, patrol and surveillance operations, and street cleaning. Water response teams were transported from Sinaloa, Oaxaca, Yucatan, Campeche, Quintana Roo and Mexico City via a Secretariat of National Defense (SEDENA) Hercules airlift and by land. The emergency operation began on November 1, 2020 and occurred mainly in the municipalities of Centro, Emiliano Zapata, Jalpa de Méndez, Jonuta, Macuspana, Nacajuca and Tacotalpa. Thirty brigades of Infrastructure Protection and Emergency Response (PIAE) were mobilized, using 40 different types of equipment. Water pumping operations were established in critical areas. Community members supported the response by monitoring the equipment and accompanying the pump operators, always alert to the need to mobilize water hoses or other equipment (PERC interview; Government of Mexico, 18/12/2020).

After removing water from the streets, the municipality carried out a clean-up before residents were allowed to return to their homes. CONAGUA finished cleaning the area in January 2021, benefiting 127,900 inhabitants in various municipalities of Tabasco (Milenio, 2021).

While the federal and state government response was effective, PERC research illustrated that the emergency initially overwhelmed the local level, which had insufficient staff and equipment to respond to the emergency, as reported by the Tabasco Red Cross Delegation. However, coordination between Mexican Red Cross (CRM) delegations helped to address these needs with volunteer response personnel and additional vehicles which arrived in Villahermosa from other states in late November and supported the response until early December.

Shelter

As a preventive measure, Civil Protection together with SEDENA and the Secretariat of the Navy (SEMAR) conducted field visits in potentially flood-impacted areas to coordinate temporary shelters in several municipalities.

TABLE 6
The response in Tabasco

Activity	Benefits
Evacuation	Ten thousand people evacuated
Relocation of household belongings	360
Needs assessment flights	27
Street cleaning	44 kilometers

Source: Government of Mexico, 18/12/2020

When the emergency occurred, the governor of the state of Tabasco, Adán Augusto López Hernández, urged the population to evacuate the affected areas and requested the installation of shelters. Through the Declarations of Emergency, it was possible to access resources from the Fund for Natural Disasters (FONDEN), which allowed the evacuation of the population from the affected areas and the set-up of shelters. Together with the Secretariat of Health, Civil Protection coordinated the installation of temporary shelters in the required areas, establishing 412 official and 29 unofficial shelters (Government of Mexico, 18/12/2020).

Due to the COVID-19 pandemic, officials maintained strict health protocols in the shelters, including the distribution of masks and antibacterial gel, the provision of medical examinations and COVID-19 tests, and the restriction of the number of unrelated persons permitted in the same space, i.e. one family per room. As a result of the latter stipulation, more space was required for shelters. In addition, specific shelters were set up for people diagnosed with COVID-19 and the Secretariat of Health generated a daily bulletin with the information provided by each health jurisdiction through the Health Emergencies Information System (SIESA), and captured the activities that took place in the temporary shelters.

Once shelters were opened, an important step was taken by the Ministry of Health to carry out activities to benefit the health of the sheltered population, which consisted mainly of women and children, as men generally stayed to protect their homes. For example, the Ministry of Health provided medical and psychological care, vaccinated people against influenza, and sprayed air sanitizer to prevent epidemiological outbreaks caused by the vectors that cause dengue, zika, and chikungunya. In addition, medical consultations were provided to treat acute respiratory infections, mycosis, hypertension, diabetes and dermatosis, and talks were given on gender and alcoholism prevention. Sheltered populations were also offered sports activities, training on hygienic practices and advice for when they returned to their homes (PERC interview; Tabasco.gov.mx; Telereportaje 2020).

Humanitarian Aid

The government, international organizations and non-governmental organizations (NGOs), the private sector and the international community mobilized to provide humanitarian assistance in the aftermath of the floods. This included provision of relief goods and supplies, as well as logistical support and financial donations.

