MORGENSTADT GLOBAL
SMART CITIES INITIATIVE
GLOBAL APPROACH – LOCAL SOLUTIONS

Full Technical Report
City Profile Saltillo

Within the MGI Global Smart Cities Initiative Morgenstadt

University of Stuttgart
Institute of Human Factors and
Technology Management IAT

Fraunhofer

IMPLAN
INSTITUTO MUNICIPAL DE PLANEACIÓN SALTILLO

Tecnológico de Monterrey

MorgenStadt
City of the Future

Supported by:

Federal Ministry
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In cooperation with

FRAUNHOFER-GESELLSCHAFT

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Foreword

FOREWORD BY THE MAYOR OF SALTILLO

The city of Saltillo was selected as a City Lab by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and the International Climate Initiative (IKI) to design and implement projects that combine technology and social participation to find local solutions to the global challenges imposed by climate change.

The City Lab project is part of the Morgenstadt Global Smart Cities Initiative and aims to support three cities in different countries - Mexico, India, and Peru - to generate viable and replicable projects with the use of technology and knowledge exchange. With international and local experts, the project supports the cities to develop the capacity to promote smart and sustainable urban development.

Three strategic areas of work were defined for Saltillo: water, energy, and mobility, as they are fundamental for the quality of life of the population, for the city´s competitiveness, and are priority areas for climate change mitigation and adaptation in the city.

With international cooperation, the work of researchers, public officials, business leaders and citizens concerned about the environment, we were able to concentrate our efforts and work towards the same objective to create a diagnosis of the city and a portfolio of specific projects.

With this work, Saltillo makes progress in fulfilling its Environmental Agenda and contributes from the local level to the accomplishment of the multinational agreements promoted by the United Nations to reduce carbon emissions and promote sustainable development.

MANOLO JIMÉNEZ SALINAS

FOREWORD BY THE DIRECTOR OF SALTILLO MUNICIPAL PLANNING INSTITUTE

Climate change poses a new challenge in planning for development and in finding solutions to the increasingly complex problems that cities face. Local governments are the first instance of contact with the people and, therefore, those who face the commitment to mitigate and prevent the impacts of global warming to preserve the quality of life and well-being of the population.

The articulation between international cooperation, research, knowledge exchange, management, and experience is an essential process in the design and implementation of local projects to guarantee a favourable impact and good results. This is what we hope to achieve with the Morgenstadt Global Smart Cities Initiative where we have worked with the University of Stuttgart and the Fraunhofer Institute.

With the opinion and knowledge of 60 local experts, including researchers, businesses, citizens, and government from national, state, and municipal levels, we identified the challenges we need to address in Saltillo to be a smart and sustainable city in the water, mobility, and energy sectors. It has been a collaborative and enriching process, guided by a strict participatory methodology and the high-quality work of the Fraunhofer Institute.

The result of this initiative is just the beginning of a strategic change for Saltillo. This is our commitment.

OSCAR PIMENTEL GONZÁLEZ

Acknowledgements

The City Lab Saltillo, as part of the MGI Global Smart Cities Initiative, was funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety BMU through the International Climate Initiative IKI. This report is the full version of the City Profile, and it documents the research and assessment of the city executed during the first phase of the project.

The City Lab team would like to thank the exceptional support and organisation of the local partner IMPLAN Saltillo along all project phases. Special thanks for the management and efforts during the city assessment which had to be executed in a virtual format due to the restrictions imposed by the COVID-19 pandemic. Furthermore, the team would also like to thank and acknowledge the local stakeholders who participated in the interviews and workshops and without whom this research could not have been completed.

During this City Lab, several participants left the project before its completion. The City Lab Saltillo team recognizes that the contributions of all participants have been crucial to its success at all stages. In particular, we would like to thank Marielisa Padilla, Ericka Toledo and Alanus von Radecki for laying the groundwork for this project proposal and it´s coordination in the initial phase, which enabled Saltillo's participation in the Morgenstadt Global Initiative and defined the working sectors of scope. We also thank Markus Schwegler and Eliana Uribe for their valuable contributions during the practical implementation of the project.

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Universität Stuttgart Institut für Arbeitswissenschaft und Technologiemanagement IAT	The **Institute of Human Factors and Technology Management (IAT)** represents within the **University of Stuttgart** the fields of Technology Management and Engineering Economics, particularly Information and Communication Technology, Organisation Design and Personnel Management. As part of this project, the IAT carries the overall responsibility for management and coordination with national and German research institutions, institutes and stakeholders and provides expertise in the relevant fields of governance, urban systems and technologies.
	Fraunhofer Society (FhG) includes Fraunhofer experts from different institutes, topics and application fields and local FhG offices, where applicable. In addition, FhG oversees management and implementation of the City Labs, expertise building and knowledge management in and for the countries of focus and provides experts for relevant fields. As a part of MGI City Lab Saltillo, the following Fraunhofer institutes carry different responsibilities.
Fraunhofer IAO	**Fraunhofer IAO:** The Fraunhofer Institute for Industrial Engineering IAO works together with companies, public-sector bodies and institutions to develop strategies, business models and solutions for digital transformation. Its focus is on holistic approaches to working design as well as the organization and corporate cultures and key areas of research range from the application of virtual and augmented reality over sustainable solutions for mobility to system innovations for liveable and adaptable cities. On behalf of the Fraunhofer Society, the Fraunhofer Institute of Industrial Engineering IAO, as a direct partner of the IAT of the University of Stuttgart, supports elaboration and implementation of the project in the three countries. In the City Lab Saltillo, Fraunhofer IAO experts contribute to the mobility sector.
Fraunhofer ISI	**Fraunhofer ISI:** The Fraunhofer Institute for Systems and Innovation Research ISI conducts applied research in seven Competence Centers with a total of 28 Business Units and sees itself as an independent institute for society, politics and industry. In two Competence Centres, ***Energy Policy and Energy Markets*** as well as ***Energy Technologies and Energy Systems***, it contributes towards developing the political and institutional framework for a sustainable energy system. The intensive utilization of renewable energy sources and improving energy efficiency are key strategies to satisfy energy demand, ensure security of supply and protect the climate in an environment- and resource-saving way. Fraunhofer ISI designs and evaluates energy and climate policy measures and instruments for a more rapid and cost-effective development of a sustainable energy system, as well as strategies for research and development. The institute supports countries worldwide in its transition towards clean energy sources, carrying out research and consultancy projects in Germany, Europe and regions such as Latin America, the Middle East, the Balkans, South Asia, South East Asia. The institute´s competences comprise assessing the potentials and possible diffusion pathways for renewable energy technologies, model-based analyses of energy systems, the evaluation of local value creation potentials for energy technologies, as well as the development of policy instruments and strategies supporting sustainable energy transitions. These analyses are

based on a broad range of methods, in particular detailed modelling of the transformation of the energy system.

Fraunhofer IGB: The Fraunhofer Institute for Interfacial Engineering and Biotechnology IGB develops and optimizes processes, technologies, and products for health, sustainable chemistry and the environment. In doing so, it relies on the unique combination of expertise in biology and the engineering sciences to contribute to human welfare, a sustainable economy, and an intact environment with the systems approach of bioeconomy as well as bioinspired, bio-integrated and bio intelligent solutions. Fraunhofer IGB's experts lead the water sector.

Climate finance specialists from **Frankfurt School of Finance – UNEP Centre (FSF)** are responsible for the creation of financial stakeholder analysis, cost-benefit analysis, investment plans and identification of financial and investment mechanisms.

The **Municipal Planning Institute of Saltillo (IMPLAN)** is a public institution responsible for planning the sustainable development of the Municipality through citizen participation and that of its officials in a responsible urban culture; as an instrument of the Municipal structure that contributes and expands the operational, financial and urban management capacity of the different public and private actors of the Municipality of Saltillo.
As a partner of the project "Morgenstadt Global Smart Cities Initiative: Global approach - local solutions" IMPLAN is responsible for coordinating activities with the government and local stakeholders identifying priorities for the city in the water, energy and mobility sectors.

The **"Instituto Tecnológico y de Estudios Superiores de Monterrey"** well known as Tecnológico de Monterrey, is the largest private university system in Latin America. We are organized in six graduate schools with 44 Strategic Research Groups, and four Research Centers, with 578 researchers. We carry out scientific and technological research in strategic areas to meet the social, economic and environmental demands of the nation: biotechnology and food, social sciences, regional development, social development, sustainable development, education, entrepreneurship, government, humanities, manufacturing and design, mechatronics, nanotechnology, business, health and information and communication technologies. As a partner of the project "Morgenstadt Global Smart Cities Initiative: Global approach – local solutions" the Tecnológico de Monterrey supports the entire City Lab process and gives technical and logistic assistance in different steps of the MGI methodology in the sectors of water, energy and mobility.

List of Abbreviations

AGSAL	Municipal water management organization, Aguas de Saltillo
AF	Action Field
BAU	Business-as-Usual
BMU	Federal Ministry of Environment, Nature Conservation and Nuclear Safety, Germany
C3	Climate Change Council
CICC	Inter-Ministerial Commission on Climate Change
CONAGUA	National Water Comission
CFE	Comision Reguladora de Electricidad
EEZ	Exclusive Economic Zone
FCC	Climate Change Fund
FhG	Fraunhofer Society, Germany
FSF	Frankfurt School of Finance
GHG	Green House Gas
HAR	Hydrological-Administrative Region
IAT	University of Stuttgart, Institute of Human Factors and Technology Management
ICLEI	International Council for Local Environmental Initiatives
ICT	Information & Communication Technology
iDROLOC	innovative helium gas injection system
IKI	International Climate Initiative
IMPLAN	Municipal Institute of Planning of Saltillo
INDC	Intended Nationally Determined Contribution
INECC	National Institute of Ecology and Climate Change
INEGI	National Institute of Geography and Statistics Information
IPCC	Intergovernmental Panel on Climate Change
LEAP	Largest Energy Analysis Programme
LGCC	General Climate Change Law
MaaS	Mobility-as-a-Service
MGI	Morgenstadt Global Smart Cities Initiative
MLD	Million Liters per Day
NBS	Nature-based solutions
NDC	Nationally Determined Contribution
OBD	On-Board Diagnostic
PACMUN	Municipal Climate Action Plan
PECC	Special Climate Change Program
PEMEX	Petroleos Méxicanos (Mexico´s state-owned Oil Company)
PV	Photovoltaics
RSD	Remote Sensing Device
SDG	Sustainable Development Goal
SEMARNAT	Ministry of Environment and Natural Resources
SINACC	National Climate Change System
SMA	Saltillo Metropolitan Area
SUDS	Sustainable urban drainage systems
TAMD	Tracking Adaptation and Measuring Development
TAP	Transformative Actions Program
TOD	Transport-Oriented Development Model
UHI	Urban Heat Island
WWTP	Wastewater treatment plant

EXECUTIVE SUMMARY

The City Lab Saltillo aims to point the way forward for the city of Saltillo, Coahuila, Mexico, to become a sustainable and resilient city of the future. The United Nations Sustainable Development Goals (SDGs) and the Paris Agreement highlight the urgency for the transformation of cities into climate-neutral and sustainable settlements while becoming more resilient to the inevitable adverse consequences of climate change.

The City Lab Saltillo is part of the Morgenstadt Global Smart Cities Initiative (MGI) funded by the German Federal Environment Ministry through the International Climate Initiative (IKI). The MGI project aims to stimulate transformational change in urban systems through an integral and cross-sectoral analysis of the status quo. It identifies potentials to improve the sustainability performance in selected sectors and develop tailored, sustainable, and integrated solutions to improve urban infrastructure processes or services. While this approach has been applied in numerous contexts[1], the current MGI deals with three cities: Saltillo (Mexico), Kochi (India) and Piura (Peru).

The selection of the three MGI cities is no coincidence. It is precisely these mid-size urban settlements in the Global South that are experiencing the most rapid growth and will face severe challenges in the future, both in terms of adaptation and mitigation in terms of climate change and sustainable urban development. The MGI aims to support these cities in developing a coherent approach that underpins urban climate resilience and sustainable urban development with innovative policies and efforts to develop cross-sectoral interventions and infrastructures.

The City Lab Saltillo builds on Saltillo's development priorities to support the city's efforts in working towards sustainable and inclusive initiatives. The goal of this City Lab is to help Saltillo become a model for innovative, locally tailored, climate-smart solutions targeted at increasing its resilience to climate change impacts while preserving the natural resources and stimulating the local economy. The City Lab focuses on three sectors. These were selected after an initial assessment of the city executed under the project's methodology and local stakeholder consultation during the kick-off visit in 2019. The resulting sectors are energy and CO_2 emissions, water, and mobility. In each of these sectors, measures were identified and assessed as a part of the City Lab process.

