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Institute of Human Factors and Technology Management IAT

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IMPLAN
INSTITUTO MUNICIPAL DE PLANEACIÓN SALTILLO

CITY LAB SALTILLO, MEXICO

CLIMATE RISK AND RESILIENCE ASSESSMENT

FULL VERSION AND RESULTS

Photo: Markus Schwegler

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GLOBAL APPROACH – LOCAL SOLUTIONS

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1 INTRODUCTION

Climate change represents one of the major global challenges of this time with immense impacts on urban life. Due to population growth and rapid urbanization it is projected that 70% of the world's population will be living in cities by 2050 (United Nations 2015). The United Nations further acknowledge the wide scope and scale of climate change impacts, ranging from shifting seasons and more extreme weather events to rising sea levels which increase the risk of flooding and inundation. These risks are especially threatening in places with low adaptation capacity and a lack of essential infrastructure and services (Aziz et al. 2018).

To combat climate change and to accelerate actions and investments required for a more sustainable and resilient future, several international policy frameworks have been developed over the years. At the United Nations Framework Convention on Climate Change of the Conference of the Parties (COP21) held in Paris in December 2015 for instance, cities were recognized as key actors in both mitigation and adaptation to climate change, encompassing low emission developments and increased urban resilience (United Nations-Framework Convention on Climate Change 2016).

Because of its topography, geographical location and socioeconomic characteristics, Mexico is extremely vulnerable to climate change. The country has experienced changes in mean precipitation and temperature over the past 50 years. Besides, extreme weather events such as floods, droughts, and tropical cyclones have occurred more frequently costing loss of human lives, and social and economic damages.

In the international sphere, Mexico ratified the Paris Agreement on climate change in 2016. In the country's Intended Nationally Determined Contribution 2020-2030 (INDC), presented in March 2015, Mexico committed to reduce its greenhouse gas (GHG) emissions by 22% and black carbon emissions by 51% as part of their unconditional goals (INDC 2015). In order to meet these targets, the participation of different sectors, such as energy, industry, agriculture and transport is needed. In early 2021, Mexico submitted its updated NDC, yet merely ratifying the mitigation commitments established in 2015 and not increasing the ambition level beyond it. Thus, Mexico's GHG emission reduction target remains to be an unconditional reduction of 22% in GHGs emissions by 2030 as compared to the baseline.

On the local level, the Municipal Planning Institute of Saltillo (IMPLAN) worked towards finalizing the Municipal Climate Action Plan (PACMUN) in 2021, which aims to include a diagnosis of the impact of climate change in Saltillo comprehending a vulnerability and risk analysis, as well as proposals for climate change mitigation and adaptation strategies. Furthermore, climate change related concepts and actions are expected to be included in the Urban Development Master Plan for the next administration (2022-2024).

The Morgenstadt Global Smart Cities Initiative (MGI) is an international development co-operation project funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety through the International Climate Initiative (IKI). It aims at inducing transformational change towards sustainable urban development in the partner cities Kochi (India), Piura (Peru) and Saltillo

(Mexico), especially with regards to mitigation and adaptation to climate change. To achieve this, a thorough analysis of the urban system, as well as the identification, and development of sustainable cross-sectoral solutions together with key local stakeholders has been conducted in each of the cities following the Morgenstadt City Lab approach (Morgenstadt Global Smart Cities Initiative 2020).

As a part of the City Lab Saltillo, a risk and vulnerability assessment for climate change impacts was carried out, including a literature review and an expert evaluation conducted by both local and city lab experts. It focused on six risk clusters, which were perceived as most critical for the city - namely heavy rainfall and stormwater flooding, snowfall and frost, temperature rise and urban heat islands, water scarcity and droughts, forest fires, as well as the change in the biological system.

It also assessed the adaptation measures that the city of Saltillo has already implemented to deal with these risks. The research was developed in close collaboration with the Municipal Institute of Planning of Saltillo (IMPLAN) which contributed with updated information and valuable insights.

This report presents the applied assessment framework, the methods used, as well as the full analysis results. It ends by summarizing overarching insights and recommendations and links the assessed climate risks and vulnerabilities to the project ideas that have been developed within the City Lab process. Moreover, a set of indicators is suggested that can be used to evaluate the contributions such projects potentially have in building up resilience towards the discussed climate risks.

2 FRAMEWORK AND DEFINITIONS

In the following, the results of a climate change risk and resilience assessment Saltillo are presented. Climate change impacts are thereby understood as the effects of extreme weather and climate-related events on human or natural systems, whereas risks are defined as potential consequences of hazardous events. Figure 1 summarizes the applied assessment framework. The following factors are considered, in close accordance with the IPCC framework for identifying key risks and vulnerabilities (Oppenheimer et al. 2014):

Magnitude and intensity: measure of how strong the impact and consequences will be.

Probability and frequency: measure of how likely and often a hazard will occur.

Irreversibility and persistence: measure of how permanent the effects will be and if they can be reversed/corrected.

Exposure (temporal and spatial): measure of how exposed a community or socio-ecological system is to climatic stressors and hazards at hand.

Susceptibility: measure related to the individual preconditions that make communities or socio-ecological systems highly susceptible to additional climatic hazards or that reduce their adaptive capacity.

Adaptive capacity: measure of the ability of a system to adapt and respond to the risk at hand to avoid and moderate potential damages, to take advantage of opportunities, or to cope with the consequences.

Climate Change Adaptation (Measures): "anticipating the adverse effects of climate change and taking appropriate action to prevent or minimize the damage they can cause, or taking advantage of opportunities that may arise" (European Commission 2020).

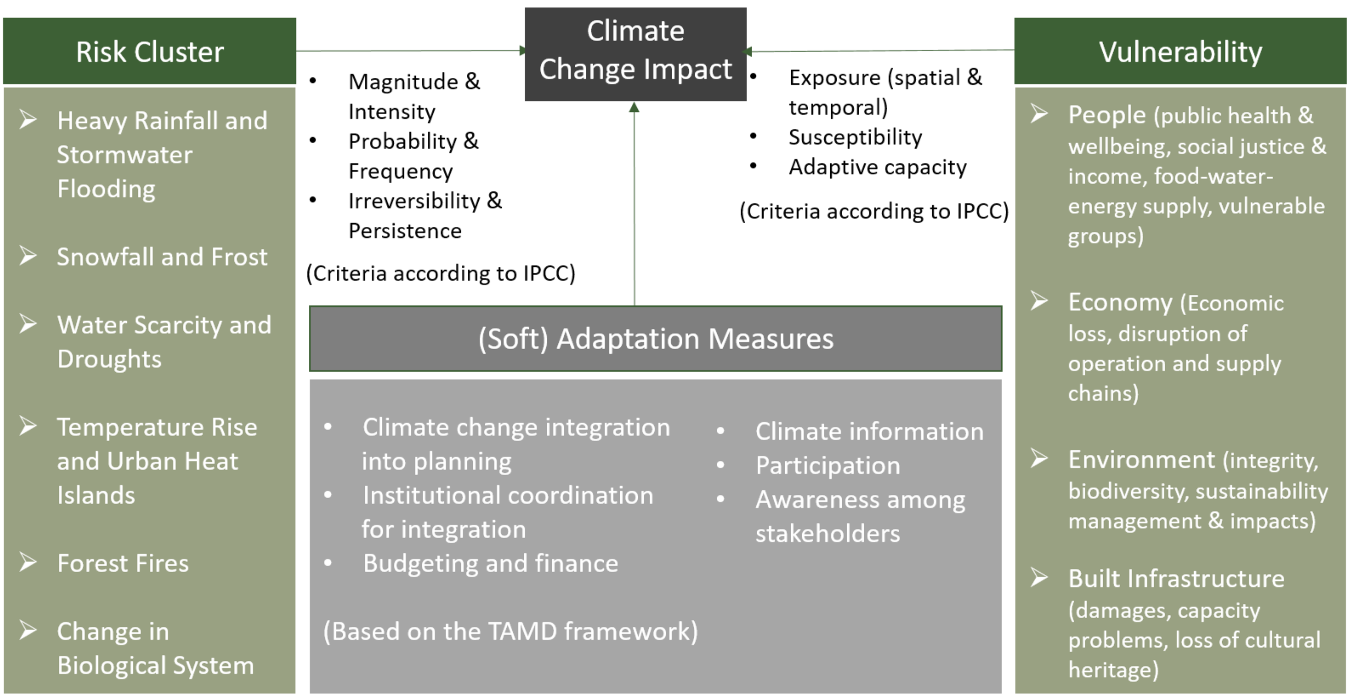

Figure 1: Risk and Resilience Assessment Framework

The first part of the assessment is organized according to six climate-related risk clusters and includes information from scientific evidence and forecasts, as well as results from an expert evaluation. The later involved twelve local and City Lab experts, to better incorporate local knowledge and on-site findings on risk clusters and vulnerabilities. In the second part, the Tracking Adaptation and Measuring Development (TAMD) framework, was used to summarize climate change adaptation measures taken by the city of Saltillo.

The TAMD framework was developed by the International Institute for Environment and Development (IIED) to track adaptation and measure its impact on development and focusses on soft adaptation and governance measures (IIED 2014). Relevant data for Saltillo was synthesized from the overall City Lab assessment, as well as from interviews with the Municipal Institute of Planning from Saltillo (IMPLAN) conducted in May and June 2021. A list of survey participants and interviewees, as well as a full table with all survey results can be found in the Annex.

3 CLIMATE RISKS AND VULNERABILITIES

3.1 HEAVY RAINFALL AND STORMWATER FLOODING

Saltillo is located 1,608 meters above sea level and its climate is classified as hot semi-arid (BSh) according to the Köppen-Geiger system, implying hot summers and warm to cool winters with relatively little precipitation (Weatherbase 2021). The average annual rainfall amounts to 484 mm and the mean annual temperature is 17.1°C (IMPLAN 2021). As it can be observed in Figure 2, the months with higher average precipitation comprehend July to September and the least rainy season runs from December to February. According to the Risk Atlas of the Municipality of Saltillo (2015), the intensity of the maximum rainfall in 24 hours is considered to be very low to medium, and its probability and frequency is subject to the entry or remnants of atmospheric phenomena coming mainly from the Gulf of Mexico.