The Mexican Red Cross

Mexican Red Cross relief staff from the Tabasco Delegation and volunteers assisted in conducting Damage and Needs Assessments (DANAs). Based on the information gathered, the Mexican Red Cross was able to provide a rapid humanitarian response

by distributing food, hygiene kits, cleaning kits and medicine[1] to families in need in 44 communities. They also adapted their response to COVID-19 protocols: instead of distributing aid centrally, which could have resulted in mass gatherings, aid was delivered house-to-house, wearing masks and using antibacterial gel in compliance with COVID-19 guidelines (PERC interview).

Compared to the 2007 flood, in which 60% of humanitarian assistance was distributed by the Mexican Red Cross, in this instance, the government took a greater role in distribution, especially in the delivery of aid to shelters. PERC research also indicates that lessons learned from the 2007 floods, particularly in regard to the duplication of aid delivery which reduced its effectiveness, helped improve aid distribution systems. Databases and censuses are now in place to avoid duplication of aid, and surveys help to capture basic family information on mobile phone devices which is later downloaded to a server, allowing for accurate knowledge of the number of families, children, people with disabilities, older people and other demographics, who were affected and in need of assistance (PERC interview).

Government of Mexico

At the governmental level, and in all municipalities, the Secretariat of National Defense (SEDENA) organized humanitarian aid in Tabasco as detailed below.

Governmental aid also included the provision of household goods (refrigerators, stoves, fans, pans, mattresses etc.) and the delivery of 10,000 Mexican pesos per affected household for sanitation and rehabilitation work (Government of Mexico, 18/12/2020).

TABLE 7
Distribution of humanitarian aid in Tabasco by the Government of Mexico

Beneficiaries/Support	Tabasco
Municipalities	17
Communities	946
Families	200,400
Individuals	812,308
Community kitchens	18
Hot meals distributed	587,453

Source: Government of Mexico, 18/12/20

International organizations and NGOs

Since 2016, a cooperation agreement has been in place between the United Nations Development Programme (UNDP), the United Nations Population Fund (UNFPA) and the Government of Tabasco for capacity development. As part of this agreement, UNDP provided support during the 2020 floods via capacity building and the distribution of humanitarian aid. For example, work teams were established within the State Civil Protection in coordination with federal agencies to generate

1 Zurich Mexico arranged funds with its foundation (Z Zurich Foundation) for the distribution of medicine.

Delivering humanitarian aid in the 2020 floods in Teapa, Tabasco © By Javier Lara, Head of Disaster Preparedness and Training, Mexican Red Cross

information based on flood susceptibility maps and self-assessment of damage and losses in rural and indigenous communities. Field workers were also mobilized to the three communities in Tabasco that suffered the greatest damage, benefiting a total of 12,500 people. In these communities, assessments were carried out and humanitarian aid (water, food and medicine) was provided. Subsequently, UNDP provided support with cleaning brigades and delivery of supplies, seeds and livestock to strengthen the livelihoods of the communities (PERC interview; Global Compact Network Mexico 1).

UNICEF also contributed through donations to Civil Protection Tabasco and the State Secretariat of Education. Donations included: 36,260 litres of drinking water in 10-litre bottles, cleaning supplies (520 kg of soap powder, 1,170 litres of chlorine, 520 litres of multi-purpose cleaner), nine early childhood kits to benefit 387 children in shelters and 2,000 blankets (Pacto Global Red México 2).

World Vision, The International Organization for Migration (IOM) and the United Nations Refugee Agency (UNHCR) also delivered humanitarian aid. The latter two institutions focused their efforts mainly on migration issues, but also contributed humanitarian aid in the shelters (PERC interview).

Other

Donations were also received from the private sector, including: Walmart Group, Televisa Foundation, BBVA, Iberdrola, Grupo Marítimo Industrial, Grupo Gesber and INAI, Producers, Ranchers and Industrialists of Ojo de Agua, Heineken, Grupo Corrado and Nestlé. Donations were also received from foreign governments such as: Germany, Russia, Turkey, Poland and Israel (Government of Mexico, 18/12/2020).