The Mexican city of Saltillo has a population of approximately one million inhabitants. Due to its flourishing economy in one of Mexico's most prosperous regions, it is characterized by high demographic growth, adding more than 25 000 inhabitants to its metropolitan area every year. Saltillo is the capital of the northeastern state of Coahuila de Zaragoza – a state with above-average economic indicators neighbouring Texas, USA, with which it shares a border of more than five hundred kilometres. The city is in the desert of Coahuila; despite its location, it has grown extensively as a sprawling city. It covers an area of 270 km², ranking sixth in Mexico in terms of the lowest population density.

In terms of sustainability, the city has great potential for action. Considering its arid climate and already-present water risks, the city has excellent potential to improve its resilience against aggravating water scarcity. Located in an area with outstanding solar potential, the city of Saltillo could harvest solar energy by integrating solar Photovoltaics (PV)

1 For more information visit https://www.morgenstadt.de/en/projekte/city_labs.html

technologies to cover its energy demand. As one of Mexico's most industrialized zones, Saltillo has excellent potential to reduce its Green House Gas (GHG) emissions in the industrial sector by improving energy efficiency and upscaling renewable energies. Considering the continual urban expansion, Saltillo could improve its sustainable mobility services by extending its public mobility services, encouraging non-motorized mobility, and integrating mobility and urban planning. These opportunities for sustainable development were a repeated subject of discussion in over 45 interviews conducted with expert local stakeholders in the academic, public, and private sectors. Likewise, the interviewees mentioned many salient challenges that impede sustainable development. The most important factors that inhibit transformational change in the long term are a lack of environmental consciousness, limited financial resources and the challenge of implementing long-term incentives in the face of changing governments.

This City Profile Report presents the results of the City Lab Saltillo as one of three pilot cities within the Morgenstadt Global Initiative project. It describes the status quo of Saltillo regarding its sustainability performance in the sector of mobility, energy and CO_2 emissions, and water, presenting the most salient challenges, solutions and a sustainability vision for each sector. Furthermore, it presents a list of concrete project ideas developed for the city of Saltillo or other interested stakeholders to develop and move towards the defined sustainability vision.

1 Introduction

This City Profile report provides the reader with a comprehensive analysis of the city of Saltillo, where the City Lab is conducted under the Morgenstadt Global Smart Cities Initiative (MGI). The primary purpose of this report is to present the main findings of the City Lab activities and the sustainability profile of Saltillo. The sustainability profile consists of an overview of the climate change policies, status quo, challenges, and measures, and an in-depth analysis of the selected sectors in Saltillo. This City Profile report builds on extensive research performed remotely and collaboratively with the local partners in Mexico. This report provides a comprehensive overview of the main findings of the digital on-site assessment and the successive Strategy Roadmap development activities.

The report is structured into five major chapters:

- **Chapter 1 Introduction** describes the MGI Initiative and its core components
- **Chapter 2 Overview of Mexico** introduces climate change impacts and vulnerabilities in Mexico, as well as the existing policies and institutional arrangements
- **Chapter 3 City Profile** discusses the sustainability profile of Saltillo
- **Chapter 4 Roadmap** shows potential measures for the future development of Saltillo and integrates them into a Strategy Roadmap
- **Chapter 5 Outlook** concludes the analysis and highlights the main findings from the City Lab assessment.

1.1 Morgenstadt Global Smart Cities Initiative

The MGI Initiative is funded by the Federal Ministry of Environment, Nature Conservation and Nuclear Safety (BMU) through the International Climate Initiative (IKI). The project aims at a transformational change through the analysis, identification, and development of sustainable cross-sectoral solutions to optimize urban infrastructures, processes, or services in Kochi (India), Piura (Peru), and Saltillo (Mexico).

The MGI aims to help the cities increase their resilience to climate change impacts and support their Green House Gas (GHG) emission reduction efforts. Climate change represents a global challenge that can only be mastered through international cooperation. As part of the IKI network, the MGI's primary objective is to mitigate the consequences of climate change in the pilot cities, increase their resilience to climate risks, and preserve their natural resources better.

The structure of the project fosters peer-to-peer learning, innovation, sustainable urban development practices, and collaboration between the local and global research communities, cities, as well as the private sector. The multi-stakeholder dialogue and the holistic urban system assessments in the participant cities are the vital elements to achieve the project's objectives. Furthermore, the project methodology supports the pilot cities in developing and implementing analytical methods, strategic planning tools, and the increase of local expertise for a

holistic, long-term, and sustainable urban development process.

The selection of the three participant cities of Kochi (India), Piura (Peru), and Saltillo (Mexico) was based on the challenges they face in terms of climate change. All of them present a high degree of urbanization or urban growth. They have identified urbanization as a source as well as a solution to many sustainability challenges in regional development strategies. However, neither Kochi, Saltillo, or Piura have a coherent approach that underpins urban climate change and sustainable urban development with innovative policies and efforts to develop clean and interconnected technologies and infrastructures.

Altogether, the MGI initiative begins a long-term and sustainable transformation process, leading to replicable and financially viable solutions for a resource-efficient, resilient, and livable city of tomorrow.

1.2 Morgenstadt Network

At the heart of the MGI project is the Fraunhofer Morgenstadt Network which has been instrumental in establishing the group of experts leading the City Lab Saltillo.

The Fraunhofer Morgenstadt is a network consisting of Fraunhofer Institutes, municipalities, and companies launched in 2011 by the Fraunhofer Institute for Industrial Engineering (IAO) to conceptualize, develop, and test innovations for the city of tomorrow. Within the framework of research projects, partners of Morgenstadt develop solution strategies for urban systems in changing environments. They work on identifying and analyzing impending disruptive developments for the city of the future and designing new management approaches, systems, and business models.

The combination of different perspectives and expertise from applied research (Fraunhofer Institutes), municipal practice (specialist offices, local politicians, citizens) and solution-oriented business (companies) allow the network to react flexibly and with agility to the public funding programs.

1.3 City Lab Approach

In cooperation with the University of Stuttgart and partners from the industry, the Fraunhofer society developed the Morgenstadt City Lab approach: a holistic, analytical framework for designing individual sustainability strategies for cities building on innovation, clean technologies and broad stakeholder dialogue. The Morgenstadt City Lab consists of an in-depth analysis of a given city based on performance indicators for assessing the quantifiable sustainability performance, key action fields essential for sustainable development and the unique impact factors that operate on each city. The Morgenstadt City Lab is a unique instrument that has been developed based on examples of cities across the globe, including Copenhagen, Singapore, Freiburg, New York City, Tokyo, Leipzig and Sabadell. It has been successfully applied in Berlin, Prague, Lisbon, Chemnitz, Joinville, Coimbatore and Tbilisi. The results of each City Lab include an individual sustainability profile, a detailed analysis of specific urban sectors, an action-oriented roadmap, and the development of innovative measures and projects. The Morgenstadt City Lab approach follows a comprehensive four-phase process which is illustrated below in Figure 1.

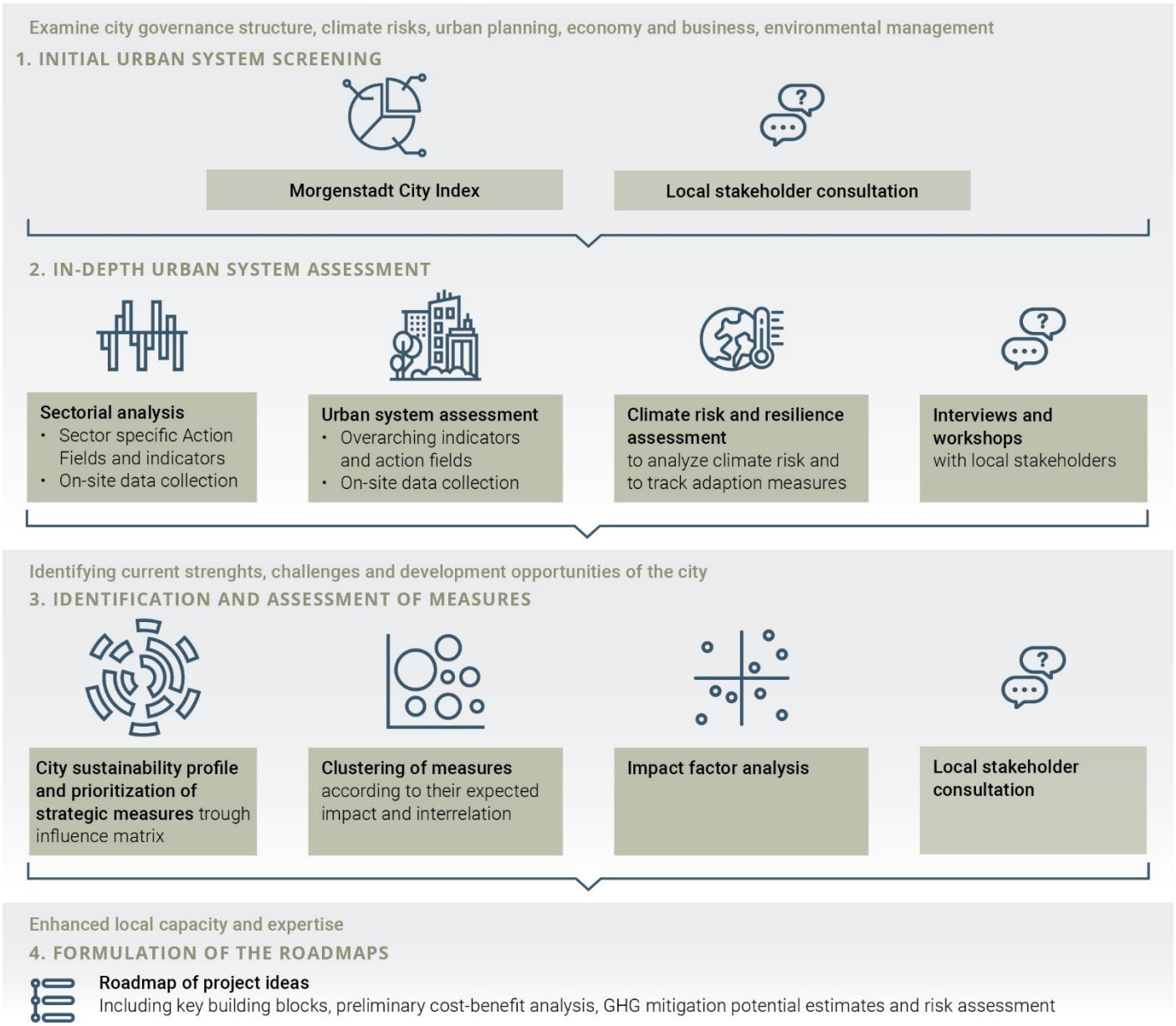


Figure 1: Morgenstadt Framework for MGI

Phase 1: Initial Urban System Screening

The initial phase of the City Lab process focuses on understanding the city structure and analyzing its challenges. As a first step, a kick-off meeting is held jointly by the experts and city partners to inaugurate the City Lab process. It includes the vision workshop where main challenges and opportunities are identified, and initial intervention ideas are discussed. A kick-off meeting is followed by the initial mapping of the relevant stakeholders.

Subsequently, the expert team carries out a preliminary assessment of the city through the Morgenstadt City Index. Based on the strategic document analysis and local partner input, the index draws a preliminary picture of the sustainability profile of the city. The results of this analysis in Saltillo can be found in chapter 3.5. The index and the strategic document analysis serve as a basis for the further stakeholder dialogue that informs the strategic sector selection.

Phase 2: In-depth Urban System Assessment

With the work sectors selected, the Fraunhofer Morgenstadt assessment framework for sustainable urban development is adapted to suit the local context and MGI project needs. The framework is based on the qualitative and quantitative assessment of the urban systems and deals with sector-specific indicators and climate change adaptation, mitigation, and municipal finance.

Additionally, the climate risk and resilience are assessed for the city through expert evaluation. The assessment framework is developed in two steps. The first step is in close accordance with the Intergovernmental Panel for Climate Change (IPCC) framework for identifying key risks and vulnerabilities. Whereas, the second step follows the Tracking Adaptation and Measuring Development (TAMD) framework to analyze the climate change adaptation measures taken by the city.

To conclude this phase, the interviews and workshops with local stakeholders take place under the on-site assessment format. The latter is a critical step in the project where the expert team and 'mirror team'[2] from the city facilitate the primary data collection through high-level expert interviews and site visits together. Based on the interviews with local stakeholders, the factors that substantially influence the city's development are defined in chapter 3.7. Due to the challenges imposed by the COVID-19 pandemic during 2020, the on-site assessment in Saltillo was executed for the first time in the history of the Morgenstadt methodology in an online format. For this purpose, the methodology was adapted, and the interviews were conducted remotely via Microsoft Teams and Zoom. Due to travel restrictions, the site visits could not take place.

Despite the challenges, the hypotheses developed during this phase were tested in the local stakeholder workshop, which gathered crucial stakeholders in the city. This workshop was also executed in an online format, and the local partner IMPLAN organized it with the support of the City Lab team members in Mexico and Germany.