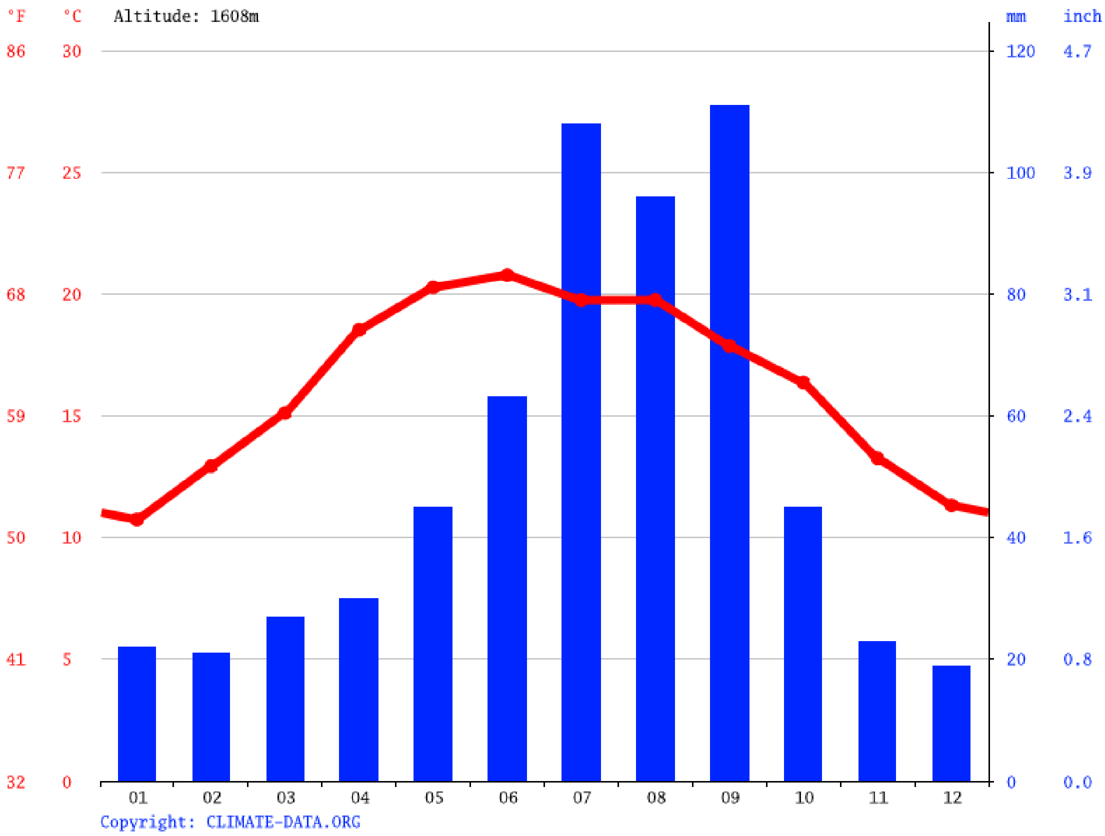

Figure 2: climate graph of the city of Saltillo showing average monthly precipitation and temperature. Weather data collected between 1999 and 2019, taken from climate-data.org (Climate-Data 2021)

Although precipitation levels in Saltillo are generally low throughout the year, the intensity of cyclones and heavy storms is expected to increase due to climate change (INECC 2019a). As shown in **Figure 3**, the magnitude of single and rapid precipitation events was perceived by experts as a very relevant risk for the city of Saltillo. Extreme precipitation episodes cause flooding, landslides and structural damages. For example, on September 2019 heavy rainfalls were recorded in Saltillo caused by the tropical storm Fernand leading to flooded areas, mobility collapse and numerous infrastructure damages (CONAGUA 2019, p. 29). Additionally, it was highlighted by the experts that the magnitude of flooding is increased due to recent urbanization patterns and sealing of natural streams. The construction of new dwellings and building complexes on unauthorized sites and the intensified blocking of creeks with solid waste have also been identified as causes of the obstruction of the natural flow of stormwater (Ríos and Chantaka 2019).

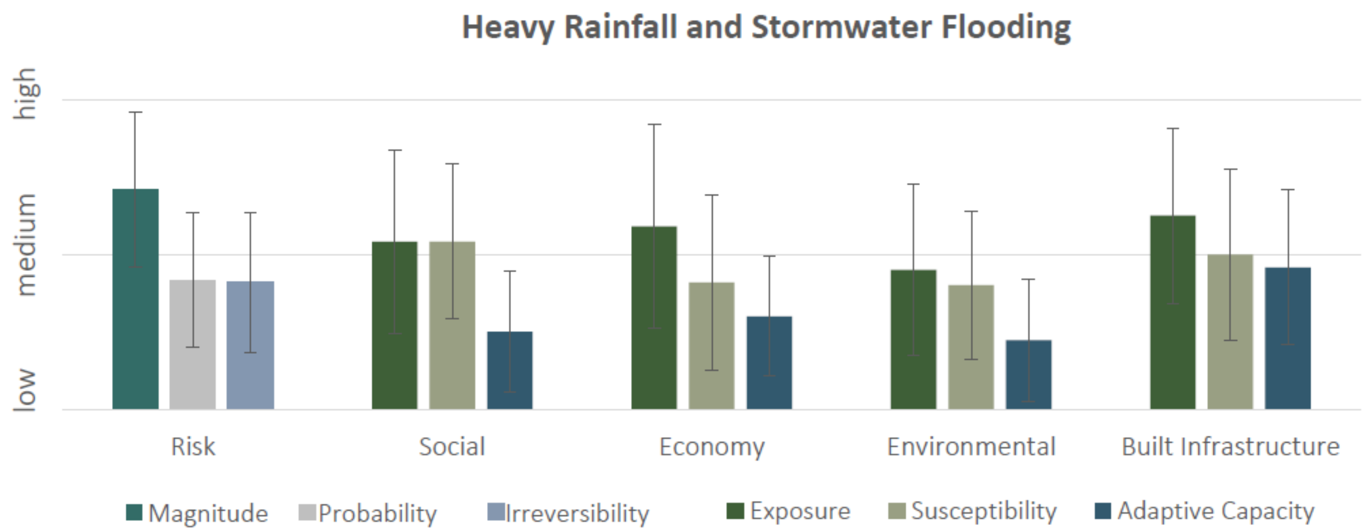

Figure 3: expert evaluation for the risk cluster "heavy rainfall and stormwater flooding" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental, and built systems in the city. Survey results with 12 participants from different local institutions and City Lab on-site experts. Standard deviation shown as black bars.

"I see three fundamental problems in the flooding issue: the lack of an environmental culture of the population that throws any amount and diversity of waste into the natural tributaries, the bad practices endorsed by the builders that modify and cover the natural streams and the lack of an emerging system of 'upstream' catchment."

Quote from the expert survey

Figure 4: flooding and heavy rainfall in Saltillo caused by the tropical storm Fernand (Source: El Siglo de Torreón 2019).

In terms of socio-economic vulnerability, low-income areas and informal settlements are especially at risk. In Mexico, 11% of dwellings in urban areas are located near or on a riverbed, constituting flood prone areas (IMPLAN and SEDATU 2015, p. 19). Specifically for Saltillo, the flood prone areas have been mapped in the Risk Atlas for the Municipality of Saltillo (2015) identifying a high susceptibility index to pluvial flooding in the southern zone (ITESM 2015, p. 349). Besides, the construction of inadequate housing infrastructure without efficient storm drainage systems intensifies the vulnerability of low-income settlements to flooding. According to the research done as part of the City Lab Saltillo, there is a lack of formal information and data about households practicing storm water harvesting and the coverage of the drainage network. This lack of information can be seen as a barrier for the implementation of adaptation measures to heavy rainfalls and flooding. The low rating given by experts to the adaptive capacity of population and environmental system, supports this observation and reveals the necessity for more socio-environmental adaptation strategies in the city.

Figure 5: flooding in Saltillo on 26th July 2020 (Source: IMPLAN)

Heavy rainfalls and flooding in Saltillo have proven not only to cause impacts in vulnerable infrastructures but also to affect key urban systems' operations and services. During the extreme precipitation event in September 2019, the garbage collection service and electricity supply were interrupted as well as attendance in school classes (El Demócrata 2019). Heavy rains can also cause disruptions in main commuting routes, such as the Monterrey-Saltillo Highway, which is key for the transport of industrial goods and facilities (El Demócrata 2019). With regards to natural ecosystems' vulnerability, the exposure and susceptibility was rated as medium to low by the surveyed experts.

Main effects mentioned on biological diversity came from the risk imposed by polluted storm water. Heavy rains wash away multiple types of debris, causing pollutants to be distributed in the waterways affecting aquatic flora and fauna. Additionally, the lack of water absorbing vegetation was identified as an intensifying factor for flooding. Overall, there is opportunity for future planning and management of urban projects to more strongly explore the potential of nature-based solutions for climate adaptation.

3.2 SNOWFALL AND FROST

The frost season in the northern and central part of Mexico occurs between the months of November and February. According to the Saltillo Risk Atlas (2015, p. 281), 58.20% of the territory in Saltillo has high risk to cold waves and 13.83% presents a medium range risk. Particularly, the southern area of the municipality is classified as a critical risk area due to an average frost season of more than 50 days per year (ITESM 2015, p. 147). Regarding continuous periods of temperatures equal to or below 0ºC, it has been registered in the Saltillo Climatological station up to 8 consecutive days, with a high frequency of 2 to 4 days (INIFAP and SAGARPA 2005b, p. 34).

In terms of snow storms, the risk level in the municipality of Saltillo is medium, registering between 1967 and 2013 a total of 15 episodes of heavy snowfalls (ITESM 2015, pp. 157–158). Due to a cold front, in January 2021 a winter storm with heavy snowfall occurred in Coahuila presenting strong winds of 80 to 90 km/h and cold temperatures of under -3°C (infobae 2021).

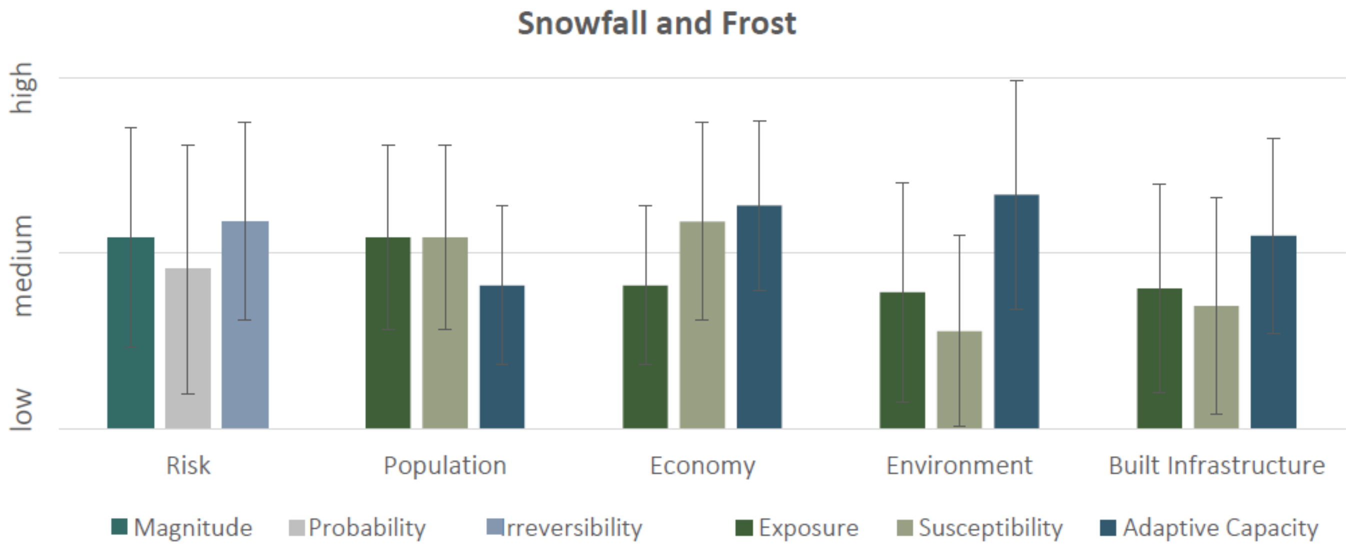

Figure 6: expert evaluation for the risk cluster "Snowfall and Frost" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental and built systems in the city. Survey results with 12 participants from different local institutions and City Lab on-site experts. Standard deviation shown as black bars

As it can be observed in Figure 6, the experts' rating of the magnitude and probability of snowfall and frost in Saltillo was medium. It was highlighted that snowfall presence is very punctual during the year and its severe magnitude is scarce. However, regarding frosts thei probability and frequency is higher, causing some material damages, mainly to crops. The effects of frost on crops include loss of leaves and tender stems, destruction of leaves, fruit, flowers, and even the total death of the plant (ITESM 2015, p. 147). In some cases, certain crops, such as fruit trees, may be affected in one year and the damage extends to subsequent crops for one or more years (INIFAP and SAGARPA 2005b, p. 1). These damages to crops have serious impacts on the economy of Saltillo and the region due to the reduced or total loss of income for producers, unemployment in the agriculture industry, loss of foreign currency and replacement of local market position by other competitors (INIFAP and SAGARPA 2005b, p. 1).