Reconstruction and prevention

The Government's investment covered planning for reconstruction and committed resources to prevention as detailed below:

Reconstruction (Government of Mexico, 18/12/2020):

- 4,316 million Mexican pesos managed by SEDATU for urban equipment, parks, housing, schools.
- 4,302 million pesos managed by the Secretariat of Communications and Transportation, primarily for the reconstruction of road infrastructure.
- 1.2 billion pesos managed by CONAGUA for reconstruction and prevention.

Prevention (Government of Mexico, 18/12/2020):

- 2,279 million pesos from CONAGUA for the hydraulic rehabilitation and reinforcement of water embankments.
- 1,130 million pesos for the Secretariat of the Navy for dredging of different bodies of water.

Infrastructure

Historically, dam infrastructure has been built to manage river flows; however, as the floods of 2007 and 2020 demonstrated, they are only successful to a certain extent and, in some cases, do not help at all. The release of water from the "Peñitas" dam, for example, illustrates how dam management can increase flooding in at-risk areas and highlights the need for a more proactive and holistic approach to decision-making that takes into account the dam as part of the river system and surrounding communities.

In December 2020, a presidential decree created the Grijalva River Dam Management Commission. It establishes the agencies, entities, and coordination measures by which the Federal Public Administration manages dams and the reduction of flood disasters in the Grijalva River basin, and their relationship in the control and dispatch of the generation of electricity, with an eye towards social and civil protection (DOF 1 & 2, 2021). Additionally, in 2021, the Commission announced the installation of a monitoring and warning system based on short-term weather forecasts. This system allows for real-time adjustment of the dam's water reserves to prevent flooding. The system also favors

TABLE 8
Declarations of Natural Disaster

Date	Municipalities
9 November 2020	Cárdenas Centro Comalcalco Cunduacán Jalapa Jalpa de Méndez Macuspana Nacajuca
20 November 2020	Teapa Huimanguillo Tacotalpa
23 November 2020	Balancán Centla Emiliano Zapata Jonuta Tenosique

Source: DOF 7, 8, 9, 2020

> *Historically, dam infrastructure has been built to manage the flow of rivers but flooding continues because what is required to reduce the vulnerability of the area is to look at the problem holistically and not just as a matter of building infrastructure.*
>
> – PERC Interview

hydroelectricity, with 56 hydrometric stations operated by the Federal Electricty Commission (CFE) and 394 by CONAGUA (Mexico Business News, 2021).

In response to the 2020 floods, CONAGUA also designed the Tabasco 4T Water Protection Plan. This plan seeks to manage dams in a "proactive and non-reactive" manner while managing water flow in a way that avoids siltation or erosion of rivers. It also intends to rehabilitate the cut-offs and protection banks of the Grijalva River and the El Macayo floodgate and, in collaboration with the Secretariat of the Navy, to carry out the dredging of the Grijalva River (PERC interview; Government of Mexico, 18/12/20).

River dredging

According to the Secretariat of the Navy, 130 billion Mexican pesos have been committed to the dredging of the river, which is a long-term project that will be implemented in three stages and which will be completed in 2023. As part of the mitigation approach, the rivers are to be dredged in accordance with the specific needs of inhabitants; namely, focusing on sections that particularly impacted certain communities. In the aftermath of the 2020 floods, a comprehensive river drainage program for the Grijalva River was proposed to support the free flow of water. The 2021-2023 river drainage program proposes to de-silt a total of 313 kilometers; with a suggested additional 900 kilometers, which is what CONAGUA has determined is necessary. River dredging will support water draining from the dams.

Delivery of household goods in the ranchería La Unión, Jalapa, Tabasco © Romelia Márquez Cardoza, resident of the community

Housing

Housing reconstruction in Tabasco is a controversial issue. Key informants interviewed for this study recommended focusing on a "new housing model" that is flood-resistant and does not replicate the same housing structure impacted by the floods in Tabasco. Examples of this alternative housing model include building with *palafitos*, as was done by ancestral populations in coastal areas where pillars were used to elevate housing, or *tapancos*, which are houses built with high roofs and attics; where people can move their belongings to in case of flooding.