Phase 3: Identification and assessment of measures

During phase 3, the expert team analyses the results collected from the sectorial analysis, the urban system, and the climate and resilience assessments. The possible measures identified are prioritized under defined criteria. Furthermore, an impact factor analysis is executed, with reflects the inherent characteristics of the city. The results inform the definition of the measure as well as the roadmap. To conclude this stage, the measures are presented to the involved local stakeholders in phase 2.

Phase 4: Formulation of the roadmaps

The City Lab process concludes with a roadmap that includes sustainable project ideas and instruments developed by the expert team (please refer to chapter 4 for more details). The resulting roadmap aims to support the city's efforts for GHG emission mitigation, climate change adaptation and conservation of biological diversity and is assessed in coordination with project experts, local stakeholders, and partner organizations.

After careful analysis of the project ideas within the roadmap and defining their preliminary technical and financial details, the city is provided with a catalogue of projects

[2] 'Mirror team' comprises of associates from local partners accompanying Fraunhofer experts during the project activities.

that can be carried out. As part of the MGI initiative, one of these project ideas receives funding to implement a pilot project.

To ensure the success of the implementation and operation of the pilot project, viable business models and alternative financing strategies need to be derived.

As a final step, capacity and expertise are developed and expanded in the partner cities, and the establishment of the internal knowledge management system and disseminated activities are carried out.

1.4 City Lab Saltillo

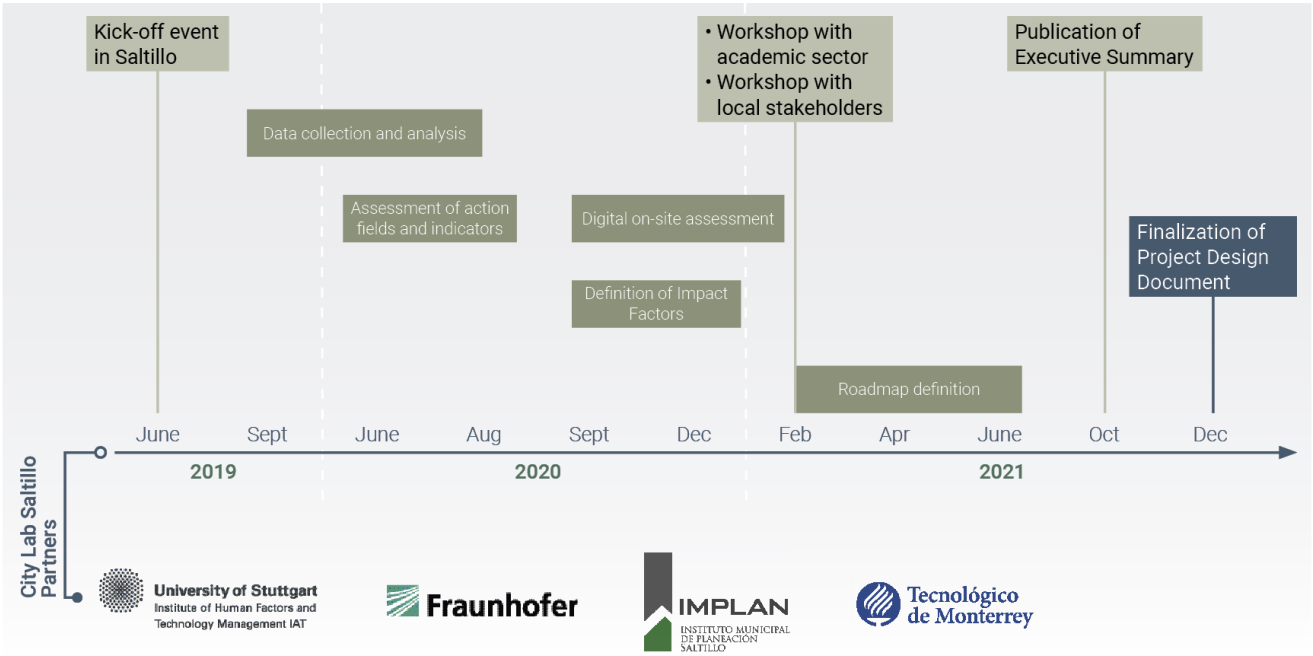
The City Lab Saltillo builds on Saltillo's development priorities to support the city's efforts in working towards sustainable and inclusive initiatives. The goal of this City Lab is to help Saltillo become a model for innovative, locally tailored, climate-smart solutions targeted at increasing its resilience to climate change impacts while preserving the natural resources and stimulating the local economy. As mentioned, the City Lab focuses on the sectors of energy and CO_2 emissions, water, and mobility. In each of them, measures were identified and assessed as a part of the City Lab process. These are discussed in the following chapters.

Figure 2 represents the project timeline applying the City Lab approach.

During Phase 1 a collaborative process between the City Lab team in Germany and local partners in Mexico started for the research of strategic documents and initial data collection.

The City Lab team then investigated the key challenges and opportunities in Saltillo following the Morgenstadt City Lab methodology. The City Lab team, therefore, assessed 83 indicators (please refer to chapter 3.6.1) and 73 Action Fields (please refer to chapter 3.6.2) to understand Saltillos' performance in the three selected sectors as well as to examine city governance structure, climate risks, urban planning, economy and business, and environmental management. The climate risk and resilience expert assessment was also carried out to analyze climate risk and track adaptation measures for Saltillo.

Furthermore, during the digital on-site from September to December 2020, the team



conducted more than 40 interviews with local stakeholders from industry, academia and the civil society focusing on the identification of current strengths, challenges and development opportunities of the city (a list of all interview partners and their organizations is provided in Annex I). The interviews phase concluded with an internal cross-sectoral workshop on the 18th of December 2020, where the sectors of energy and CO_2 emissions, water, and mobility presented a summary of the main results from the research of indicators, action fields and impact factors as well as identified challenges and opportunities for Saltillo. A total of 26 project ideas were presented, followed by a discussion to find synergies and possible cross-sectoral integration between the proposed project ideas.

In February 2021, two workshops with local stakeholders were organized to present and discuss the initial project ideas per sector. Firstly, a session with the academic sector was held on the 4th of February 2021, where the main results of the research and analysis phase of the project were presented to key local academic stakeholders. During the second workshop, organized on the 11th of February, the project ideas per sector were presented and discussed with local relevant stakeholders. The participants had the opportunity to give their feedback and comments regarding the projects and highlight those they found more attractive. After the feedback received in these two sessions, a refinement process of the project ideas was carried out.

After having concluded the city assessment, the definition of project ideas, and the roadmap, the City Lab team conducted various presentations with key political stakeholders in the city. For instance, a summary presentation of the project´s progress was given to the director of the Municipal Institute of Planning (IMPLAN) Lic. in Saltillo, Oscar Pimentel. Mr Pimentel is a well-known political personality of Saltillo, as former Major of the City and Member of the National Mexican Parliament. In particular, he has played an active role in informing the Mayor of the City about the City Lab Results, as they coincide with an environmental agenda postulated and carried out by IMPLAN Saltillo and Major Manolo Jiménez. Mr Oscar Pimentel developed Saltillo's first environmental agenda and has a very active role in supporting the Morgenstadt City Lab and the PACMUN as key initiatives of IMPLAN.
Furthermore, the results were also presented to the Secretary of Environment Biol. Eglantina Canales, who was interviewed during the digital on-site assessment phase. Ms Canales expressed her interest and support to IMPLAN in the implementation of all projects in the portfolio generated during the City Lab (see chapter 4). The implementation of all project ideas after the end of the MGI project would depend on available funds; however, finding new funding sources is already part of IMPLAN´s agenda.

To conclude this contextual review and to form a holistic overview of the current status quo in Saltillo, it is necessary to understand the climate change and policy landscape in Mexico. It is crucial because many of the policies affecting urban development in Saltillo are closely linked to and initiated at the state or national level. Therefore, the next chapter provides an overview of the significant climate change challenges and policies in Mexico.

2 Mexico

Country background

Mexico is a Latin American country of high human development[3], with a population of 126 million inhabitants and a total area of 1,964,375 km², (INEGI 2011). With abundant natural resources, Mexico is the 15th largest economy in the world and the second-largest economy in Latin America (INEGI 2021). As for 2020, 1.7% of Mexico's population was living below the international poverty line (1.9 USD per day), while 6.6 % of Mexico´s population was living below the lower middle income class poverty line (3.2 USD per day) (World Bank 2021b). Besides poverty, high criminality rates and corruption also pose challenges to Mexico's development.

Mexico has free trade agreements with over 40 countries, and in the last decades, it has diversified its exports from raw materials to manufactured products, including machinery, electronics and transport vehicles (World Bank 2021a). Its primary trading partner is the United States, which accounts for 80% of the country's exports (Nordea Trade 2020), revealing Mexico's mutual dependence with his neighbouring country. Mexico is considered one of the major oil exporters in global markets, yet the oil production has been declining, dropping from 2.6 mbbl/ day to 1.6 mbbl/ day over the last decade, from 9% to 4% of Mexico´s total GDP, and from 16% to 6% of total exports over the same time period (OECD 2019; World Bank Group 2016).

Over the last three decades, Mexico has benefited from exports of natural resources, working-age population growth, and open trade and investment policies. A solid macroeconomic framework has delivered fiscal discipline, abated inflation and enabled Mexico to weather well various commodity price and emerging markets shocks (OECD 2019). The economic growth averaged approx. 2 per cent a year between 1980 and 2018, and last years' GDP activity revealed an unsteady growth, ranging around a 2.1% GDP increase (INEGI 2019). All these economic tendencies traduce in moderate growth in terms of economic, inclusion and poverty reduction compared to similar countries. Besides, moderate growth reflects low productivity due to larger structural factors: high informality influenced by complex labour and business regulations, resource misallocation, poorly functioning credit markets, low competition in key sectors, poor educational outcomes, and large infrastructure gaps (OECD 2019).

Mexico's Cities and Urbanization

On the other hand, the unequal geographical development and rapid increase in population have produced a continuous urbanization and the uncontrolled growth in Mexican cities, reaching an urbanization rate of approx. 80% by 2019, a figure that is projected to increase to 90% by 2050 (Figure 3) (UN DESA 2021).

[3] With a Human Development Index value of 0,78, ranking 74 globally (UNDP 2021)

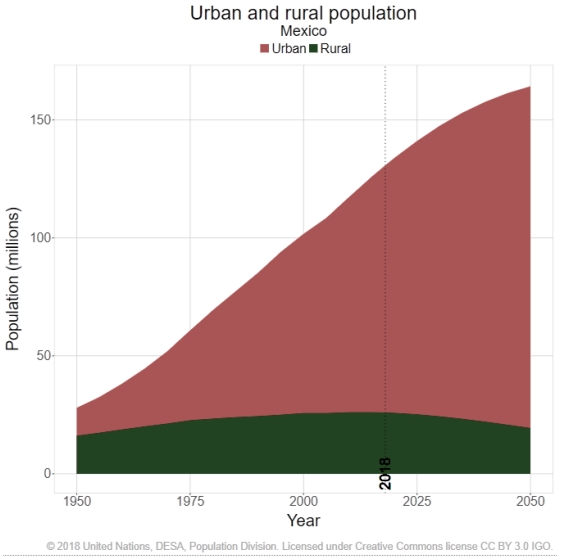


Figure 3: Population growth, rural and urban population 1950-2050 (UN DESA 2021)

Thereby, cities are defined as those localities with more than 15,000 inhabitants. According to the national population council CONAPO, by 2019 there are approx. 400 such urban locations in Mexico. Next to the Mexico City metropolitan area, home to the 27% of the population, it is big cities (1-10 million inhabitants) located in central Mexico and on the border to the United States, such as the City of Saltillo which are home to the largest fraction (23%) of its urban population (Figure 4) (World Bank 2016).

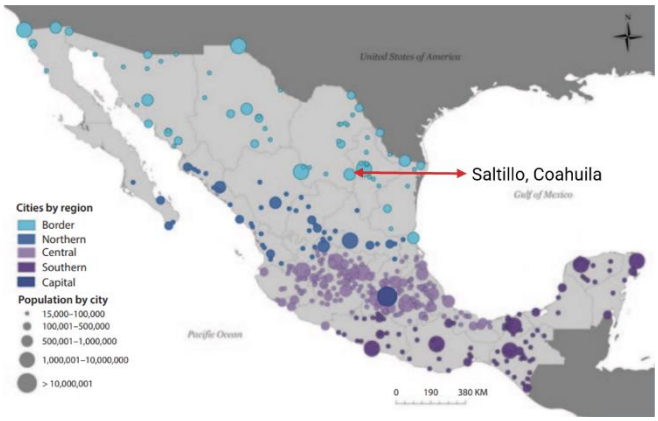


Figure 4: Mexican Cities by size and location (World Bank, 2016)

In terms of local governance, Mexico is a federal republic, subdivided in 32 states and 2454 municipalities, with distinct responsibilities regarding urban planning and the provision of urban services. Following article 115 of the Mexican constitution (Constitución Política de los Estados Unidos Mexicanos 2021) municipalities are in charge of:

- Drinking water, drainage, sewerage, treatment, and disposal of their waste waters
- Public lighting
- Cleaning, collection, transfer, treatment and final disposal of waste
- Markets and supply centers
- Cemeteries
- Landfills
- Streets, parks and gardens and their equipment
- Public safety and security: municipal preventive police and transit

Further, the general law on human settlements, land use and urban development stipulates that municipalities are in charge of urban planning and development (LEY GENERAL DE ASENTAMIENTOS HUMANOS, ORDENAMIENTO TERRITORIAL Y DESARROLLO URBANO 2016).