According to previous heavy snowfall events in Coahuila, impacts to infrastructure and economy further include the closure of road sections of important highways due to snow accumulation and crystallization of the asphalt. Additionally, certain basic services, such as gas and electricity can be suspended affecting companies' general operation as well as causing disruption in manufacturing value chains (Guardiola 2021).

As for environmental vulnerability, it can be considered exposed but not susceptible to irreparable damage, since the region's ecosystems are adapted to the cold weather conditions. Among all areas, the environmental adaptive capacity to snowfall and frost rated the highest. The effects on biodiversity due to snowfalls or frosts are medium, as endemic species adapt and recover quickly.

According to experts' observations, the population is aware of cold waves and frost periods and has experience dealing with them. Only in the case of severe snowfall and extreme weather conditions, bigger impacts on population can be observed. Similar to the vulnerability situation explained in the previous section regarding informal settlements in case of flooding, the risk for vulnerable groups, which do not have access to proper shelter during snowfall and frost events is higher. In general, during these type of events the Sub Secretary of Civil Protection is in charge of assisting the population and issuing early warnings of risks (UNIMEDIOS 2015).

Looking towards the future, climate variability represents a significant uncertainty for the future of agricultural production. Therefore, the study of this phenomenon is of fundamental importance for adopting strategies to mitigate the probability of damaging effects on production (INIFAP and SAGARPA 2005b, p. 2). Although it was mentioned by experts that snowfall and frost do not pose severe damages to infrastructure, when the frequency and magnitude of these events increase in the future, especially housing infrastructure are in need of adaption to these conditions. Making dwellings hydraulically prepared to withstand freezing temperatures and avoid massive damage to water pipes is deemed as especially important. Generally, the adaptive capacity is seen as above medium.

3.3 TEMPERATURE RISE AND URBAN HEAT ISLANDS

According to the Risk Atlas of Saltillo (2015), the city reports heat waves during the spring-summer season; although, historical measures show that the prolongation and intensity of these events vary among years (ITESM 2015, p. 121). As Figure 7 shows, the months between April and August present the highest temperatures during the year. Studies developed by the National Institute of Ecology and Climate Change (INECC 2019b) have determined that for the period between 1985 and 2018 in the state of Coahuila, annual maximum (+0.089 °C/year) and minimal temperature (+0.119 °C/year) had a tendency to become warmer, while annual cumulative precipitation was not changing. This situation can lead to drier seasons and impacts on natural ecosystems.

Over the last 100 years, increased temperatures of 1.2°C and 1.5°C have been recorded for the northern part of Mexico (Mexican Government 2015, p. 2). A more recent study for Coahuila presented two possible scenarios for annual temperature increase based on the climatic scenarios established by the IPCC: A2) Regional condition without restrictions and B1) Global conditions with certain restrictive and control measures. According to the most drastic scenario (A2), for the projection year 2080 the average annual temperature increase for Coahuila will be 4.4°C, while for the least drastic scenario (B1), it will be 2.7°C (Mendoza-Hernández et al. 2013, p. 529).

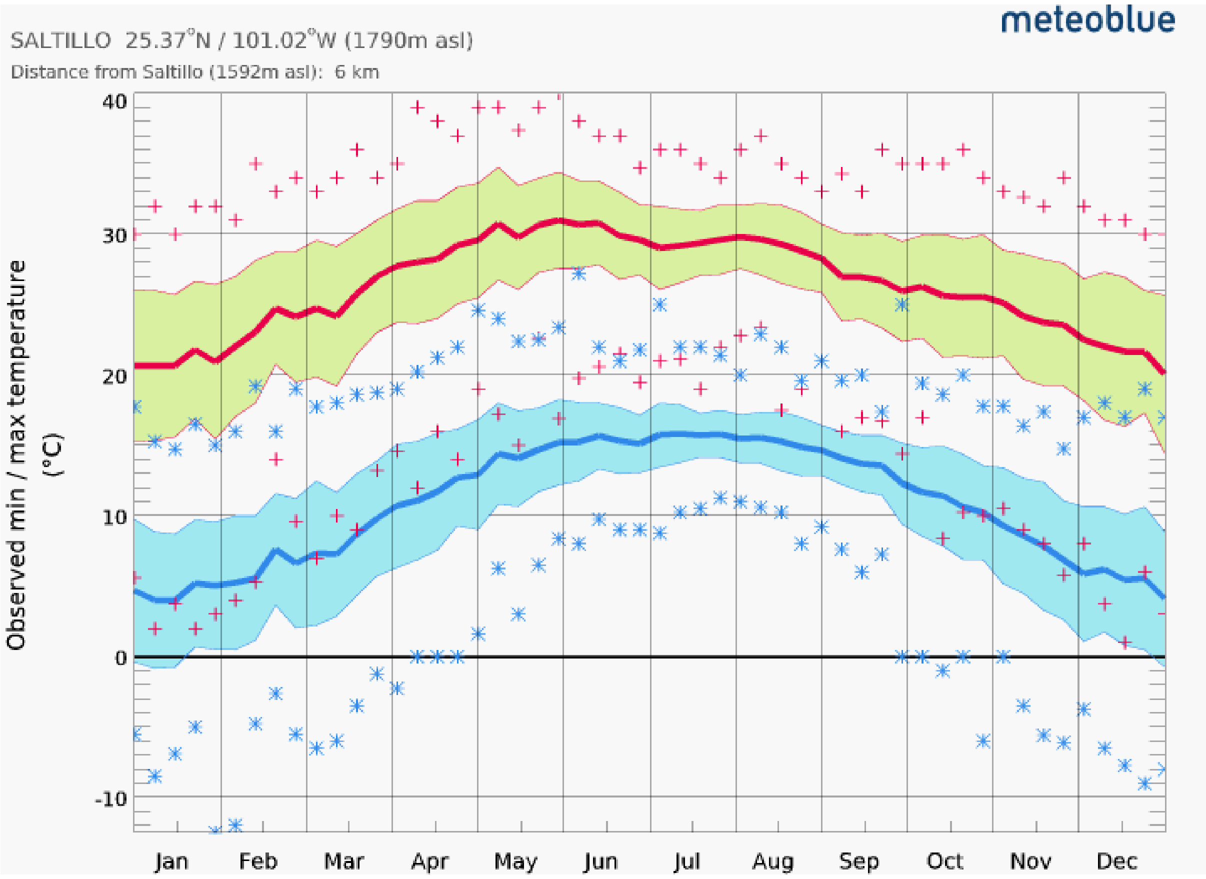

*Figure 7: observed maximum (red) and minimum (blue) temperatures in the city of Saltillo. Extreme values are represented by + and * characters. Two thirds of observed temperatures lie within the colored temperature range. Graph taken from meteoblue; Saltillo 25.37°N / 101.02°W (1790m asl); measurements of at least 10 years (meteoblue 2021).*

A major contributor to the high temperatures in cities is the urban heat island effect (UHI), which is a predominant climate risk in urban areas. Among others, it is a result of extensive paved surfaces, lacking vegetation and surface moisture, the canyon effect of buildings, as well as heat-trapping pollutants in the atmosphere. Between the years 2000 and 2018, the population of Saltillo saw an increase of 32% going from 637.273 habitants in 2000 to approximately 935.663 in 2018 (SEDATU et al. 2018).This accelerated urban and population growth could be an intensifying factor of the UHI effect when natural ventilation and cooling structures, such as vegetation and water bodies are blocked in the city. Although Saltillo counts on screening of climate risks with general studies, more specific and focused research on the urban heat island effect in the city is missing. It would be valuable to identify main areas in the city where the thermal islands are present as well as trends in order to develop mitigation and adaptation measures. Figure 8 presents the expert evaluation with regards to temperature rise and urban heat islands in Saltillo.

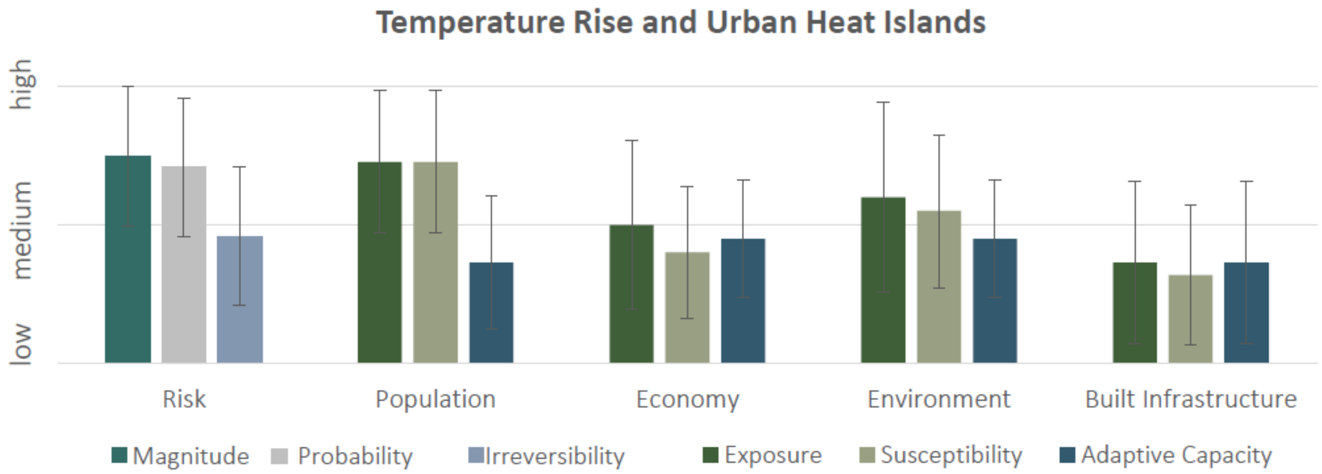

Figure 8: expert evaluation for the risk cluster "Temperature Rise and Urban Heat Islands" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental and built systems in the city. Survey results with 12 participants from different local institutions and City Lab on-site experts. Standard deviation shown as black bars.