The Government of Tabasco is already promoting a stilt house program in the El Zapote ranchería, municipality of Nacajuca, where 120 stilt houses are being built (La Verdad 2022). Habitat for Humanity is also supporting a pilot project to build 20 raised housing units in the municipality of Jonuta (Habitat for Humanity Mexico, 2021).

Land use planning

Land use planning, led by the Secretariat of Agrarian, Land and Urban Development (SEDATU), includes the coordination of a State Program for Sustainable Development in the state of Tabasco. This program seeks to coordinate the responsibility of the territory and natural water boundaries with state and municipal governments, with the purpose of mitigating and managing risk. To this end, 17 Municipal Urban Development and Land Management programs will be updated with an investment of 30 million Mexican pesos (SEDATU, 2021). As of October 30, 2021, SEDATU and the Government of the State of Tabasco have initiated the State Council for Land Use and Urban Development, with the new local authorities of the 17 municipalities. Consultations are planned to be held until April 2022 to develop three specific programs:

- Land use planning program for the south-southeastern region
- State program for land use planning and urban development
- Municipal land use planning and urban development programs (SEDATU, 2021).

> *"The territory is one, so environmental, territorial and urban dimensions, the watershed approach, integrated risk management, heritage, agricultural productive activities, community aspects, among others, should all be considered in a systematic and integrated manner to acheive the development of the territory in terms of its management and to contribute consistently to the welfare of the inhabitants of the region.*
>
> – SEDATU, 2021
> Undersecretary of Land Management,
> David Cervantes Peredo

SECTION IV
KEY POINTS

Mexico has a strong institutional structure to respond to disasters. Since the 2007 floods, flood response has improved.

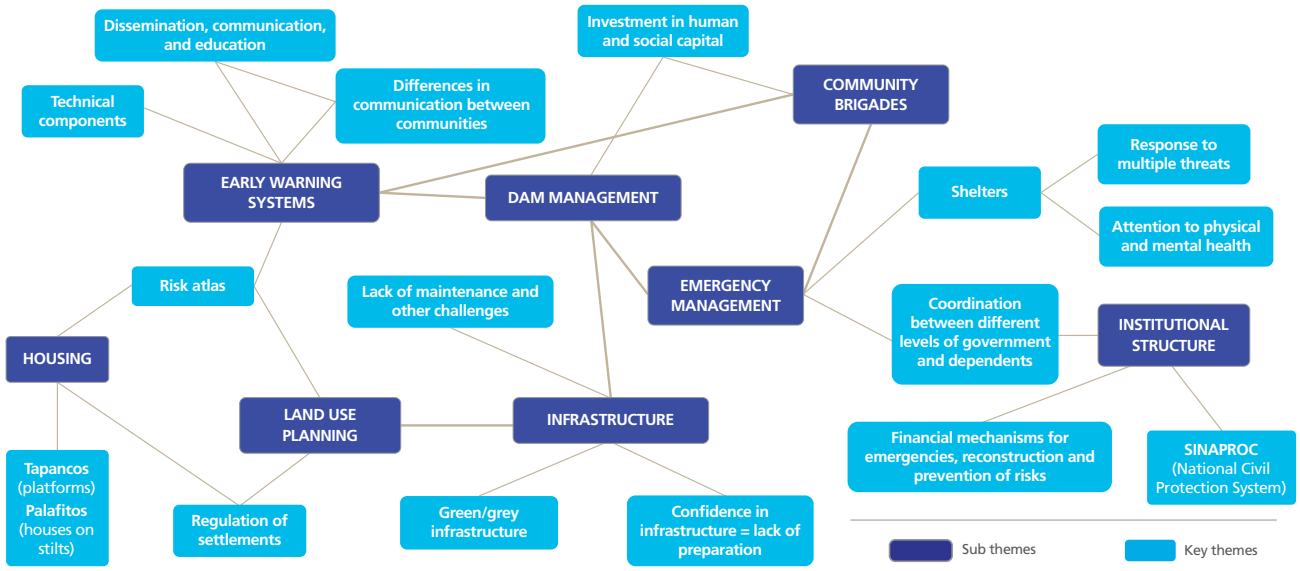
- The National Civil Protection System (SINAPROC) has evolved from providing a reactive response to risk management, enabling the reduction of damages and impacts.
- An emergency response protocol was established outlining the coordination of tasks between the different levels of government and agencies.
    - In 2020, the majority of humanitarian aid was delivered through the funds managed by the Mexican government and was complemented by the support of the Mexican Red Cross, unlike during the 2007 floods, when, because of the lack of coordination and management, a higher percentage of the affected population was primarily served by the same institution.