2.1 Mexico´s Climate Change Impacts and Vulnerabilities

Mexico counts with a rich cultural history and is considered a 'Megadiverse' country according to the U.N. Environment Programme due to its variety of fauna and flora species (Geo-Mexico 2010). Mexico is considered one of the most important countries globally in terms of biological diversity, it is home to 10-12% of the world´s biodiversity in 1.3% of the world land area. Besides, Mexico hosts about 12% of known

terrestrial biota and is one of the world's 12 mega-diverse countries (OECD 2012).

Mexico is highly vulnerable to climate change due to its geographical location, topography, and socioeconomic characteristics. Besides, socioeconomic and ecological trends, including the urbanization phenomena and pressures on natural resources due to economic and population growth, suggest that under a business as usual scenario, the climate risk will compound other social and economic problems in the country (INECC 2019a; SEMARNAT und INECC 2016). In the last 50 years, Mexico has experienced changes in temperature and mean precipitation. The country has become warmer, with an average temperature increase greater than 0.85°C. At the same time, Mexico has suffered an increased number of extreme weather events such as tropical cyclones, floods and droughts that have led to the loss of human lives as well as high social and economic costs. According to data provided in the PECC 2014-2018 (Diario Oficial de la Federación 2014), 13% of municipalities in Mexico present the highest degree of vulnerability to climate change. About 25% of the population lives in irregular settlements and flood risk areas, while droughts in the north of the country are increasingly recurrent and threaten the population's water and food security.

Climate change impacts can be observed in the territory's ecosystems as well as on variations in natural cycles. For example, land and sea surface temperatures have increased over the whole country, incrementing between 1.2 and 1.5° C above the historical average (Mexican Government 2015, S. 2). This warming tendency has caused more frequent heatwaves in dense cities such as Mexico City, Veracruz and Mexicali (Tejada Martínez et al. 2010).

According to what is described in the National Atlas of Vulnerability to Climate Change in Mexico published in 2019, the projected effects for Mexico are the following:

- **Storms and severe weather:** Possible increase in the intensity of cyclones in the Northeast, Pacific and Atlantic. The dynamics of watersheds' vulnerability to heavy rainfall are becoming higher due to continuous changes in land cover, and consequently, the risk of floods has risen (INECC 2019a).
- **Floods:** increase in the intensity and frequency of strong storms, which would increase the risk of flooding. It has been estimated that 162,000 km^2 of Mexican territory is susceptible to flooding. Although this accounted for only 8 % of its territory, the socio-economic impact may be equivalent to up to billions of dollars, according to the affected urban zone, population density, economic activities, existing infrastructure, and vulnerability and resilience (INECC 2019a).
- **Loss of Biodiversity:** Reduction of vegetation cover, decrease in the range of some mammals. Habitat destruction has led to an increase in the rate of animal species' loss, causing 40% of them to be in danger of extinction (WWF 2010).
- **Water resources:** Most of the country will become drier and droughts more frequent, with the consequent increase in water demand (INECC 2019a). Regarding droughts, the states in the north of the country have been more affected causing rivers to dry and certain land portions to become barren (SEMARNAT 2016). It is expected that in the following 15 years, rainfall will decrease between 10 and 20% (Mexican Government 2015, S. 4).
- **Coastal Plains:** Sea Level Rise, the coastal areas of Mexico are highly vulnerable due to the potential increase in sea level, mainly

the states of Sinaloa, Tabasco, Tamaulipas, Quintana Roo, Veracruz and Yucatán (INECC 2019a).

- **Food:** Decrease in corn productivity by the 2050s. There is evidence that most crops will be less suitable for production in Mexico by 2030 (INECC 2019a).

Additionally, Mexico has reported the appearance of dengue cases in regions where they were not before (SEMARNAT 2016). Infectious and vector diseases (e.g., dengue, malaria) are especially risky in low-income settlements where high population density and insufficient sanitary conditions increase the probability of a quick spread of diseases.

2.2 Mexico´s Climate Policies and Institutional Arrangements

Conscious of the necessity to develop institutional collaborations and strategies to address climate change's effects, the Mexican Government established the General Climate Change Law in 2012 (LGCC). This law determines the institutional and legislative frameworks for the national climate change policy, including the definition of duties for States' authorities as well as the establishment of financial, regulatory and planning instruments (INECC 2018). To achieve effective coordination of public institutions at different governmental levels (i.e. national, federal, state and municipal) and allow consultation with the private and social sectors, the LGCC included the creation of a National Climate Change System (SINACC) (CICC 2013). This system is composed by:

1. **The Inter-Ministerial Commission on Climate Change (CICC):** Coordinating organism gathers together 13 State's ministries intending to formulate and implement public policies for the mitigation and adaptation to climate change (CICC 2013).
2. **Climate Change Council (C3):** Advisory board for the CICC on climate change-related topics. It is composed of members from the civil society, private and academic sectors, including experts in addressing climate change effects (CICC 2013).
3. **National Institute of Ecology and Climate Change (INECC):** Research Institute responsible for developing studies and scientific research in climate change matters. It collaborates in the elaboration of plans and strategies regarding climate change mitigation and adaptation.
4. **Mexican Congress**
5. **Mexican states' governments**
6. **Municipal Authorities**

Two main planning instruments developed by the SINACC are the National Strategy on Climate Change, Vision 10-20-40, presented in 2013, and the Special Climate Change Program (PECC) for the period 2014-2018. The National Strategy aims to present a medium and long-term roadmap for Mexico in terms of strategic axis and action lines to face the effects of climate change and achieve a more resilient and sustainable future (CICC 2013). Similarly, the PECC builds on the National Strategy on Climate Change guidelines to define the priority actions for mitigation and adaptation to climate change and set more concrete aspects of the strategy execution (e.g. responsible actors, timeline, and cost estimates).

As part of an international partnership, the Municipal Climate Action Plan (PACMUN) was launched in 2011. This program, initiated by International Council for Local Environmental Initiatives (ICLEI) counted with the technical support of the INECC and financial contributions from the British Embassy in Mexico (Climate Initiatives Platform 2019a). Currently, Saltillo is developing its PACMUN,

with the objective of identifying the main sources of GHG emissions in the Municipality and propose lines of action for mitigation and adaptation measures. The research done during the course of the two first phases of the MGI project will be part of PACMUN and provide a scientific base and information that the city was not able to compile in the previous years due to the lack of resources.

Additionally, in the international sphere, Mexico ratified the Paris Agreement on climate change in 2016. In the country's Intended Nationally Determined Contribution (INDC) 2020-2030, presented in March 2015, Mexico committed to reducing its GHG emissions by 22% and black carbon emissions by 51% as part of their unconditional goals (INDC 2015). 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 Nationally Determined Contribution (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 an unconditional reduction of 22% in GHGs emissions by 2030 compared to the baseline.

3 City Profile of Saltillo

This chapter provides an introduction to the City of Saltillo and an in-depth analysis across different sectors, based on the Morgenstadt Methodology analysis. To start, this chapter gives an overview of the city in terms of economy and society, governance structure, finances, and climate observations. After this portion of relevant contextual information, the Morgenstadt City Index and the City Systems Analysis results are presented. Later, the assessment of the three sectors of work (water, mobility, and energy and CO_2 emissions) is presented, and the sensitivity analysis, which opens the discussion on the City Roadmap in chapter 4.

POPULATION
Above one million inhabitants and 2.6% growth per year, among the top 10 fastest growing Mexican cities.

GEOGRAPHY
Area of 270 km², ranking sixth in terms of the lowest population density of Mexico.

ECONOMY
Located in Coahuila, among Mexico's wealthiest states, with a per capita income 25% above the national average and a per capita Gross Domestic Product 33% above the national average (Gobierno del Estado de Coahuila de Zaragoza 2021). Firmly based on industrial activities, in particular automobile, machinery and steel products manufacturing. More than 40 industrial parks are located in Saltillos industrial zone

WEATHER
Semi-arid, dry weather with high solar radiation and low precipitation throughout the year. Vast solar potentials above 1,900 kWh/kWp (~22% of the year).

Figure 5: Overview of Saltillo

3.1 Economy and Society

Saltillo is the capital of Coahuila de Zaragoza, a state in the northeast of Mexico that shares more than five hundred kilometers with Texas, U.S.A. and that borders the States of Chihuahua, Durango, Zacatecas, San Luis Potosí and Nuevo León. Coahuila has 7.73% of the country's territory. According to the National Institute of Geography and Statistics Information (INEGI 2015). Saltillo has a land area of 6,837 km2, it is located 1,560 meters above sea level, and its coordinates are 25 ° 26 ’00” latitude and 101 ° 00 ’00” longitude. Due to the infrastructure, regional broadening, economy and demography expansion, the metropolitan area of Saltillo has increased and made up a bond, not only with economic agents; individuals and collectives, but also with the exchange of natural or artificial entities - goods, services, and money, in a myriad of combinations between the municipalities of Ramos Arizpe and Arteaga. The metropolitan area has approximately one million inhabitants, with a growth rate of 20 thousand inhabitants per year (INEGI 2020a).

In particular, the total population of Saltillo is 864,082 people, representing 28.24% of the total population of Coahuila (INEGI 2020a). 72.2% is officially part of the working-age population, and the number of economically active inhabitants in Saltillo is 393,409 people, which translates approximately to 49% of the population (INEGI 2020c). It is the municipality with the largest population and the nucleus of a highly competitive region in the national economy and the world market.

The city's economic activities are centered on the secondary sector, representing 83% of the economic activity, and within this sector, the

manufacturing industry represents 97.3% of the total (INEGI 2020b). The city has a strong concentration of automotive, metallurgical, and aerospace companies. Since 1970, plants such as Grupo Industrial Saltillo, General Motors, Magna, Fiat Group, Chrysler, Daimler, Freightliner, Delphi, Nemak, Plastic Omnium have been installed in the region. It has a predominantly manufacturing economy. The production of machinery and equipment is mainly focused on the region of Saltillo. The State of Coahuila contributes 3.7% of the country's Gross Domestic Product, mainly focusing on machinery and equipment production (INEGI 2020b).

3.2 City Governance Structure

The municipality of Saltillo is part of the 38 municipalities of the State of Coahuila de Zaragoza. The municipality has five main axes; population, territory, organization, the functioning of public institutions and finances (Administración de Coahuila 2020). It is characterized by being autonomous since it has its legal personality, its assets, does not have hierarchical subordination links with the State government, freely administers its property, and direct and democratic elections every 4 years.

The Municipal President is the head of the Municipal Public Administration and has the attributions, functions and obligations indicated by the Political Constitution of the United States of Mexico, the Political Constitution of the State of Coahuila de Zaragoza, the Municipal Code for the State of Coahuila de Zaragoza, and the Internal Regulations of the Municipality. The head of the Municipal Administration has different powers and obligations as direct, coordinate, organize, supervise and evaluate the Municipal Public Administration in all of its centralized, deconcentrated, decentralized and para-municipal entities (para-municipal is defined as an organization with public and private administration; Administración de Coahuila 2020, S. 6).

The municipal administration, also known as the City Hall, has councilors and trustees. The councilors are the members of the City Hall in charge of governing and administrate as a collegiate body.

Each councilor must assist the municipal president and be a member of the commission assigned by the council in the different branches of the administration. Individually they don´t have decision-making power; however, all the councilors, together as a collegiate organization called Cabildo, meet at least every fifteen days to make decisions and prioritize the agenda. Each commission is entrusted with studying, analyzing, and reporting every decision that matters to them or any specialized administrative topic. By 2021, Saltillo has twenty-two commissions; as Treasury, Heritage, Public Account and Medical Expenses; Planning, Urbanism, Public Works and Historical Center; Municipal Assets, Unusable Equipment and Acquisitions; Markets and Rastro, Education, Security and Public Transit; Show, Recreations and Sports; Mobility and Public Transport; Human Rights and Gender Equality; Water and Sanitation; Environment and Sustainable Development; Alcohol; Rural Development; Rules and Government; Administrative and Transparency; Public Services and Pantheons; Youth; Public Health; Human Development; Economic Development and Tourism; Culture and Human Value; Conurbation.

In addition, there is a trustee, who is the member of the City Hall in charge of overseeing the financial aspects of the same, procuring and defending the interests of the municipality and representing them legally.