In general, the magnitude and probability of rising temperatures and UHIs in Saltillo was rated as medium to high. Due to Saltillo's hot semi-arid climatic conditions as well as urbanization patterns, temperature rise and UHIs represent important risks, which will be intensified with climate change. The impacts range from harmful effects in the environment such as desiccation, forest fires, loss of crops to danger for livestock and human population (ITESM 2015). However, it is perceived that these possible effects can be controlled, and their irreversibility is rather low.

As shown in Figure, the exposure and vulnerability of population to temperature rise and UHIs was perceived as the highest among all evaluated areas. Increased temperatures in cities may lead to climate-related health issues for people, especially for vulnerable groups (i.e. elderly and children). The impacts on human population include loss of comfort and dehydration. It could also cause a higher incidence of diseases and pests posing major dangers to public health.

Furthermore, UHIs generate a higher demand in water and electricity (e.g., for cooling and refrigeration devices) increasing the city's energy consumption. Temperature rise can also affect agriculture and the cattle industry in Saltillo as heat waves are generally accompanied by loss of crops and livestock. In general, the environmental adaptive capacity was rated to be medium.

Nevertheless, the increasing temperatures in summer are affecting species, which are mutating, and these changing temperature conditions are allowing invasive species to adapt to the local environment, affecting established ecosystems. This is an issue that requires further attention and research aiming at minimizing negative impacts on the environment and local ecosystems.

"The heat island could begin to expand not only to the center of the city, but also to the periphery where the industrial parks and the roads leading to them are located, due to the high emissions of pollutants from both vehicles and industry."

Quote from expert survey.

Overall, a considerable number of publications highlight the importance of parks and green infrastructure, such as roofs and walls with vegetation, in order to reduce the areas of heat capture in cities. Green infrastructure across the city has the potential to create microclimates with lower temperatures and shaded areas due to the presence of vegetation. This situation brings more comfort to citizens, additionally fostering walkability and biking as transportation mode among them.

The municipality of Saltillo, aware of the importance of green elements, lists the conservation and restoration of natural areas among its action lines in the Environmental Agenda (Saltillo Gobierno Municipal). One of the main activities of this action line is the planting of trees and maintenance of green areas in the city center, which can contribute positively to UHIs mitigation.

3.4 WATER SCARCITY AND DROUGHTS

As explained in the previous section, Saltillo's location in the Coahuila desert and its semi-arid climate makes it an area highly vulnerable to water scarcity and droughts. Due to climate change, it is expected that most of Mexico's land will become drier and droughts will increase in intensity and frequency (INECC 2019a). In the following 15 years, it is also predicted that rainfall will decrease between 10 and 20% (Mexican Government 2015, p. 4).

Particularly in Saltillo, the water supply for domestic and economic activities comes mainly from groundwater sources. Three aquifers serve the water demands of the Municipality: "Saltillo-Ramos Arizpe", "Saltillo Sur", and "Cañón del Derramadero". The total annual volume of water extracted for Saltillo municipality alone accounts for 100.5 hm^3, and the total exploitation of the aquifers increases when considering the extracted volume for use of other municipalities (CCRB 2019). Based on the estimation of annual water recharge, the annual water availability for Saltillo would be of around 119.3 m^3/cap when considering a population of 860,000 (Fraunhofer Institute for Industrial Engineering IAO et al. 2021). This figure locates Saltillo in a water scarcity scenario according to the Falkenmark Indicator, which considers any value below 500 m^3/cap as absolute water scarcity (Global Water Forum 2012).

Despite evident water shortages in Saltillo, the municipal water management organization, *Aguas de Saltillo* (AGSAL) has made a considerable effort to keep the city supplied with water. Water supply to the city is of around 146 MLD (million liters per day) which are extracted from 90 wells and treated through 6 chlorination plants distributed around the city before reaching the final users, making it safe for drinking (Fraunhofer Institute for Industrial Engineering IAO et al. 2021). Saltillo's water supply coverage is high, at 99,60% (Aguas de Saltillo 2018), while the average water per capita consumption in Mexico is 184.6 liters per day (L/d), users in Saltillo consume around 170 L/d (FCEA 2017).

Regarding droughts, the municipality of Saltillo presents a medium level risk with a 30 to 60% probability of occurrence during the year (INIFAP and SAGARPA 2005a, p. 48). A study conducted by the National Institute of Forestry, Agriculture and Livestock Research (INIFAP and SAGARPA 2005a, p. 48) took as a reference the years from 1970 to 2003 and determined that the reduced type of drought is the most common in Saltillo, registering in only one occasion, during the studied timeframe, a severe drought episode.

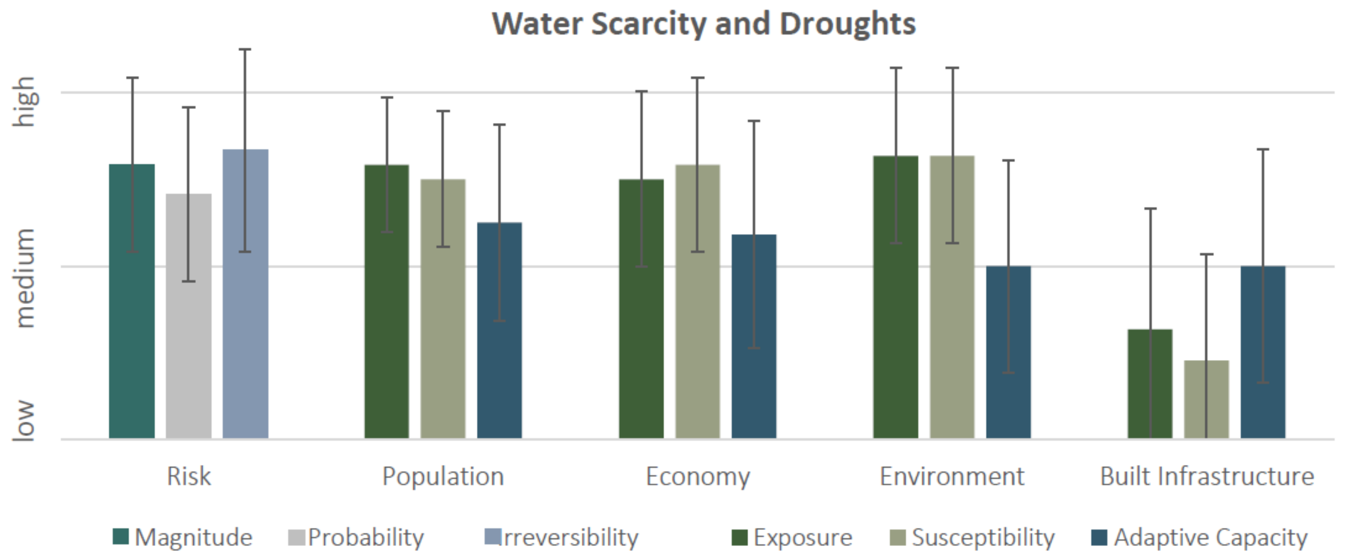

Figure 9: expert evaluation for the risk cluster "Water Scarcity and Droughts" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental, and built systems in the city. Survey results with 12 participants from different local institutions and City Lab on-site experts. Standard deviation shown as black bars.

According to the experts' evaluation, the cluster water scarcity and droughts had the highest ratings among all identified risk clusters. As observed in Figure 9, the magnitude and irreversibility of this risk is perceived as relatively high considering that all the water in Saltillo comes from the subsoil and in the event of depletion of the aquifers, recovery would be very difficult. Experts highlighted the fact that the aquifers are being exploited at a higher rate than they are being recharged, which will eventually lead to an absolute exploitation of these water reserves. Therefore, this aspect represents a matter of concern for the city and should be addressed accordingly in current and future urban planning development plans to ensure Saltillo's resilience.

Water scarcity and droughts affect not only the population of Saltillo but also agriculture, the economic sector and biodiversity. According to experts' observations, the population can be considered exposed and susceptible to damage, having a medium adaptive capacity. Similar to the impacts of temperature rise and UHIs described in the previous section, the effects of water scarcity on human health range from loss of comfort to extreme dehydration. It thereby stresses social inequalities in the city affecting the most vulnerable population groups of children and the elderly in low socioeconomic sectors (ITESM 2015, p. 121). Livestock and many plant species are also particularly vulnerable. According to the Saltillo Risk Atlas (ITESM 2015, p. 131), more than 80 shared lands and 15 rural annexes in Saltillo experience serious problems due to constant droughts, including the death of 2,000 head of cattle. During extreme drought periods, CONAGUA organizes operations to distribute drinking water to the most vulnerable populations, as well as to support for agricultural irrigation (Comisión Nacional del Agua 2021).

In terms of economic impacts, farmers and industries related to agriculture production are the most affected as water scarcity and droughts can result in agricultural, livestock and forestry production losses. It can also cause, in a longer term, recession in the regional economic growth rate as well as a disincentive for new companies to establish and invest in Saltillo due to the lack of water as a basic operating resource (Comisión Nacional del Agua 2021).

Figure 10 crop damage in Saltillo and neighbouring municipalities due to low rainfall levels and drought season (source: El Tiempo de Monclova 2021).

Overall, sustainable water management is of high importance in Saltillo in order to effectively administrate the limited existent water resources. The Municipality of Saltillo has done a first step in this direction with the "Environmental Agenda" and the action line related to "responsible water care and consumption". Experts stressesthe necessity to protect key water recharge systems such as the Zapalinamé Sierra as well as to improve catchment and infiltration systems. Besides, these actions could be accompanied with environmental education programs focused on promoting a water saving culture.

For the city's outlook, it would be also relevant to explore alternative water sources to aquifers, which could include wastewater treatment and rainwater harvesting. According to IDEAL and IMPLAN, around 100% of wastewater is treated complying with national standards. However, the challenge is to reuse the treated water, as there is no pipeline for its distribution. The vast majority of the treated water is reintroduced into streams and a low percentage is reused for irrigation of green areas through pipes. There is a great area of opportunity for the reuse of treated water in the industrial sector. Additionally, information on rainwater harvesting practices in households was found to be very limited, requiring more research and measures to consider it as a feasible water source.

"An environmental education program focused on water culture is urgently needed"

Quote from the expert survey

3.5 FOREST FIRES

Due to the geographical location of the Coahuila state and its climate, forest fires occur naturally every year between March and May (Secretaría de Medio Ambiente 2018) . A considerable number of fires of natural origin have a recurrent location, meaning that they originate in areas where they have already occurred. Nevertheless, state records indicate that 60% of forest fires every year are caused by human activities related with agriculture and recreation in housing complexes in forested areas (Secretaría de Medio Ambiente 2018, p. 3). According to Mexico's Secretariat of Environment and Natural Resources (2018), the number of fires and the affected area has increased in the last decade, partly due to more intense and frequent meteorological phenomena (e.g., prolonged droughts and frosts) that have altered environmental conditions, modifying the availability of fuels and creating both more extensive and more intensive risk periods.