Financial mechanisms were created for emergency response, reconstruction, and prevention.

- Resources to provide immediate relief to the population (evacuation and humanitarian aid) are delivered expeditiously via emergency declarations through the Natural Hazards Emergency Response Program.
- Resources for the reconstruction of infrastructure are released through declarations of natural disasters through the execution of the Response to Damage caused by Natural Phenoma Program. The objective of these funds is to finance programs that reduce vulnerabilities to future threats.
- Resources for the development of preventative actions such as the identification and reduction of risks, and to promote a culture of prevention and self-protection are released through the National Fund for the Prevention of Natural Disasters (FOPREDEN).

FIGURE 7

Central themes in the management of the 2020 floods



Tabasco has made significant investments in grey flood protection infrastructure. These investments have helped to reduce flood impacts, but the 2020 hydrometeorological events highlighted that:

- Grey infrastructure requires constant maintenance for it to function properly and it can only mitigate part of the risk.
- In some localities, community members place full confidence in existing infrastructure, and therefore do not carry out prevention and preparedness actions in case of floods. Community members need to know how to respond and what to do to reduce flood impacts in the event that infrastructure fails due to a lack of maintenance or because its threshold has been exceeded.

Different housing designs/models are needed in Tabasco to make houses more resilient to flooding. In the past, ancestral and alternative housing models such as *tapancos* (platforms) and *palafitos* (houses on stilts) have been used in Tabasco.

The floods illustrated that communication and coordination among decision-makers are critical for effective dam management. In December 2020, the Grijalva River Dam Management Commission was created to strengthen coordination among agencies and entities involved in dam management to determine the volumes of water released and the reservoir levels required to ensure people's safety.

Technical components of the early warning system exist, and bulletins and messages were disseminated and received in some areas. However, there are still gaps in the early warning system, which requires improvements in the communication strategy, especially to reach more remote communities. Additionally, there is also no warning system for dams, a critical gap that influenced the 2020 floods.

Taking into account the context of the COVID-19 pandemic, the flood shelters were well managed. The Ministry of Health carried out activities in support of general physical and mental health in parallel with COVID-19 specific precautions. For example, the Ministry of Health provided influenza vaccinations and conducted spatial spraying of disinfectant to prevent epidemiological outbreaks. Medical consultations were provided to treat acute respiratory infections, mycosis, hypertension, diabetes and dermatosis. In addition, talks were given on gender issues and prevention of alcoholism.

The distribution of humanitarian aid by the Mexican Red Cross was more efficient than in the 2007 floods. Surveys captured basic family information on mobile phone devices which was later downloaded to a server and contributed to the creation of databases and censuses which helped to avoid the duplication of aid. This made it possible to know the exact number of families, children, people with disabilities, and elderly who were affected and needed help.

The land use planning process, coordinated by the Secretary of Agrarian, Territorial and Urban Development (SEDATU), is an opportunity to re-think land-use with a basin-wide approach. It is also an opportunity to instruct on how to "build better" in terms of flood resilient infrastructure and housing.