The IMPLAN, is a public institution responsible for the planning of the sustainable development of the municipality, through the participation and promotion among its citizens

and officials of a responsible urban culture; as an instrument of the municipal structure that contributes and expands the operational, financial, and urban management capacity of the different public and private actors of the municipality. It is a planning body that maintains its autonomy and transparency in which decisions are made with its assets and legal personality and has a governing board with majority participation of citizens, who seek at all times the common good.

The IMPLAN is an instrument and ally of the City Council that supports and helps effectively and strategically in the decision-making process, and also serves as a center of reflection and research with a scientific orientation that is carried out through studies and the preparation of strategic projects in essentially municipal issues, without less attention to the regional and metropolitan context (Saltillo Gobierno Municipal 2016).

3.3 Climate Finance and Project Landscape in Saltillo

Saltillo has a strong budget performance and liquidity position, plus zero debt commitments. As a result, the city has a positive credit rating by Fitch Ratings (AAA) and Standards and Poors (mxAA).

The City has implemented a couple of green infrastructure projects in the past, mainly with national funds or with third party financing (i.e. with no debt instruments, international financing or grants). Past projects include the following:

- Water treatment plant (in collaboration with a private company and the fund was a federal grant)
- Sanitary landfill (currently operated by Lorean, who was responsible for seeking the financing)
- Public LED lighting (where a private party committed the investment –the borrower-, and Saltillo must make repayments –not debt-)

As indicated in the above examples, until now the City has sourced financing from the Federal Government or has collaborated with private parties. Going forward, Saltillo would like to have a catalogue of assessed projects to seek alternative financing solutions, chiefly third-party financing (e.g. vendor finance) or international grants, but neither concessional nor commercial debt.

For example, the city would benefit from detailed feasibility analyses to tap into different funding options and participate in international initiatives such as the Transformative Actions Program (TAP). They already participated but were unsuccessful as they lacked a portfolio of projects with financial analysis/proposals.

Last, the city is in transition because the Administration will change in 2022, but it is not expected that this will result in any change to priorities in green infrastructure. Indeed, the city priorities align with the objectives of the Morgenstadt Global Smart Cities Initiative, i.e., to enable Saltillo to implement a long-term, sustainable and innovation-based urban development independently.

3.4 Climate Observations, Impacts of the Climate Change

As part of the *City Lab Saltillo*, a risk and vulnerability assessment of climate change impacts was carried out, including a literature review, a systematic expert consultation and a survey involving local and City Lab experts. A group of six main risk clusters were identified.

3.4.1 Heavy Rainfall and Stormwater Flooding

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). Experts perceive the magnitude of individual, rapid precipitation events as a considerable risk to the city. Extreme precipitation episodes cause flooding in urban spaces, often causing structural damage to urban infrastructure. Experts highlighted the fact that flooding has increased due to recent urbanization patterns and the sealing of natural streams. In addition, the construction of new dwellings and building complexes on unauthorized sites and the intensified blocking of creeks with solid waste has also been identified as causes of the obstruction of the natural flow of stormwater (Ríos und Chantaka 2019).

In terms of socio-economic vulnerability, low-income areas and informal settlements are especially at risk. According to the Saltillo Risk Atlas (2015), the city's southern zone has a high susceptibility index to pluvial flooding (ITESM 2015, S. 349). Heavy rainfalls in Saltillo have also historically impacted key urban system operations and services, such as disruptions on the main highways, a lack of electricity supply and interruptions to the solid waste collection system (El Demócrata 2019).

3.4.2 Water Scarcity and Droughts

Saltillo's location in the Coahuila desert makes it an area highly vulnerable to water scarcity and drought. 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). When considering the volume of water extracted for the metropolitan areas and industry in proximity to Saltillo, the water supply for domestic and economic activities comes mainly from aquifers already suffering from overexploitation (CCRB 2019). 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. Saltillo's water supply coverage is high, at 99,60% (Aguas de Saltillo 2018). Although Mexico's average water per capita consumption is 184.6 litres per day (L/d), users in Saltillo consume around 170 L/d (FCEA 2017b).

The main concern raised by multiple experts was the magnitude and irreversibility of water scarcity and drought, considering that recovery would be a challenge in the event of aquifer depletion. In terms of the economic impact, farms and industries related to agricultural production are the most affected as water scarcity and droughts can result in agricultural, livestock and forestry production losses. Overall, the experts regard sustainable water management as a priority in Saltillo to effectively manage the limited existent water resources.

3.4.3 Temperature Rise and Urban Heat Islands

Due to Saltillo's semi-arid climate and urbanization patterns characterized by the concentration of the population in the downtown area (Saltillo Gobierno Municipal 2019), temperature increases and Urban Heat Islands (UHIs) represent critical risks to the city, which will intensify with climate change. Studies undertaken by Mexico's National Institute of Ecology and Climate Change

(INECC 2019b) have determined that between 1985 and 2018 in the state of Coahuila, annual maximum and minimum temperatures have tended to become warmer. In the coming years, a continuation of this trend could lead to drier seasons and harmful effects on the environment, such as desiccation, forest fires, and crop losses (ITESM 2015).

A significant contributor to the higher temperatures in cities is the UHI effect, where there is a lack of vegetation and surface moisture and extensive paved surfaces in the urban space (Mok et al. 2021). Between the years 2000 and 2018, the population in Saltillo increased by 32%, going from 637.273 inhabitants in 2000 to approximately 935.663 in 2018 (SEDATU et al. 2018). This accelerated urban and population growth could intensify the UHI effect when natural ventilation and cooling structures, such as vegetation and water bodies, are blocked in the city. Saltillo's population's exposure to and vulnerability to temperature increases and UHIs were perceived as high among multiple experts, considering the associated risks to human health, including dehydration and loss of comfort in vulnerable groups, such as the elderly and children. Lastly, UHIs generate higher demand in water and electricity (e.g., for cooling and refrigeration devices), which would further increase Saltillo's energy consumption.

3.4.4 Forest Fires

Forest fires occur naturally every year between March and May in Coahuila (Secretaría de Medio Ambiente 2018). State records indicate that 60% of forest fires are caused by human activities relating to agriculture and recreation in housing complexes in forested areas (Secretaría de Medio Ambiente 2018, S. 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.

Experts perceived the risk of forest fires as high due to a combination between their magnitude, probability, and irreversibility. Experts highlighted the irreversible damage that fires caused in the mountains near Saltillo, especially in the Zapalinamé mountain range, located in the southeast of the state. It was noted that the tremendous damage from forest fires affects the environment as it poses a high risk to biological diversity and causes erosion and the loss of vegetation and fauna. Since the forest fires originate in the areas surrounding 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.

3.4.5 Snowfall and Frost

While experts describe the magnitude and probability of snowfall and frost in Saltillo as a medium, 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, S. 147). The frost season in the northern and central parts of Mexico occurs between November and February. This climatological phenomenon affects mainly crops through the loss of leaves and tender stems, the destruction of the leaves, fruit and flowers and even the complete death of the plant (ITESM 2015, S. 147). In addition, crop damages can impact the region's agriculture sector due to reduced or complete loss of income for

producers, unemployment, foreign currency loss, and competitors replacing the local market (INIFAP und SAGARPA 2005, S. 1).

Climate variability is 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 und SAGARPA 2005, S. 2). In terms of infrastructure, these events' increased frequency and magnitude could also impact dwellings and their utility systems. Since the hydraulic networks are the most vulnerable due to water pipes damages, adapting these to freezing temperature conditions is necessary.

3.4.6 Changes in the Biological System

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. The main concern for Saltillo, raised by multiple experts, relates 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 C hikungunya and Zika. Although these increasing incidents requiring hospital care present a low risk to the existing infrastructure, they could affect the city's economic performance.

3.4.7 Climate Change Adaptation Measures

In face of the aforementioned risks, climate change adaptation needs to play a more important role in the future of 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.

In terms of climate change integration into planning, Saltillo is currently developing its Municipal Climate Action Plan (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. The PACMUN program was launched in Mexico in 2011 with the initiative from ICLEI-Local Governments for Sustainability and was developed with the technical support of the INECC and financial contributions from the British Embassy in Mexico (Climate Initiatives Platform 2019b). Although some documents, such as the Saltillo Risk Atlas (ITESM 2015), present climate change mitigation measures and suggestions for climate action, 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.

When looking at institutional coordination for integration, the municipal administration has delegated the main responsibility regarding climate change issues 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 of 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.

Saltillo does not have a specific budget allocation for climate change adaptation and risk management at the city level in terms of available financing and funding sources. In the past, Saltillo has implemented several Green Infrastructure projects with national funds or third-party financings like international financing or grants. Examples of these projects are a water treatment plant, a sanitary landfill, and street LED lightning, which private parties mainly financed. According to the Ethos Public Policy Lab (2020), Mexico was a pioneer in climate finance mechanisms, both on the national and subnational levels. However, the weak enforcement has jeopardized the Climate Change Fund (FCC), leaving no availability of funds at the national or state level for Climate change adaptation measures. In this instance, the need to tap international funds through international initiatives, such as the Transformative Actions Program (TAP), to execute climate change initiatives were perceived as crucial for the city's future.

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 at 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 the formulation of climate change mitigation 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. Regarding early warnings and action plans in case of emergencies, the Sub Secretary of Civil Protection has established protocols for 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, leverage local knowledge, and engage citizens in these actions.

Interviews with experts highlighted that the municipality of Saltillo has stood out for having 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 the early design stage followed by planning until 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 and civil society in designing and following the activities included in the environmental agenda. 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. It would be beneficial for future events and decision-making spaces to include vulnerable groups, especially the people who might be adversely impacted by climate change.

According to the interviews, general awareness among stakeholders on climate risks and impacts is rather high. 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 to contribute to and monitor compliance of actions committed to improving 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, engage 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. 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). Despite 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. Lastly, stakeholders' high response rate and participation 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.

3.4.8 Overarching Insights

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.

As the highest-rated risk cluster by experts, water scarcity and droughts were 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. Furthermore, literature research, surveys and interviews highlighted agriculture as one of the most vulnerable sectors to climate risks. Hence, it is essential to strengthen this sector's adaptive capacity, 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 phenomena and developing regular risk assessment and monitoring schemes. It was found that most data and studies are available at the national and state level. On the local level, few publications on the topic exist, being the Risk Atlas from the Municipality of Saltillo, the main one having wide use by experts and municipal institutions. Nevertheless, it was published in 2015, and therefore, it is suggested to update regularly the information regarding climate risks and vulnerabilities according to the identified critical areas and mapping activities. 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.

While developing assessment and monitoring, strategies for climate risks are crucial to involve citizens, 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). Additionally, Saltillo could leverage established participatory experiences, such as the Citizen Council of the Environmental Agenda, to raise awareness and interest in climate action. Alliances with (local) educational and science institutions could be further strengthened as well as local capacity building activities. 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 PACMUN and Urban Development Plan are being developed for the next city administration. 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 stable and continuous planning and execution of climate change initiatives and projects.

3.5 Morgenstadt City Index

The Morgenstadt City Index analysis was conducted as part of the City Lab Saltillo activities in phase one to gather preliminary data on the state-of-play of the urban systems in Saltillo.

The holistic four-pillar model of the Index evaluates city sustainability on the following themes: Maximum Liveability, Innovative Leadership, Urban Resilience and Zero-Emission/Waste.

The graphic visualization of the results is shown in Figure 6. Completely filled fields indicate the higher performance of the indicator, whereas lesser-filled fields indicate lower performance according to the pre-defined benchmarks. Nevertheless, data was unavailable for two out of 28 indicators marked in dark grey colour, and the data for seven indicators was found only on the regional level and therefore is not included in this graph.

The results articulate the performance of Saltillo according to the four themes:

Maximum Liveability: suggests a liveable city, which offers its citizens jobs, adequate incomes, safety, attractive public space that are inviting and good environmental quality. As depicted in the graph, the city presents a high performance concerning poverty and unemployment rates, with 18,1% poor population/city population (CONEVAL 2015; INEGI 2017), and a very low unemployment rate of 4.6% (INEGI 2020d). The rate of household income is unfortunately only available at the state level. When it comes to health and safety, the rate of doctors per 100.000 residents is above average (188.4/100.000 inhabitants). Unfortunately, the data for life expectancy at birth and the crime ratio are not available for the city. In terms of the quality of the mobility system, the city ranks high in personal automobile usage (0.18 per capita; IMPLAN 2015b), which can be explained by the fact that Saltillo is the heart of the automotive industry in the country. This factor could explain the low rate of bicycle paths and lanes in the city (4,3km/100.000 residents; IMPLAN 2016c). In terms of environment, the city ranks within the average in green areas (47ha/100.000 inhabitants; IMPLAN 2017) yet, the air quality is significantly poor (4,7 LBI calculation NO2 PM10, O3) reaching a high level of pollution, higher than the maximum limit established by the WHO for 24 hours (World Air Map 2020).

Urban Resilience: indicates a resilient city, which is prepared for sudden or permanent changes in climatic, demographic or economic basics.