As it can be observed, risks previously mentioned such as droughts and frost are closely related with the origin of forest fires.

In Saltillo, the high frequency of frosts contributes to the desiccation of large amounts of vegetation which in turn become fuel for fires (Secretaría de Medio Ambiente 2018). Furthermore, after frosts and snowfalls, there is usually a period of thunderstorms with electrical discharges, which can trigger the lighting of dried out vegetation starting a fire. The accumulation of combustible material resulting from forest clearing activities further represents a risk in Saltillo, which can be intensified due to an inappropriate management of natural waste. In 2011, the second highest number of forest fires during the past 20 years was recorded in Coahuila (160), presenting events with high magnitude which affected several municipalities, including Saltillo, and led to the declaration of more than 300,000 hectares as disaster zones (Gobierno del Estado de Coahuila de Zaragoza 2018, p. 20). Figure 11 below shows trends of forest fires in the past five years in Saltillo. Wherein 2017, a total of 17 forest fires affected 862.15 hectares of natural area (Secretaría de Medio Ambiente 2018, p. 14); 10 such events were recorded in the year 2020 affecting 1015.66 hectares, out of which only 3 were due to natural causes.

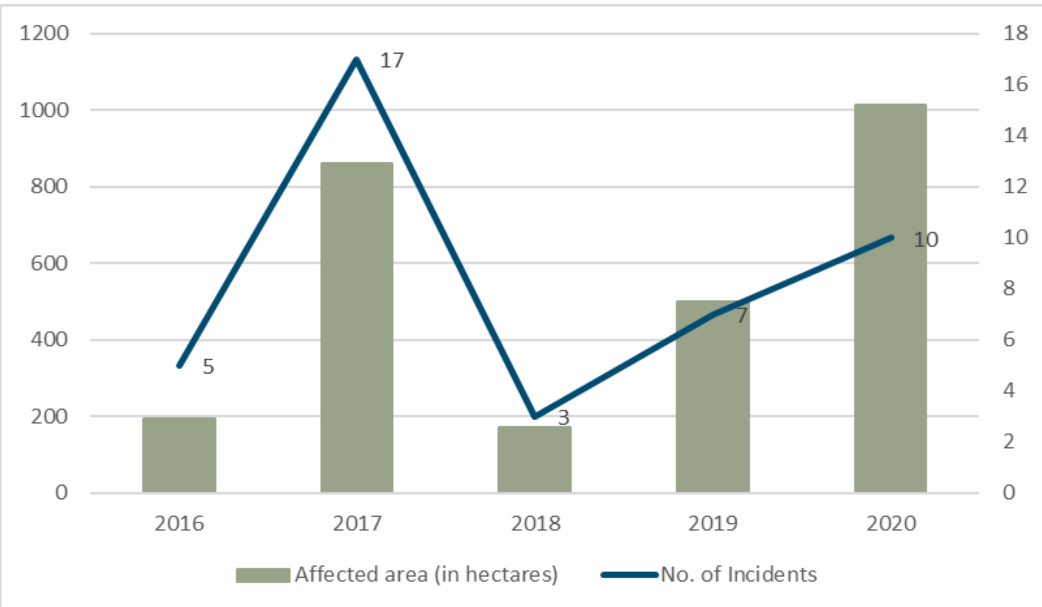

Figure 11 forest fire incidents in Saltillo. In 2020, 10 forest fires were recorded, affecting an area of 1,015.66 ha, of which only 3 were due to natural causes.

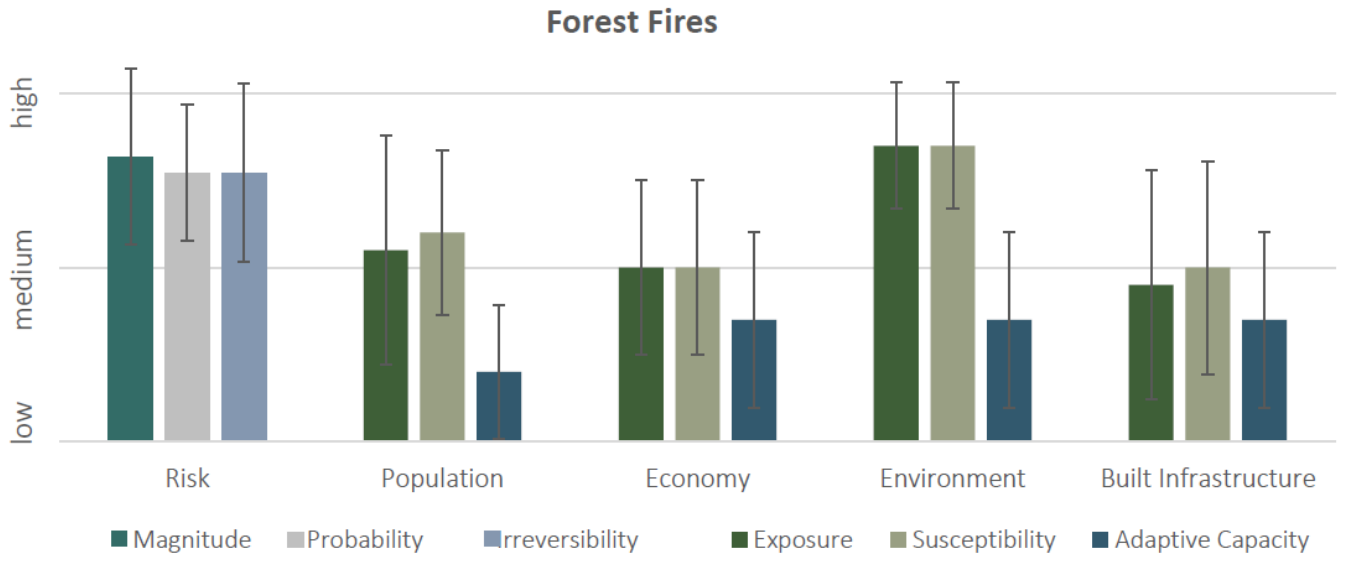

Figure 12: expert evaluation for the risk cluster "forest fires" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental and built systems in the city. Survey results with 12 participants from different local institutions and City Lab on-site experts. Standard deviation shown as black bars.

As shown in **Figure 12**, the risk of forest fires was perceived by experts as high due to a combination between its magnitude, probability, and irreversibility. Experts highlighted the irreversible damage that fires cause in mountains near Saltillo, especially in the Zapalinamé mountain range, located at the southeast of the state (see **Figure 13**). It was noted that there is tremendous damage from forest fires on the environment as it poses high risks to biological diversity and causes erosion as well as loss of vegetation and fauna.

Figure 13: fire in the Zapalinamé mountain range June 2020 affected 15 hectares and vegetation, mainly scrub and grassland (source: El Heraldo de Saltillo 2020).

A study conducted in 2017 by the Ministry of Environment (2018) determined that the plant species most affected by forest fires in Coahuila were the herbaceous and shrub.

"What does represent a major threat to biodiversity, vegetation loss and environmental damage are fires, and here Coahuila and Saltillo in particular do not have the equipment, infrastructure and expert human capital to provide a prompt and forceful response. This is aggravated by the dry seasons of the year"

Quote from the expert survey

Since forest fires originate in the surrounding areas of Saltillo, the population in the city is not highly exposed to this risk. However, many of the experts noted that the level of exposure is higher in the rural highland areas. In contrast, indirect impacts can be observed in urban areas, including air quality problems caused by pollutants from fire smoke. Although population vulnerability to forest fires is not massive, their adaptive capacity is perceived as low. Conscious of the irreversible impacts of forest fires, programs for the prevention and control of fires have been developed at the national and state level. In Coahuila, a State Program has been developed, aligned with the National Program for the Prevention of Forest Fires and operated through the Secretariat of Environment and Urban Development with support of other national and state institutions as well as civil organizations and volunteers (Secretaría de Medio Ambiente 2018, p. 3). The focus of the program is set on implementing preventive actions in order to reduce the damages and negative impacts of forest fires as well as the area of affected surfaces. A central axis is the inter-institutional coordination with the civil society for timely and effective actions in case of fires. Additionally, special importance is set for the communication and dissemination of information, which is a key tool for the prevention of anthropogenic-caused fires. However, at the municipality level, programs like these need to be strengthen and further developed.

3.6 CHANGE IN BIOLOGICAL SYSTEM

Climate change has a direct impact on biological systems as it affects the conditions in which vegetation and animal species develop, producing changes in population dynamics, local ecosystems composition and migratory patterns, among other aspects. Because Mexico is an enormously diverse country – home to nearly 10% of the world's recorded species (Secretaría de Medio Ambiente y Recursos Naturales 2016) – the consequences of climate change pose high risks to the country's biological diversity and endemic species. Although the actual impacts on biodiversity are difficult to measure and still remain uncertain, the INECC and UNAM (2017) developed a study to assess the current and future vulnerability of endemic, priority and at-risk species in the Natural Protected Areas (NPAs) in Mexico. As a reference, the study took into account climate change scenarios until 2039 in order to determine the potential distribution of 206 species, including birds, mammals, amphibians, insects and plants. Through maps, the study showed how the species in the NPAs located in the center-west part of the country (I.e., Jalisco, Nayarit and Zacatecas states) had higher probability of changing their habitat due to climate change conditions (INECC 2019a, p. 216).

On state and municipal level, more research is needed to identify and measure the impacts of climate change on local ecosystems and the biological system. These studies are especially relevant considering Mexico´s objective to contribute to the conservation of the country's unique natural conditions as well as prevent risk situations caused by disease vectors (e.g., mosquitoes, flies, and rodents) which can transmit diseases to humans. Figure 14 summarizes the experts' evaluation with regards to changes in the biological system in Saltillo.