BOX 4. PROGRESS OBSERVED

Management of the 2020 floods

- The State Council of Civil Protection held daily meetings to review emerging issues and to coordinate emergency operations among the different sectors involved. They also carried out the actions necessary for extracting flood water and protecting the public.
- Coordination between the different levels of government and institutions involved in risk management was remarkable. The PERC review shows a notable improvement in inter-institutional coordination compared to 2007. Coordination is based on the legal foundation underpinning the National Civil Protection system in Mexico.

Emergency shelters

- The emergency occurred in the midst of the COVID-19 pandemic. Shelters were considered to be well organized, despite the fact that the situation was unprecedented. For example, the officials maintained strict sanitation protocols.
- The Ministry of Health successfully carried out complementary measures to benefit the health of those staying in the shelters. For example, the Ministry of Health provided ongoing medical and psychological care, vaccinated people against influenza and conducted spatial spraying of disinfectant to prevent possible outbreaks of dengue, zika, malaria or chikungunya.

Community brigades

- In recent years, communities have participated in the disaster risk management cycle through community brigades, neighborhood groups, and civil society organizations.
- In the 2020 floods, for example, the community brigades facilitated the dissemination of early warnings and monitored the river using hydrometric scales painted on wooden stakes or trees.

SECTION V
RECOMMENDATIONS

1

Improve early warnings so that they reach the most remote communities.
The technical components of the early warning system exist, but dissemination, communication and risk management education need to be improved, especially to reach the most remote communities.

What is needed?

- A comprehensive training program for both urban and rural populations where experts in early warning management explain in detail, using non-scientific language, how early warnings work. The training components should include dissemination and communication campaigns that involve traditional media such as radio and television, but also social networks (WhatsApp, Facebook, Twitter), podcasts and websites.
- Citizen science: train the public to record and monitor rainfall locally as part of a participatory monitoring network that shares information to contribute to the effectiveness of early warning systems, following the example of the MOP Rímac Network in Peru (See Box 4).

Expected results

- Urban and rural citizens will be better informed about the components of the early warning system and can respond more quickly in the event of an emergency.
- An active population that can collaborate with national authorities by providing data that complements official hydrometeorological data.

2007 floods in Villahermosa, Tabasco © Mexican Red Cross photo archive, 2007

BOX 4. PARTICIPATORY RAINFALL MONITORING NETWORK IN THE RÍMAC RIVER BASIN (MOP RÍMAC NETWORK).[2]

Citizen science is a form of collaboration in which lay volunteers actively participate in scientific research, contributing to joint knowledge to address problems in their environment.

The Participatory Monitoring Network of the Rímac River Basin (Red MOP Rímac) in Peru was created with the objective of recording local rainfall information in several different districts of the basin and collaborating with national authorities. The Rímac MOP Network is made up of members of the communities living in and around the Rímac river basin. Community volunteers are trained to measure rainfall using handmade rain gauges, complementing data from national monitoring networks and other sources. The active participation of community members who are exposed to risk and have local knowledge about the areas in which they live provides both communities and authorities with a more complete picture of risk, which can help make early warning systems more effective.

2 https://infoinundaciones.com/noticias/capturando-informacion-valiosa/

2 **Go beyond grey infrastructure.** While grey infrastructure helps in mitigating risk, as illustrated by the 2020 floods, it has limitations insofar as it manages to mitigate only part of the risk. These limitations include: lack of maintenance, hard thresholds that can have devastating consequences when exceeded, and a false sense of security. Integrating green infrastructure[3], such as bio-dikes and natural buffer zones, into flood risk management can minimize some of the challenges of grey infrastructure and can help to broaden the approach to risk mitigation in the state of Tabasco. Green infrastructure projects can also have a high return on investment, as they can also provide co-benefits for the social welfare of the local community.

What is needed?