Saltillo presents a remarkable performance when it comes to the City Finances, with a 0% debt service ratio (Saltillo Gobierno Municipal 2018b) and a 100% share of own-source revenues in total revenues (Congreso Coahuila 2018). In terms of risk awareness, the city counts with a contingency plan for different types of natural disasters, which is updated. However, information about tests through simulations drills at least once a year is not available (IMPLAN und SEDATU 2015).

Zero-emission and waste: suggests the city is environmentally friendly making its contribution to CO_2 emission based on economy and strives for sustainable use of resources.

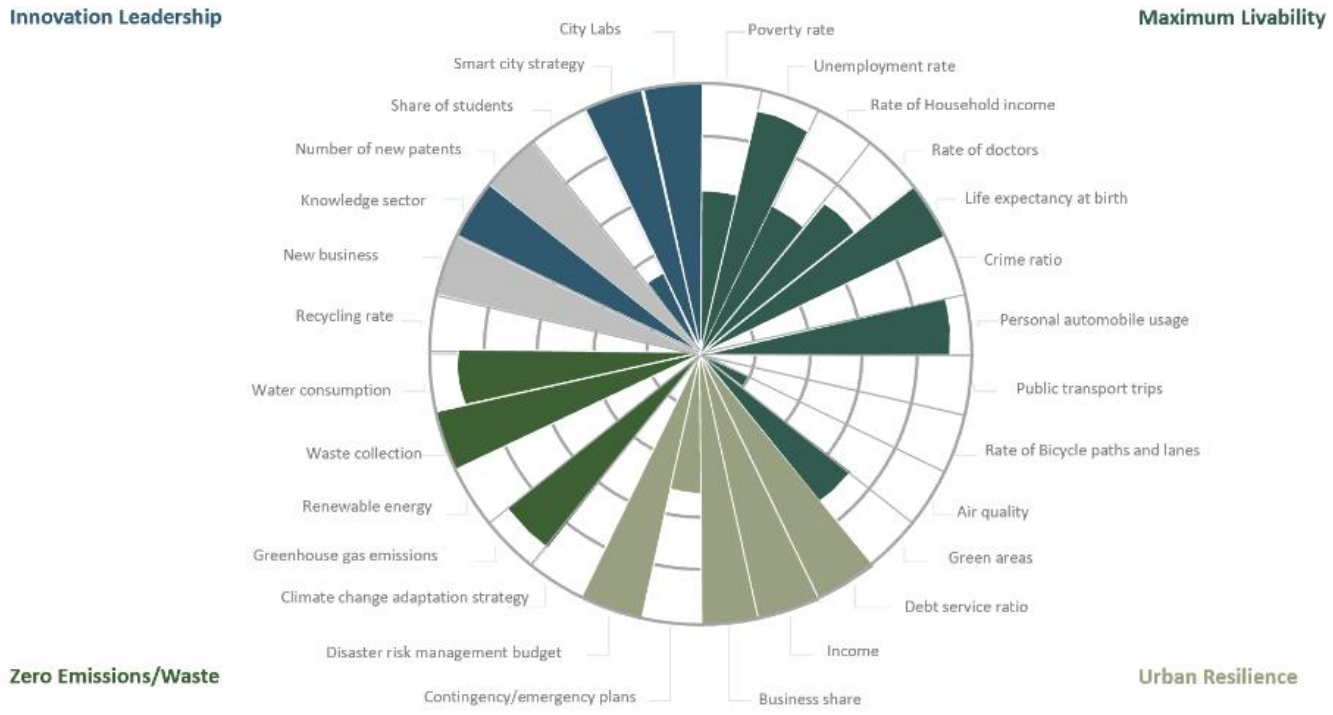


Figure 6: Morgenstadt City Index – Saltillo.

The Greenhouse Gas Emissions are only calculated at the regional level. Therefore, it is not possible to know where Saltillo is standing in this regard. The percentage of renewable energy in total energy generations is, unfortunately, 0% for the city (ONU-Habitat 2015). In the category waste and recycling, the total collected municipal waste per capita per year (259,6 kg; SEMARNAT 2014) ranks Saltillo on a high mark. The same happens in terms of water consumption (115l per capita per day; Aguas de Saltillo 2017). Lastly, the percentage of solid waste that is recycled is unfortunately low at 7,46% (SEMA 2013).

Innovation Leadership: indicates an innovative city seizing its opportunities as the laboratory of the future and becoming a magnet for research institutions and highly qualified employees.

In this category, there was no data available for newly registered businesses in the last three years, nor the annual number of new patents. However, the city presents a high performance with a high percentage of formal employees working in the secondary and tertiary sectors against the total number of formal employees in the city (97,30%; INEGI 2017). In contrast, the share of university and college students in the city population is significantly low (4.17%; SEDUCOAHUILA 2018). Regarding innovation strategy, Saltillo counts on a smart city or innovation strategy (Saltillo Gobierno Municipal 2018a), and with the existence of city labs or experimental fields for testing innovative technologies and solutions (CONACYT 2015).

3.6 City Systems Analysis

Based on the Morgenstadt City Lab Methodology Framework, the city was analysed from a general perspective that included the three sectors of work and additional qualitative and quantitative assessments of the city as a whole and its urban systems. The analysis provided insights on the key characteristics of the major infrastructure, governance, ecological, social,

and economic dimensions of Saltillo. The data collected through this exercise is used to inform the sector-specific findings and the definition of potential projects and roadmap. It is an expert-driven assessment constituting five major steps:

1. Analysis of the indicators
2. Evaluation and analysis of the Action Fields
3. Sensitivity analysis of the impact factors
4. Prioritization of the Action Fields
5. Clustering of measures and their conversion to the roadmap

The methodology process is illustrated in Figure 7 below. The Morgenstadt City Lab methodology is an integral part of the City Lab process (discussed in chapter 1.3. It has been used and tested in several cities around the globe. However, since climate change adaptation and mitigation actions are central to the MGI project, the City Lab methodology framework had to be adapted to satisfy the requirements of the project, as well as to reflect the local situation in Kochi, Piura, and Saltillo.

The sections 3.6.1, 3.6.2, 3.6.3 provide a detailed overview of Step 1, Step 2 and Step 4, respectively; whereas, section 3.7 discusses Step 3. The introduction to the roadmap and its corresponding project proposals can be found in chapter 4.

3.6.1 City Indicators

The indicator analysis has been performed based on the benchmarking system. This system implies that each indicator value is assessed against a specified benchmark to determine the performance of the indicator in terms of poor-medium-high performance.

The data for the indicator analysis has been collected using primary and secondary sources including remote data collection, assessment of various statistical reports, such as policy documents, and development plans of Saltillo along with information obtained during onsite interviews with local experts and knowledge shared by local partners.

The indicator assessment is a crucial part of the City Lab methodology because it delivers a comprehensive quantified evaluation of Saltillo´s sustainability performance. The list of 83 indicators evaluates social, environmental, and economic dimensions of the city. Nevertheless, data is unavailable for 17 out of 83 indicators.

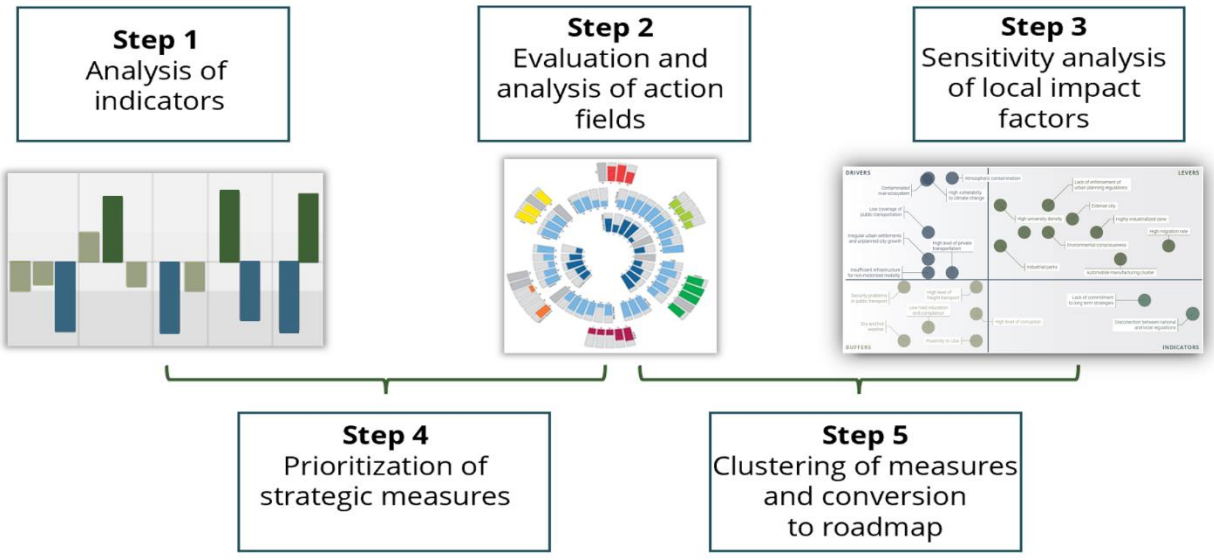


Figure 7: Morgenstadt City Lab methodology process diagram

The list below gives an overview of indicators in Saltillo, which performed well:

Mobility (see Chapter 3.7.2)
- Freight system by road
- Number of cars per person
- Traffic fatalities

Water (see Chapter 3.7.1)
- % of water samples/ year that comply with national potable water quality standards (%)
- Annual per capita water consumption (homes connected to the city water supply)
- Water supply coverage (%)
- Cost recovery (Difference between cost of water supply and collected water tariffs)
- Non-revenue water (Ratio of water not accounted for to total water supply)
- Share of households within the city that are connected to a sewer system (%)
- Performance of wastewater treatment
- Water consumption measurement
- Share of households within the city that are connected to a wastewater treatment plant (%)
- Energy demand for Wastewater treatment

Energy and GHG Emissions (see Chapter 3.7.3)
- Energy produced on the WWTP
- Total electricity demand per capita for residential sector only (kWh/a/cap)
- Authorized electrical service
- GHG Emissions from Building Stock ($tCO_2eq/m2$ GFA)
- Financial Performance (see Chapter 3.3)
- Reserve Levels (Total Reserves and Discretionary Reserve Funds as a % of Operating Expenses)
- Total Cash and Cash Equivalents as a % of Operating Expenses
- Net Working Capital as a % of Operating Expenses

Indicators with relatively low performance in Saltillo were:

Mobility (see Chapter 3.7.2)
- Share of traffic by bicycle
- Share of traffic by public transport
- Travel time by public transport
- Accessibility to ramps for wheelchairs
- Airport Traffic
- Transport costs efficiently priced
- Transport affordability
- Accessibility to public transport stations
- Percentage of traffic light intersections
- Total Length of road network

Water (see Chapter 3.7.1)
- Water security

Energy and GHG Emissions (see Chapter 3.7.3)
- GHG Emissions per capita ($tCO_2eq/capita$)
- GHG Emissions from electricity generation ($tCO_2eq/capita$)
- Total energy demand per capita (kWh/a/cap)
- Share of electricity demand produced within the city (%)
- Share of electricity demand produced by renewable energy sources (%)

Climate, environment, and green infrastructure (see Chapter 3.4 & Chapter 3.7.2)
- Green Space Intensity
- Air Quality Index
- Average annual rainfall (mm/year)
- Extreme precipitation events
- Green spaces in public spaces
- Sustainability

The data collected from this list of indicators shows dichotomies and highlights the main areas in the city where work should be concentrated. To start, Saltillo performs well in the provision of water services. However, one of the city´s main threats is water scarcity, which is highly related to the climatic and environmental conditions of the city, where the indicators also ranked poorly. In terms of mobility, the city stands out with low traffic fatalities and a lower number of cars per person compared to other Mexican (and Latin-American) cities. However, the public or alternative transport indicators show another reality, with very low shares of traffic by bikes or public transport, longer travel time with the public service, insufficient accessibility to ramps for wheelchairs and bikes, and high fares. In terms of energy and GHG Emissions, the demand and emissions per capita are significantly higher, while at the same time, the share of electricity demand and produced within the city and from renewable sources is very low.

It is worth highlighting the indicators related to finance performance where the city ranking was outstanding. The Saltillo Municipality had adequate total reserves (as of 31 December 2020) which are 65% of the total operating expenses incurred during the year 2020. This adequate percentage indicates that the municipality can meet its operating expense through its reserves just in case. Over the years operating expenses could be reduced through various operations efficiency improvement measures. A positive indicator suggests that the Saltillo Municipality has sufficient working capital and can pay off short-term liabilities immediately.

3.6.2 Action fields

Evaluation and analysis of Action Fields (AFs) is part of step 2 after the city indicators analysis, as shown in Figure 7 above. It is a qualitative analysis of identified essential AFs for the sustainable development of Saltillo. It shows measures taken by the city while addressing its sustainability challenges. The AFs model analyses seventeen essential aspects of the urban environment consisting of 73 AFs. Each action field is operationalized via 3-5 sub-questions, which in sum are worth 10 points when answered affirmatively. Therefore, with all the sub-questions answered affirmatively, an action field receives 10 points out of 10. Yet, if some of the sub-questions are answered with a “no”, the total score of the AF is reduced correspondingly.