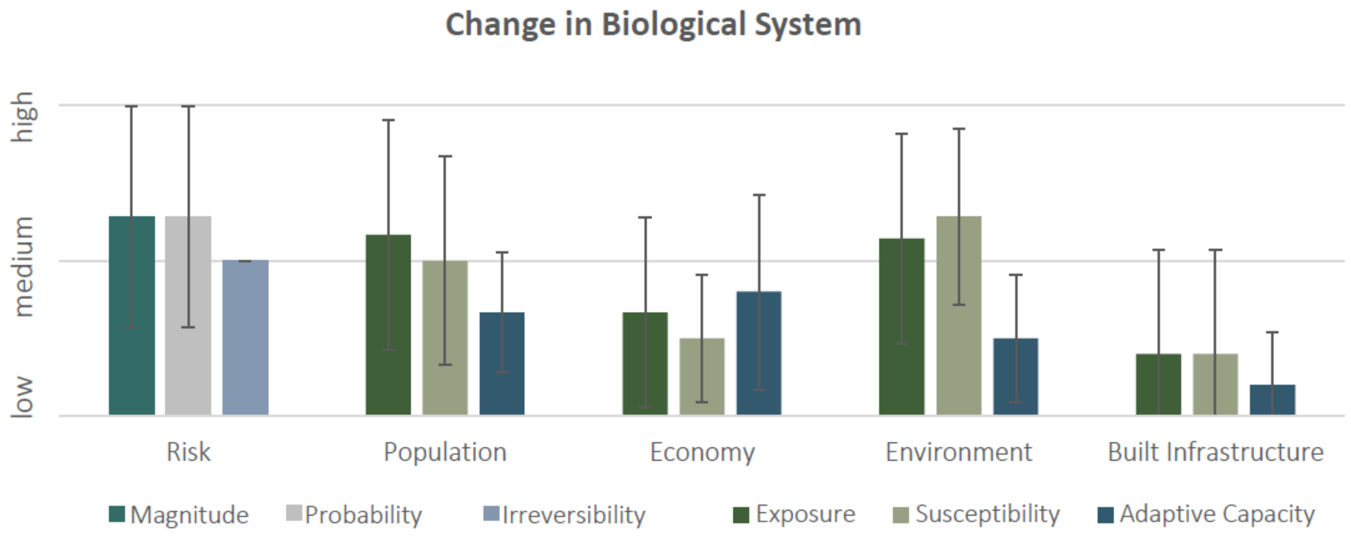

Figure 14: expert evaluation for the risk cluster "Change in Biological System" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental, and built systems in the city. Survey results with 12 participants from different local institutions and City Lab on-site experts. Standard deviation shown as black bars

In general, experts indicated a mixed response. Half of them replied that they do not know about specific changes in biological system in Saltillo derived from climate change conditions, which shows that there is not a high level of research and knowledge about the topic. The main concern, raised by multiple experts, was related to temperature variations and their negative impact on flora and fauna. An increase in both temperature and severe cold events could result in crop losses or degradation. Changes in biological systems due to climate change also increase competition between native species and invasive species, where the invasive species sometimes displace native species, causing them to disappear. This issue requires special attention, especially in streams, where reeds can cause severe problems.

Experts further stated that the deviation in temperature levels could impact public health by an increase in the spreading of diseases. Saltillo already experiences the occurrence of diseases from non-local species, including mosquitoes transmitting Chikungunya and Zika (see **Figure 15**). Although these increasing incidents requiring hospital care present a low risk to the existing infrastructure, they could affect the city's economic performance.

Figure 15: Mosquito Aedes which spread Chikungunya and Zika viruses (Source: CDC 2021).

4 CLIMATE CHANGE ADAPTION MEASURES

In face of the aforementioned risks, climate change adaptation needs to play a more important role in future urban planning and development. Next to the more technical, nature-based, and infrastructural adaptation measures, which have been hinted at throughout the previous sections, softer measures as governance approaches will be needed to support strategic and lasting change.

Figure 16 summarizes the current state in Saltillo with regards to seven distinct indicator areas from the TAMD framework based on the city lab data collection and the resilience interviews. The result suggests many opportunities to further deepen and improve existing climate governance and adaptation measures, of which some of the most prominent will be outlined in the following two sections.

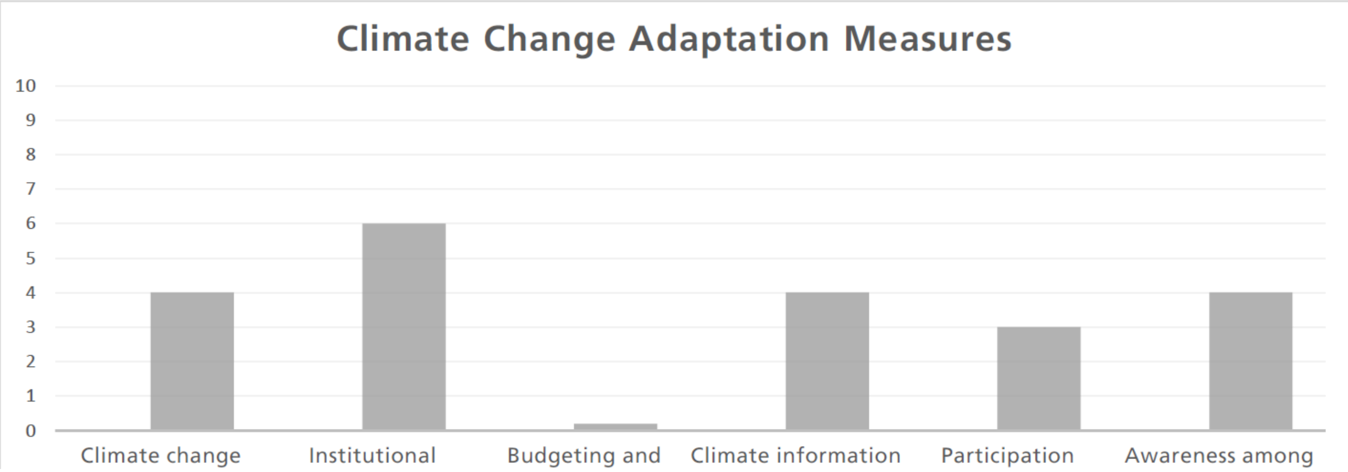

Figure 16: climate change adaptation assessment according to the TAMD framework (iied 2014). Each indicator consists of 3 to 5 questions, which amount to a maximum score of 10.

Climate Change Integration into Planning

As part of an international partnership, the *Climate Action Plan for Municipalities* (PACMUN) was launched in Mexico in 2011. This program, initiated by ICLEI-Local Governments for Sustainability, was developed with the technical support of the INECC and financial contributions from the British Embassy in Mexico (Climate Initiatives Platform 2019). Currently, Saltillo is developing its PACMUN, which aims to include a diagnosis of the impact of climate change in the municipality, comprehending a vulnerability and risk analysis, as well as proposed lines of action for climate change mitigation and adaptation measures.

In the past years, a key document for Saltillo in the area of climate risks has been the Municipality Risk Atlas published in 2015. Although this document presents some climate change adaptation measures, suggestions for climate action in public policies, as well as education and communication strategies, these recommendations have not been integrated into other planning instruments within the Municipality. So far, there have been scattered activities and projects for addressing the identified climate risks, but a coordinated approach is missing. By mid-2021 the Urban Development Master Plan for the next administration (2022- 2024) was being developed with the premise of incorporating findings and suggestions from the Saltillo Risk Atlas and the PACMUN. It is expected that the effort of integrating key information from various studies and planning instruments into the Urban Development Master Plan 2022-2024 will set the base towards more coordinated climate change mitigation and adaptation strategies.

Understanding that climate change impacts are highly variable and that the measures addressing them have to be regularly evaluated and adapted is key in the process of effectively integrating climate change strategies into urban planning. For the moment, Saltillo does not count with an established loop process for the identification, prioritization, implementation and evaluation of climate risks and measures. Therefore, the municipality could benefit from the use of frameworks and methodologies that address uncertainty, such as scenario planning exercises based on climate projections and key climatic parameters.

Institutional Coordination for Integration

Currently, the task of coordinating climate change planning and actions has been delegated by the municipal administration to IMPLAN. Although a specific area or department for this task does not exist nowadays, it is on IMPLAN's agenda to create such an area in the future.

Another relevant organism in the climate change action landscape in Saltillo is the Citizen Council of the Environmental Agenda (Consejo Ciudadano de la Agenda Ambiental) composed by representatives from different sectors including business, academy, municipality, and civil society organizations. The function of this council is to follow up on the actions and programs from the Environmental Agenda which is concerned with responsible water management and consumption, air quality monitoring, conservation of natural areas, separation of solid waste and strengthening of renewable energy generation (Jiménez Salinas 2019). Additionally, as part of the MGI project, a City Board has been created with members of the Citizen Council of the Environmental Agenda. The City Board is a key body in the supervision of the implementation of the pilot project from the MGI initiative as well as project monitoring and evaluation activities.

Regarding institutional capacity and knowledge about climate change issues, members from IMPLAN are constantly involved in trainings on this topic as a result of cooperation agreements with international organizations such as WWF, ICLEI, the World Bank and City Lab spin-offs. For example, in 2015, IMPLAN staff received training on climate change and environmental topics through the Friedrich Naumann Foundation, in addition to participating regularly in the ICLEI National Congresses. However, on the local level, there is no permanent training program offered by the municipality and each area needs to seek for its own training. Therefore, the city could benefit from strengthening local capacity and expertise building activities in which an exchange of knowledge among individuals from different Municipality's departments is promoted.

Budgeting and Finance

Saltillo's strong budget performance and zero debt commitments have resulted in getting positive credit rating by Fitch Ratings (AAA) and Standard's and Poors (mxAA). However, a specific budget allocation for climate change adaptation and risk management does not exist at the city level. In the past, Saltillo has implemented a number of green infrastructure projects with national funds or third-party financing like international financing or grants. Examples of these projects are a water treatment plant, a sanitary landfill, and street LED lighting, which were mainly financed by private parties. Furthermore, The *Gran Bosque Urbano* (Great Urban Forest), financed by the State Government, was a project which aimed to increase green areas in Saltillo, capture water for aquifer recharge and use treated water for irrigation.

According to the Ethos Public Policy Lab (2020), Mexico was a pioneer in climate finance mechanisms, both on national and subnational level. However, the weak enforcement has jeopardized the Climate Change Fund (FCC), leaving no availability of funds at national or state level for Climate change adaptation measures. In this instance, the need for tapping international funds through international initiatives, such as the Transformative Actions Program (TAP), to execute climate change initiatives was perceived as crucial for the city's future.

Climate Information

Regarding the availability of climate information, Saltillo has an extensive characterization of the hydro meteorological phenomena of the municipality as well as climate related risks and vulnerabilities compiled in the Risk Atlas (2015), which is publicly available on IMPLAN's website. Although it is a well-known and used document by experts and municipal institutions, the city is lacking additional information sources and more updated climate information. Hence, there is a need for regular climate-related risk assessment and monitoring schemes, which could serve as an up-to-date basis for climate risks and adaptation measures.

Additionally, in the framework of international cooperation, Saltillo uses climate information generated by international research projects or university partnerships. As an example, the research developed during the two first phases of the MGI project, including the identification of primary sources of GHG emissions in the Municipality, is being used by IMPLAN as a scientific foundation for the development of the PACMUN and the formulation of climate protection strategies.

In terms of early warnings and action plans in case of emergencies, the Sub Secretary of Civil Protection has established protocols, for example in case of floods or fires. Nevertheless, these protocols are not explicitly associated with climate change. The city could benefit from more inter-institutional integration regarding measures and plans to address climate risks, as well as leveraging on local knowledge and engaging citizens in these actions.

Participation

Interviews with experts highlighted that the municipality of Saltillo has stood out for having active citizen participation from the beginning of urban projects. The city practices active participation through citizen councils on different issues. In Saltillo, on the one hand, an Urban Development Council exists, which is involved in urban regeneration projects, from an early design stage followed by planning until the final implementation. On the other hand, the Citizen Council of the Environmental Agenda works together with IMPLAN promoting the participation of the different public, private, and academic sectors as well as civil society in the design and follow-up of the activities included in the environmental agenda (see section 4.2 Institutional Coordination for Integration).