- Studies of where and how green infrastructure can be integrated with, or replace, grey infrastructure. This includes understanding how nature-based solutions can be successfully implemented (e.g. through community ownership).
- Investment in grey and green flood risk management infrastructure.
- Capacity and skills to build a system for flood risk management where grey and green infrastructure are integrated.
- Training for community members on the limitations of infrastructure and how they can prepare and protect themselves.

Expected results

- Financial support for flood risk management plans including grey and green infrastructure.
- Implementation of flood risk management plans.
- Increased citizen awareness of necessary actions to be taken before and during a flood in the event that protective infrastructure fails.

3 Green infrastructure also has limitations, including having thresholds and providing a false sense of security; however, knowing its limitations in advance and integrating it into a holistic flood risk management approach can minimize these limitations.

2007 Floods in Villahermosa, Tabasco © Mexican Red Cross photo archive, 2007

3

Investing in social and human capital. Governments, communities and other interested stakeholders should develop complementary risk reduction capacities, particularly the human and social capacities of communities. Developing the knowledge, education, skills and health of community members while strengthening social relationships and networks can help address flood risk along with long-term participatory projects focused on prevention. Opportunities to increase social and human capital include:

- Recognizing that building human and social capital in communities requires investment: disaster risk reduction budgets should be allocated to fund capacity building efforts at the community level.
- Establishing a broad network of community brigades and strengthening existing ones.

What is needed?

- Allocation of disaster risk reduction budgets to finance development efforts. Capacity building (knowledge, skills, etc.) at the community level.
- Training on how to create and strengthen brigades.
- Resources and training on evacuation, emergency shelters, and first aid for brigades.

Expected results

- Improved knowledge, education, skills and health of community members at risk of flooding.
- Strengthened social relationships and networks among community members, as well as building connections between the members of the community affected by the floods and external actors and support organizations to strengthen the exchange of and access to ideas and resources.

4 **Investigate alternative housing models.** Experience has shown that the current design of housing in Tabasco is not flood resilient. To minimize both losses and damage to housing and community assets, it is recommended that alternative construction models be considered.

What is needed?

- The Government of Tabasco is already promoting a program in the El Zapote ranch in the municipality of Nacajuca, where 120 stilt houses are being built. Habitat for Humanity is also supporting a pilot project to build 20 elevated houses in the municipality of Jonuta. Using these projects as references, it is recommended to continue with this construction plan. Historically, the population of Tabasco used *tapancos* and embankments in and around their homes, and these models can also be considered.
- Include flood-resilient housing as a priority in land use planning.

Expected results

- Tabasco has flood-resilient housing and avoids loss of homes, belongings, and community assets.

5 **Follow land management policies.** Disorganized urban sprawl resulting from irregular settlements in at-risk areas has contributed to flooding in Tabasco. Governments, communities, civil society and the private sector must be part of the participatory planning for the management of their land.

What is needed?

- Update information in municipal risk maps to identify flood risk areas.
- Provide training to the population on the use of risk maps.
- Participate in forums for citizen consultation on land use planning.

Expected results

- Consensus between different social actors for land use planning based on informed decisions.
- Increased awareness of the public on deciding where to live and/or adapting spaces for flood risk reduction.

6

Create an approach to dam management with public participation. Dams are fundamental for development since they generate part of the country's electric power; are sources of drinking water, and water for agricultural, urban, and industrial uses; and contribute to flood control and flood reduction in some areas. However, their operation can be improved and alternatives sought for populations that suffer flooding when the dams release large amounts of water.

What is needed?

- Surveillance and monitoring of dam activity. Direct observation with regular visits, or a population trained in dam observation, can accomplish this task.
- Adequate communication and coordination among decision-makers on the operation of dams.
- Inform the public about dam management decisions so that they know what to do in case of flooding.
- Convene communities living in surrounding areas to learn about their perceptions of dams, and how they act with respect to the dams, with the goal of informing emergency plans.

Expected results

- A population that participates in the surveillance and monitoring of the situation of dams.
- Emergency plans for dams that are agreed upon between decision-makers and the public.
- Protocols for action in the event of intentional release of water or dam overflow.

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