Figure 8 gives a complete overview of the performance of AFs for Saltillo. In the graph, complete fields indicate higher measures towards sustainability, whereas lesser-filled fields indicate lower actions taken. Nevertheless, data is unavailable for 3 out of 73 AFs that are marked in dark grey colour. As depicted in the graph, there is space for improvement in Municipal Strategy, Urban Planning, and Urban Regeneration, as well as in the energy, buildings and mobility sectors. Measures in the water sector considering green and blue infrastructures can build upon the already existing initiatives taking place in the city and are very relevant for climate restoration and vulnerabilities that are now a matter of concern. Regulations and incentives, as well as Information & Communication Technology (ICT) and Data Governance, are worth exploring to support interventions in these areas.

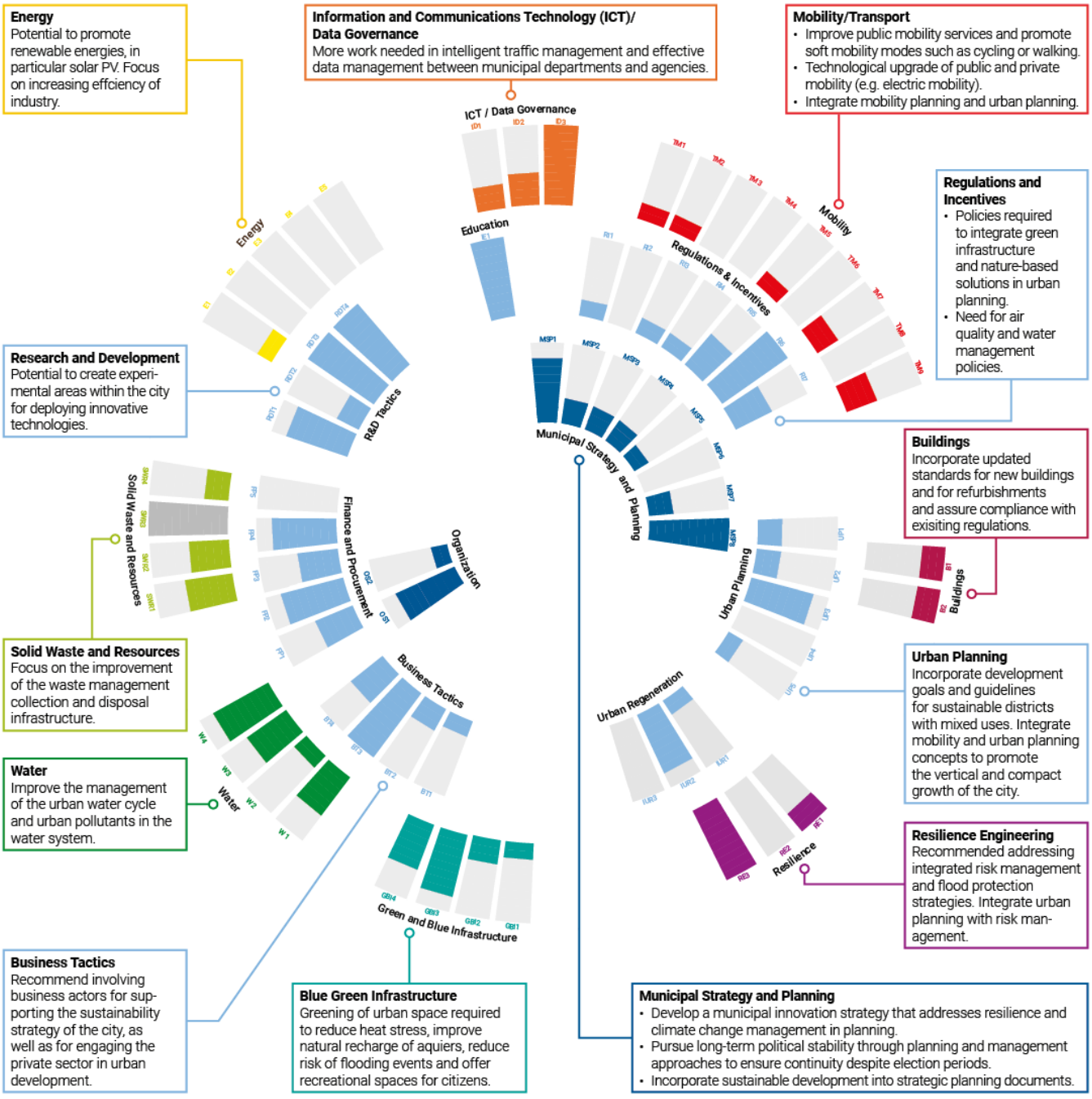


Figure 8: Action Field Analysis Outcomes

3.6.3 Prioritization of Action fields

The results of Step 1 and Step 2, as seen in Figure 7 are used for further analysis. As a next step, a relationship between each indicator and the AF is established. This relationship is based on a cross-impact matrix computed by the Fraunhofer experts. The results of this analysis are plugged into a computational Morgenstadt model. In a nutshell, this model considers the performance of each indicator (i.e. either poor/medium/high) and links it with the corresponding AFs. This exercise is useful for determining which AFs should be addressed by a city if the poor performing indicators were to be improved. Consequently, the model ranks AFs based on their relevance. The resulting list of the ranked AF can be used to inform the roadmap development process,

as well as provide useful insights to the local experts, stakeholders and policymakers.

Performing this analysis in the City Lab Saltillo has yielded a list of 10 AFs that suggest the potential intervention areas in the city. Based on the analysis, the top AFs in Saltillo are:

1. Integrated Risk Management – **Resilience Engineering**
2. Financial sustainability of the waste management system – **Solid Waste and Resources**
3. Promotion of public transport – **Transport/Mobility**
4. Intermodality and sharing systems – **Transport/Mobility**
5. Increasing efficiency of industry through efficiency networks (linking production sites with each other) – **Energy**
6. Management of the urban water cycle (rainwater, water bodies, green infrastructures, demand management) – **Water**
7. High-efficient centralized energy supply (District Heating / District Cooling) – **Energy**
8. Transport Oriented Development – **Urban Planning**
9. Development of resilience strategy and planning – **Municipal Strategy and Planning**

The list of prioritized action fields shows a wide variety of areas where work is needed. This proves that transversal efforts and projects that cover more than one field of work are interesting and desirable to tackle the areas where the city needs to improve in an integrated way. The action fields complement well the results from the indicators. Highlighting once again that projects addressing the improvement of the green and blue infrastructure of the city, the promotion and intramodality of public transport systems, and high energy efficiency are needed in Saltillo.

The evident gaps in these fields were highlighted as well throughout the interviews conducted during the virtual onsite assessment. They were also considered in the formulation of project ideas for the city (See Chapter 4).

It is important to note that the results of this model are primarily dependent on the data inputs. Since obtaining comprehensive data sets in Saltillo has proven challenging for some categories, these results should be viewed with caution. The model's outcome informs the subsequent roadmap development, yet other factors are taken into consideration too.

As mentioned in chapter 1.4, the City Lab Saltillo is focused on three sectors of work. The latter have been selected after the first assessment of the city executed with the MGI City Index as well as with local stakeholder consultation that took place during the kick-off visit in 2019. As a result, the sectors of work are water, mobility, and energy and CO_2 emissions.

The analysis and results of the research executed across the three sectors are illustrated in the following sections. The work included the revision of city policies, studies, planning documents and initiatives, interviews and workshops with key local stakeholders, and close and careful work developed by the team members.

3.7 Sectorial Analysis

3.7.1 Water

Figure 9: Vision, challenges, and solutions in the water sector.

Sector Description

Water is one of the most important resources linked to social and economic development for Saltillo's Municipality. Due to Saltillo's geographical location in the Coahuila Desert, water scarcity is a big threat and climate change-induced effects, such as extended droughts and flooding events, are expected to increase in intensity and frequency. Over the past decades, water has played a vital role in the urban and economic development of Saltillo. Thus, sustainable water management is regarded as a high-level priority by the city administration as it can be noticed in their "Environmental Agenda", document in which the city makes clear its commitment to initiate a transition towards a sustainable city.

Raw water is sourced from the groundwater of the Rio Bravo-Conchos Basin. Three aquifers serve the water demands for domestic and economic activities of Saltillo's municipality. These aquifers are "Saltillo-Ramos Arizpe", "Saltillo Sur", and "Cañón del Derramadero", all of which can be identified in Figure 10. The total annual recharge of these aquifers is estimated at around 103.1 hm3. While the total annual volume of water extracted for Saltillo municipality alone accounts for 100.5 hm3, and the total exploitation of the aquifers increases when considering the extracted volume for the use of other municipalities (CCRB 2019).

Based on the estimation of annual water recharge, the annual water availability for Saltillo would be around 119.3 m3/cap when considering a population of 860,000. Whereas the Falkenmark Indicator considers any value below 500 m3/cap as absolute water scarcity (Global Water Forum 2012). Further on, according to the national water authority, when considering the total water extraction of the aquifers, including other municipalities, the aquifers suffer an added overexploitation of 109.5 hm3/a, thus, posing a major threat to water security in Saltillo (CONAGUA 2020a, 2020b, 2020c).

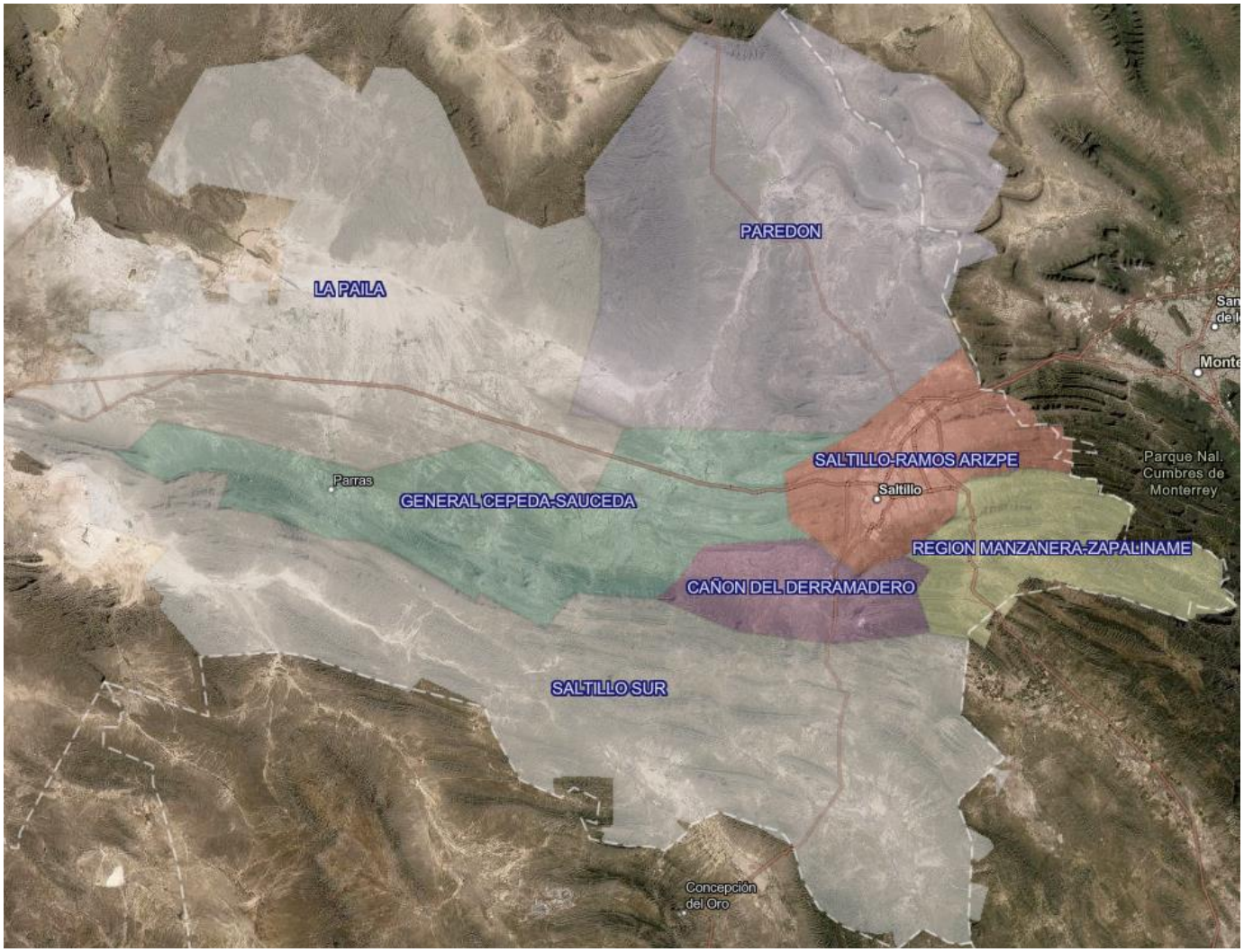


Figure 10: Aquifer's location in Saltillo's region (CONAGUA 2020)

Water production for urban domestic and commercial use in Saltillo accounts for around 53% of the total water extracted, being the major type of use. Water for agriculture accounts for around 27%, while the industrial sector makes up for approximately 5% of total water use in the municipality. The remaining 15% of the resources are distributed for other uses such as rural services. Around 200 companies from the automotive, steel melting, personal hygiene, and cement industries are established in Saltillo and Ramos Arizpe. Most industries require water only for office uses. However, most factories that require this resource for industrial purposes obtain their water from on-site wells, while the municipal water company supplies some other companies in Ramos Arizpe. Furthermore, some companies have their wastewater treatment plants (WWTP) on-site (Aguilera et al. 2013).