Furthermore, IMPLAN has received training from organizations such as *Cuadra Urbanismo* in participatory design workshops, which they have used on different occasions and projects. As a part of the MGI project, more than 40 actors within the public sector, academia, industry, and civil society participated in a workshop held in February 2021 to visualize Saltillo in the future and discuss the feasibility of project ideas. For the future events and decision-making, it would be beneficial to also include vulnerable groups and especially those people who might be adversely impacted by climate change.

Awareness among Stakeholders

According to the interviews, general awareness levels on climate risks and impacts is rather high among the citizens. During the workshops for the elaboration of the Municipal Development Plan 2019-2021, citizens expressed interest in prioritizing environmental issues. As a result, in June 2019, the Environmental Agenda was proposed with the aim to contribute to, and monitor compliance of actions committed to improve the environment. With the environmental issue stated as a priority by the current city administration, IMPLAN in partnership with universities, private companies, and citizens in general, engages in projects to foster awareness of environmental threats and climate change impacts. Examples of these activities include a Mega Reforestation project, a No Plastic Bag Campaign, support to Vehicle Verification, and *Yo Cuido Zapalinamé* program. Despite of these efforts developed by IMPLAN and the municipality, there is no adequate funding available for awareness-raising campaigns. Interviewees further suggested that the alliance with educational institutions can be strengthened through environmental education.

Additionally, the Secretary of Environment and Urban Development of Saltillo coordinates the Green Office program, which promotes responsible and sustainable practices in offices for the benefit of the environment (Municipio de Saltillo 2018). Lastly, the high response rate and participation from stakeholders during online workshops in Saltillo held in February 2021 under the MGI Initiative and City Lab Saltillo showed their high interest in sustainable urban planning practices and climate change issues. For instance, a workshop with the academic sector congregated more than 60 researchers from the region where the results from the digital on-site assessment of the City Lab Saltillo were presented producing valuable contributions and synergies among stakeholders.

Figure 17: the Mega Reforestation project, with the participation of citizens, universities and companies, aims at planting one million trees in Saltillo (source: Vanguardia Mexico 2020)

5 OVERARCHING INSIGHTS AND SUGGESTIONS

Following the assessment of Saltillo's climate risks and vulnerabilities as well as selected climate change adaptation measures, some conclusions could be drawn, especially with regards to main priorities, potential levers and opportunities for future climate change mitigation and adaptation.

Water scarcity and droughts, as the highest rated risk cluster by experts, was identified as one of the most pressing issues in Saltillo, which requires increased attention. Suggested actions to address this issue include improving the city's soil permeability and the recharging of overexploited aquifers through nature-based solutions, such as green and blue infrastructure. Additionally, the use of treated water has a big potential as an alternative water source, considering the already existing infrastructure of the purple line* (Fraunhofer Institute for Industrial Engineering IAO et al. 2021).

Furthermore, literature research, surveys, and interviews highlighted agriculture as one of the most vulnerable sectors to climate risks. Farmers, agriculture, and livestock production are being highly affected not only by water scarcity and droughts but also by frost and extreme temperature variations. Hence, it is important to strengthen the adaptive capacity of this sector and especially local farmers, which are an important economic pillar of the region. Potential alternatives to consider include diversifying crops, using permaculture principles, and exploring alternative cultivation practices, such as controlled environment agriculture and indoor farming.

Saltillo could also benefit from having updated information about climate phenomenon and developing regular risk assessment and monitoring schemes. It was found that the majority of data and studies are available at national and state level. On local level, few publications on the topic exist, the Risk Atlas from the Municipality of Saltillo being the major one in wide use by experts and municipal institutions. Nevertheless, it was published in 2015 and therefore, it is suggested to update the information regarding climate risks and vulnerabilities according to the identified critical areas and mapping activities on a regular basis. Additionally, a topic that requires more research and attention is the impact of climate change on the biological system (native and endemic flora and fauna under climate change), as surveys revealed that expert knowledge in this field is not very high.

In the process of developing assessment and monitoring strategies for climate risks it is crucial to involve citizens and especially the population vulnerable to climate change impacts. Studies have shown the importance of combining technical knowledge with local knowledge from people on the ground as well as working towards co-production models with high engagement from local communities (Mitlin 2008; Nesti 2018). For example, in Tijuana, Mexico, a project to create collaborative flood hazard models and maps based on community participation and knowledge was developed to understand pluvial flash flooding threads and guide planning and decision-making (Goodrich et al. 2020). Community forest management initiatives have also been implemented in Mexico with potential positive impacts on the

** The purple line is an engineering project for the distribution and posterior reuse of treated water, which would connect the main wastewater treatment plant in Saltillo with the industrial parks in the municipality of Ramos Arizpe.*

environment, such as carbon mitigation and sustainable rural development (Klooster and Masera 2000).

Additionally, Saltillo could leverage on established participatory experiences, such as the Citizen Council of the Environmental Agenda to raise awareness and interest on climate action. Alliances with (local) educational and science institutions as well as local capacity building activities could be further strengthened. In general, well-informed citizens and resilient communities can enhance the adaptive capacity of people, limiting the magnitude of climate change impacts and enabling efficient emergency response.

Finally, Saltillo is currently experiencing a moment of enormous opportunity to integrate climate change topics into planning as the Municipal Climate Action Plan (PACMUN) and Urban Development Plan for the next city administration are being developed. It is important to create guiding principles for climate change mitigation and adaptation which can be translated into clear targets and indicators allowing the operationalization of measures involving key institutions and stakeholders. Moreover, it is needed to establish a local budget for climate action and not only be dependent on national or international funding programs, which vary in nature and therefore do not allow a stable and continuous planning and execution of climate change initiatives and projects.

6 SALTILLO CITY LAB – CONTRIBUTIONS TO CLIMATE RISK ADAPTION

As part of the MGI Saltillo City Lab, a roadmap is currently under development, which includes concrete project ideas that could support the city in its climate-friendly future development. While most of these projects target specific challenges in the focus sectors of the City Lab – namely water, mobility, and energy – they also hold great potential to help enhancing climate resilience. Figure 18 shows the links between the developed project ideas and the risk clusters as described above

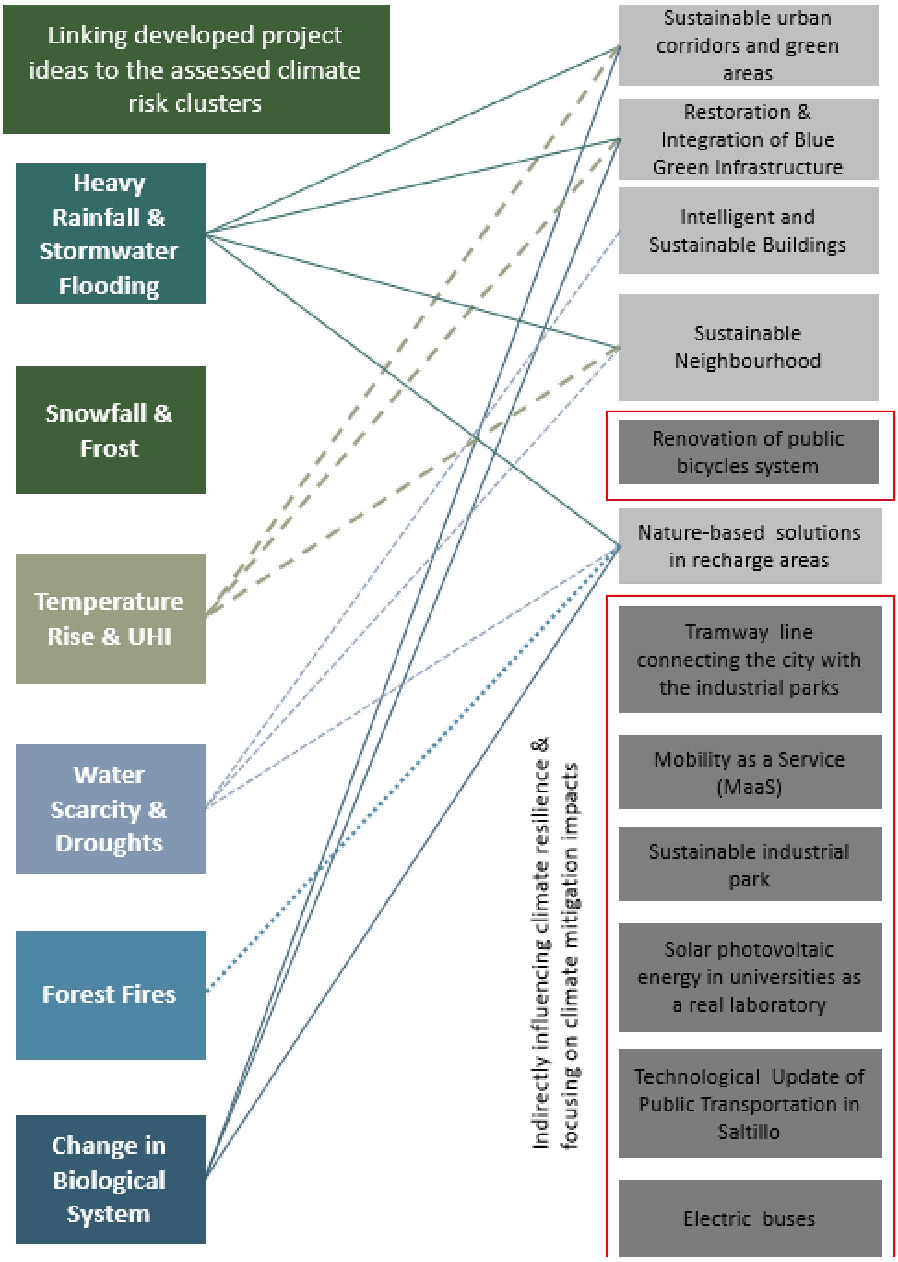

Figure 18: linking project development ideas to the assessed climate risk clusters (the project ideas are ordered as per rating based on the Project Ranking Tool)

To enhance the synergies between climate change mitigation and adaptation and the potential in combatting climate risks, the individual project planning needs to take resilience considerations into account from the very beginning on. The use of selected key performance indicators (KPIs) and their integration in a holistic project monitoring plan can for instance be a way to make sure that the achieved effects can be measured, tracked, and improved. **Table 1** presents an overview and collection of different KPIs that can be used in assessing project performance in the area of climate resilience. According to the scale and occupied area of the project to be assessed, some indicators might be more suitable than others.

Furthermore, the TAMD framework that was used in this initial assessment can be used to keep track of undertaken adaptation measures. The full list of framework criteria can be found on the IIED official website. These examples are intended as a first guiding support for future project planning, implementation, and monitoring in the city of Saltillo. The adequate choice of relevant indicators, availability of reliable baseline data, as well as well-chosen measurement boundaries (project to city level) can help to prove impact and provide evidence on achieved project objectives.

Table 1: overview of indicators to be used in the monitoring and performance evaluation of certain climate change risk categories (exemplary compilation).

Indicator Cluster	Indicator	Unit of Measure	Description	Source
Heavy Rainfalls & Flooding	Flood peak height	TBD	Increase flowrate (peakflow) reduction due to a given rain event, thanks to the project intervention. The peakflow is the maximum value of the flowrate due to a given rain event. Peakflow variation is defined by the relative error in peakflow between the peakflow of the catchment where the project intervention is located and the peakflow of a catchment without the intervention. **This indicator can be calculated as the average value of a sample of peakflows deduced from a rain/runoff time series (typically one year) and may be obtained with observed runoff or simulated runoff.** This indicator will directly assess the impact of the project intervention in the reduction of the flowrate, which peakflow is a characteristic value.	Nature 4 Cities
	Stormwater run-off	mm/%	Run-off coefficient in relation to precipitation quantities	UnaLab
	WDT - Water Detention Time	Water flow/hr	Increased infiltration. The detention time corresponds to the theoretically calculated time required for a given amount of water to flow from a given area to another area at a given flow rate.	Nature 4 Cities
	Areas exposed to flooding	ha	Updated flood maps and monitoring data	MAES
	Regulation of quantity of water	%	Measures for instance flood reduction due to increased soil permeability (Total permeable area) ÷ (Total terrestrial area of the city) × 100% (The aim of this indicator is to know if the project intervention increased soil permeability, which impacts on flood reduction)	Singapore Index
	Coverage of stormwater drainage network	%	How much % of the project infrastructure has storm water drainage system in place	MGI

Indicator Cluster	Indicator	Unit of Measure	Description	Source
Snowfall and Frost	Number of fatalities	Number of events/year	Reduction in road fatalities where the frost maintenance is completed	MGI
	Crops damages due to the frost and snowfall	e.g. per hectare	Reduction in damage of crops due to frost compared to previous year upon practicing active/passive frost protection measures	MGI
	Frost related Infrastructure damages	e.g. in $	Reduction in damages of water pipelines where the frost maintenance is completed	MGI
Water Scarcity and Droughts	Rainwater or greywater use	% of houses	Percentage of houses equipped to reuse grey and rain water	CITYkeys
	Increase in water re-used	% in m3	Increase in percentage of rain and grey water re-used to replace potable water	CITYkeys
	Water Exploitation Index	% of m3	Reduction in annual total water abstraction as a percentage of available long-term freshwater resources in the geographically relevant area (basin) from which the city gets its water	CITYkeys
	Reduction of drought events	n°	Ratio between droughts since the project implementation / historic data (min. 50 years).	GreenSurge
	Reduction in water consumption	% in m3	Reduced water consumption through more careful and/or efficient use	CITYkeys
Temperature Rise & UHI	Temperature reduction	°C	Decrease in mean or peak daytime local temperatures. For specific project areas, (mobile) measurement of the microclimate on local level will be useful.	UnaLab
	Urban Heat Island (UHI) Effect	°C	Reduction in Urban Heat Island (UHI) effect within the project zone	CITYkeys
Forest Fires	Reduced number of incidents	Number of events/year	Reduction of Forest Fires within a certain area	DFES
	Fire prevention	TBD	Number of strategies and/or raising awareness campaigns for preventing (bush-) forest fires	Melville
	Ignition and fuel reduction	TBD	Clearing illegally dumped rubbish within 1 week of notification; clearing of firebreaks to be completed within 1 month of maintenance notification	
		%	Percent of firebreaks for which firebreak maintenance is completed	
Change in Biological System	Green Space Intensity	total area / %	Proportion of natural areas within a defined project zone	MGI
	Increase in green and blue space	% in m2	% increase of green and blue spaces due to the project	CITYkeys
	Increased connectivity	e.g. km	Structural and functional connectivity of green spaces and habitats	
		e.g. km	Ecological connectivity	UnaLab
	Conservation	Number per unit area	Number and abundance of species of conservation interest (#/ha)	UnaLab
	Species diversity	Number per unit area	Number and abundance of, e.g., species of birds (#/ha)	UnaLab
	Relative abundance of insect pollinators	n°/ha or m2		MAES

7 ANNEX

7.1 CLIMATE RISK AND RESILIENCE EXPERT SURVEY RESPONSE VALUES

Heavy Rainfall and Stormwater Flooding

RISK factors	Magnitude/ intensity	Probability /Frequency	Irreversibility/ Persistence
Expert rating	2.42	1.83	1.82
Mean deviation	0.67	0.58	0.60
Response rate	100%	100%	90%

Vulnerability		People	Economy	Environmental	Built infrastructure
Expert rating	Exposure	2.08	2.18	1.90	2.25
	Susceptibility	2.08	1.82	1.80	2.00
	Adaptive Capacity	1.50	1.60	1.44	1.92
Mean deviation	Exposure	0.79	0.87	0.74	0.75
	Susceptibility	0.67	0.75	0.63	0.74
	Adaptive Capacity	0.52	0.52	0.53	0.67
Response rate	Exposure	100%	90%	80%	100%
	Susceptibility	100%	90%	80%	100%
	Adaptive Capacity	100%	80%	75%	100%

Snowfall and Frost

RISK factors	Magnitude/ intensity	Probability /Frequency	Irreversibility/ Persistence
Expert rating	2.09	1.91	2.18
Mean deviation	0.83	0.94	0.75
Response rate	90%	90%	90%

Vulnerability		People	Economy	Environmental	Built infrastructure
Expert rating	Exposure	2.09	1.82	1.78	1.80
	Susceptibility	2.09	2.18	1.56	1.70
	Adaptive Capacity	1.82	2.27	2.33	2.10
Mean deviation	Exposure	0.70	0.60	0.83	0.79
	Susceptibility	0.70	0.75	0.73	0.82
	Adaptive Capacity	0.60	0.65	0.87	0.74
Response rate	Exposure	90%	90%	75%	80%
	Susceptibility	90%	90%	75%	80%
	Adaptive Capacity	90%	90%	75%	80%

Temperature Rise and Urban Heat Islands

RISK factors	Magnitude/ intensity	Probability /Frequency	Irreversibility/ Persistence
Expert rating	2.50	2.42	1.92
Mean deviation	0.67	0.67	0.67
Response rate	100%	100%	100%

Vulnerability		People	Economy	Environmental	Built infrastructure
Expert rating	Exposure	2.45	2.00	2.20	1.73
	Susceptibility	2.45	1.80	2.10	1.64
	Adaptive Capacity	1.73	1.90	1.90	1.73
Mean deviation	Exposure	0.69	0.82	0.92	0.79
	Susceptibility	0.69	0.63	0.74	0.67
	Adaptive Capacity	0.65	0.57	0.57	0.79
Response rate	Exposure	90%	80%	80%	90%
	Susceptibility	90%	80%	80%	90%
	Adaptive Capacity	90%	80%	80%	90%

Water Scarcity and Droughts

RISK factors	Magnitude/ intensity	Probability /Frequency	Irreversibility/ Persistence
Expert rating	2.58	2.42	2.67
Mean deviation	0.67	0.67	0.78
Response rate	100%	100%	100%

Vulnerability		People	Economy	Environmental	Built infrastructure
Expert rating	Exposure	2.58	2.50	2.64	1.64
	Susceptibility	2.50	2.58	2.64	1.45
	Adaptive Capacity	2.25	2.18	2.00	2.00
Mean deviation	Exposure	0.51	0.67	0.67	0.92
	Susceptibility	0.52	0.67	0.67	0.82
	Adaptive Capacity	0.75	0.87	0.82	0.89

Response rate	Exposure	100%	100%	90%	90%
	Susceptibility	100%	100%	90%	90%
	Adaptive Capacity	100%	90%	80%	90%

Forest Fires

RISK factors	Magnitude/ intensity	Probability /Frequency	Irreversibility/ Persistence
Expert rating	2.64	2.55	2.55
Mean deviation	0.67	0.52	0.69
Response rate	90%	90%	90%

Vulnerability		People	Economy	Environmental	Built infrastructure
Expert rating	Exposure	2.10	2.00	2.70	1.90
	Susceptibility	2.20	2.00	2.70	2.00
	Adaptive Capacity	1.40	1.70	1.70	1.70
Mean deviation	Exposure	0.88	0.67	0.48	0.88
	Susceptibility	0.63	0.67	0.48	0.82
	Adaptive Capacity	0.52	0.67	0.67	0.67
Response rate	Exposure	80%	80%	80%	80%
	Susceptibility	80%	80%	80%	80%
	Adaptive Capacity	80%	80%	80%	80%

Change in Biological System

RISK factors	Magnitude/ intensity	Probability /Frequency	Irreversibility/ Persistence
Expert rating	2.29	2.29	2.00
Mean deviation	0.95	0.95	0.00
Response rate	60%	60%	50%

Vulnerability		People	Economy	Environmental	Built infrastructure
Expert rating	Exposure	2.17	1.67	2.14	1.40
	Susceptibility	2.00	1.50	2.29	1.40
	Adaptive Capacity	1.67	1.80	1.50	1.20
Mean deviation	Exposure	0.98	0.82	0.90	0.89
	Susceptibility	0.89	0.55	0.76	0.89
	Adaptive Capacity	0.52	0.84	0.55	0.45
Response rate	Exposure	50%	50%	60%	40%
	Susceptibility	50%	50%	60%	40%
	Adaptive Capacity	50%	40%	50%	40%

7.2 INVOLVED EXPERTS

Climate Risk and Resilience Expert Survey Participants:

	Participants	Organization
Ms.	Rocío Cárdenas G.	Subsecretaría de Transporte y Movilidad
Ms.	Juana Griselda Salas Alemán	Facultad de Arquitectura de la Universidad Autónoma de Coahuila
Mr.	Avelino Hernández Corichi	Consejo Estatal De Ciencia Y Tecnología
Mr.	Eduardo Santillán Gutiérrez	Instituto Tecnológico y de Estudios Superiores de Monterrey
Mr.	Santiago Barrios Rosillo	Secretaría de Ambiente del Estado de Coahuila
	Anonymous (Climate Change Expert)	University
	Anonymous (Agro-industrial Waste Management Expert)	University
	Anonymous (Energy Expert)	University
	Anonymous (Social Service)	ONG
	Anonymous (Water & Climate Change Expert)	Research Organization
	Anonymous (Water Expert)	University
	Anonymous (Energy Expert)	Regional and Local Government

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9 AUTHORS

SOPHIE MOK
Researcher, Head of MGI Climate Assessment and Capacity Building
Fraunhofer Institute for Industrial Engineering IAO

ANA MARÍA VIVAS
Research Assistant
Fraunhofer Institute for Industrial Engineering IAO

CATALINA DÍAZ
Project Coordinator, Co-Lead City Lab Saltillo
University of Stuttgart IAT

AMRUTA JAYAWANT
Research Assistant, Co-Lead City Lab Kochi
University of Stuttgart IAT

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