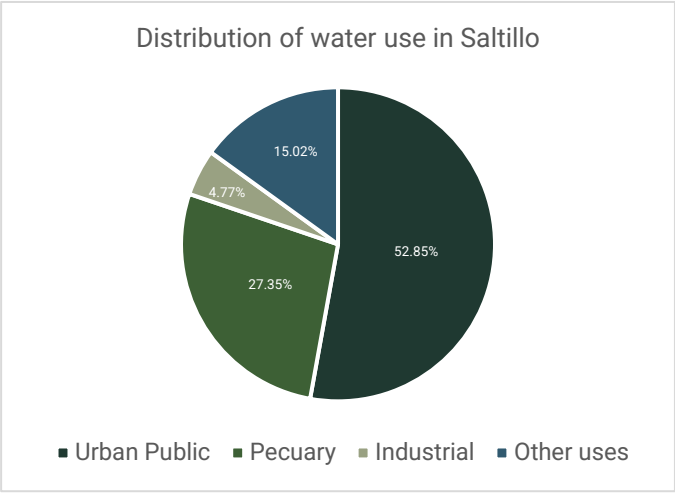


Figure 11: Water use distribution in Saltillo municipality (Beckett, Reyes, 2021)

Having an average annual rainfall of around 370 mm, the climate in Saltillo classifies as semi-arid (CONAGUA 2020c). Despite the relatively low annual rainfall, atypical rains have repeatedly caused flooding events in the city, especially in the vicinities of the urban surface water bodies “el Pueblo”, “Río Hondo” and “Ceballos”. These events are expected to increase in frequency and intensity due to climate change (Saltillo Gobierno Municipal 2018a).

In 2001, the municipal water management responsibility was transferred to the private-public-partnership, AGSAL, which made noticeable efforts to amending the city's hydraulic system. Water supply to the city is around 146 million litres per day (MLD) extracted from 90 wells and treated through 6 chlorination plants distributed around the city before reaching the final users, making it safe for drinking. While Mexico's average water per capita consumption is 184.6 litres per day (L/d), users in Saltillo consume around 170 L/d, including water lost in pipe leakages (FCEA 2017a; AGSAL 2019).

Furthermore, over 97% of households in Saltillo are connected to the sewer network and to WWTP. However, only 12% (7% concerning total extracted water) is currently being reused for industrial and urban purposes, which can demonstrate the significant potential to keep developing the water reuse capacity in Saltillo. While the WWTPs are managed efficiently, the discharge struggles to comply with national quality standards. This is mainly attributed to the incoming water quality that exceeds the WWTPs design capacity regarding Nitrogen values (Saltillo Gobierno Municipal 2020).

Figure 12: Flooding events in Saltillo a) nearby to stream “el Pueblo b) nearby to stream “Ceballos” (Gudiño 2018; Muñiz 2020)

Currently, AGSAL manages around 3,000 km of water supply & sewerage network in Saltillo. In contrast, the Spanish metropolis of Barcelona, with over 5 million inhabitants, counts with a network of around 2,500 km. This comparison highlights the large efforts undertaken by AGSAL and the challenges associated with the horizontal expansion of the city in comparison to densified urban planning.

Despite this, AGSAL can reflect its operational costs, mainly due to its efforts to decrease water losses in pipes, by reducing the number of unregistered users (approx. 100% water meter coverage) and through the implementation of a successful “Cross subsidization system”. This charging scheme consists of 3 types of domestic tariffs, which apply to 94% of AGSAL users. The cross-subsidizing scheme enables the users with

less economic capacity (58% of the city in 2019) to pay less per invoiced cubic meter (m^3) in comparison to high-income users. Additionally, businesses (5% of AGSAL users) and industries (1%) pay a non-domestic tariff. The average cost for water in Saltillo was 12.52 Mexican pesos (around 0.56€) per m^3 in 2019, making it one of the cheapest domestic waters in the region (AGSAL 2019).

In light of the geographical conditions of Saltillo, the city and AGSAL are highly effective in delivering water to its residents, commercial and industrial users. Challenged by climate change effects, further measures on water efficiency, stormwater management and the exploration of alternative water sources (e.g. treated water, stormwater, dew harvesting) are investigated by the city and the utilities.

Finally, Saltillo's administrative boundary includes a total of 31 surface water bodies, of which 19 discharge into the creek Ceballos and 12 discharge into La Encantada. Both cross the city from south to north. According to a previous study by the city, all of the surface waters are currently in a deficient condition. The main affectations suffered by these water bodies include pollution with solid waste and wastewater, and comprehensive alteration of the natural flow regimes due to the development of the built environment (Saltillo Gobierno Municipal 2018a). Rain induced recharge of these creeks poses an interesting opportunity to restore these natural spaces and integrate them into the urban environment. This would have a positive impact on the quality of life and would allow for an increase in the natural drainage capacity in the city. There are already existing public and academic initiatives to improve the status of the creeks, such as the program "Adopta un arroyo". Principles of water stewardship towards shared responsibility for water management involve multiple parties to distribute the efforts for restoring their ecological status. The local Universities play an essential role in the programme.

Key developments and Status Quo in the sector

The National Commission of Water (CONAGUA) has implemented control measures for the depletion of aquifers, limiting the daily water supply to 18 hours per day for Saltillo in 2019 (Saltillo Gobierno Municipal 2018a; AGSAL 2019). The intermittent supply of water is compensated at the household level by storing water in tanks called "tinacos", usually located on the rooftops. The pipeline distribution system reaches 99.6% of the city households, while a small fraction, representing 11 neighbourhoods, is supplied through water trucks operated by AGSAL (AGSAL 2019). Thanks to the treatment applied to water before supplying it to users, more than 99% of samples comply with the national standards for potable water (e.g. residual chlorine values).

Despite important efforts from the water company, the water losses in the distribution system are around 40%. These leaks mainly result from old age and the low quality they were originally built (Aguilera et al. 2013). Last century, when the pipeline network started to be constructed in the city, the materials and techniques for their implementation were less durable and efficient than those seen in present days. Aguas de Saltillo reports a pipe network technical efficiency of 60.48% in 2018, which is referred to as the ratio of registered volume at the household level and the real extracted volume. On the other hand, (AGSAL 2019) reports a physical efficiency of 78%, meaning that they invoice 78 litres for every 100 extracted litres, while the national average for this indicator is 40%. The reason why the physical efficiency is higher than the technical efficiency is that a minimum fixed tariff of 10 m^3 is charged to the users, regardless of whether they consumed this complete minimum volume or not.

Every year AGSAL carries out projects on the modernization and maintenance of the distribution network to reduce the number of leaks. Particularly interesting is the digital network monitoring systems and the recent application of an innovative helium gas injection system (iDROLOC) for the detection of "invisible leaks", which are those in which the leaked water does not reach the surface and instead is directly infiltrated through the permeable soil (AGSAL 2019). According to AGSAL (2019), it is the first water company to use this technology at a national level, which enabled it to increase the number of annual detected invisible leaks from 13 (record before implementing the iDROLOC system) to 74 in 2019.

Figure 13: AGSAL workers using iDroloc system for detecting invisible leaks (AGSAL 2019)

Regarding rainwater management, the responsibility falls entirely under the municipality and not under the water companies. There is little information available, and there are no records of the percentage of households or businesses performing rainwater collection. According to the interviewed stakeholders, rainwater as an alternative source of water in Saltillo is neither economically nor technically attractive due to the low average annual rainfall of around 370 mm that falls in a short period (CONAGUA 2020c).

Furthermore, the existing pluvial drainage system, and the implemented combined sewer system, which collects both sewage and rainwater, struggle to prevent flooding events. This type of natural disaster is expected to occur more frequently in the upcoming years as a result of climate change. Thus, the risk of flooding has been identified as one of the main challenges faced by Saltillo in the framework of the City Lab project.

In the last century, sanitation projects in the city were limited to building wastewater collectors and drainage systems (Aguilera et al. 2013). It was not until 2006-2008, that in compliance with the norms set by the Ministry of Environment and Natural Resources (SEMARNAT), Saltillo built two public WWTPs, which added a treatment capacity of 1,270 L/s (this figure increases to 1,568 L/s when including 7 private plants and the metropolitan area). However, it is to be mentioned that none of the WWTPs is operating at full capacity. In 2019, the plants were running at 65-80% capacity.

The WWTP "Principal" is the biggest facility and is located in the boundaries between Saltillo and Ramos Arizpe municipalities. It has a design capacity of 1,200 L/s but treats around 870 L/s (approximately 73% design capacity). The other public WWTP in Saltillo's, "Gran Bosque Urbano" (GBU), is located at the centre of the city and is designed for treating 70 L/s, while its real operation is around 50 L/s (approximately 70% design capacity).

The private company operating the WWTPs is IDEAL Saneamiento. When including the private WWTPs, the treated water volume in the metropolitan area is estimated at 1,077 L/s, representing 64% of the total produced water considering infiltration, losses, and water usage. The process performed in these plants consists of primary, secondary and tertiary treatment.

The mechanical pre-treatment includes primary clarifiers with flocculation (only at Principal), while the biological treatment consists of a conventional activated sludge system including secondary clarifiers and posterior disinfection through chlorination.

Regarding sludge treatment, this is only performed in the plant "Principal", and it covers dewatering through band filter as well as stabilization by adding lime. Finally, energy is produced from the obtained biogas (Saltillo Gobierno Municipal 2020).

Figure 14: Sketch of public WWTPs in Saltillo (Saltillo Gobierno Municipal 2020)

About 97% of the households in Saltillo are connected to one of the aforementioned WWTPs, while the remaining fraction discharges untreated sewage to nearby streams (Saltillo Gobierno Municipal 2018a). Important is also to mention that only a fraction of the collected sewage is reaching the plants. This is presumably due to leakages in the sewer network and to illegal tapping by farmers interested in using the sewage due to its high content of nutrients needed in agriculture. This situation explains the difference between the total produced water by AGSAL and the volume being treated at the plants.

The treated effluent of the public WWTPs is partially reused but mostly discharged into the streams “La Encantada” and “Ceballos” flowing across the city from south to north (Aguilera et al. 2013). The plant which presents a higher percentage of reuse is GBU, with around 40% of its effluent being used for urban public purposes, such as irrigation of green areas. The reuse of the WWTP “Principal” effluent sums up to 5.6%, whose applications are production and cooling water in local manufacturing (around 25 L/s) (Saltillo Gobierno Municipal 2020).

However, in 2011, the municipality started constructing a purple line for the distribution and posterior reuse of the treated effluent, which would connect the WWTP “Principal” with the industrial parks in Ramos Arizpe municipality downstream. The project is intended to be carried out in two stages, each of approximately 7 km and reaching different industrial parks. According to oral statements,

the construction of the first stage was finalized at the end of 2019 but has not yet come into operation as expected, allegedly due to a lack of interest from the industry.

At the beginning of the project, the purple line was expected to provide the treated effluent to almost 200 companies located in the industrial complexes, which could use up to 400 L/s of this flow. However, skepticism and quality requirements have driven most of the enterprises to refuse the use of this water. Currently, only 20 companies are still interested in using this resource.

The main indicators for the water sector are summarized in the following table.

Indicator	Value	Unit	Source
% of water samples/ year that comply with national potable water quality standards	99.2	%	AGSAL 2019
Daily consumption of water per capita of people whose homes have a water connection to the city's network	170	Liters/capita/day	AGSAL 2019
Water supply coverage	99.6	%	AGSAL 2018
Ratio of reused water to total water consumption	7	%	SALTILLO Gobierno Municipal 2020
Ratio of reused water to total treated water	12	%	SALTILLO Gobierno Municipal 2020
Non-revenue water	22	%	AGSAL 2019
Water losses	39.5	%	AGSAL 2018
Share of households within the city that are connected to a sewer system	98.7	%	SALTILLO Gobierno Municipal 2018
Frequency of piped water supply	18	Hours/day	AGSAL 2019
Wastewater treated according to national standards	58	%	SALTILLO Gobierno Municipal 2020
Water security	119.3	m^3/capita/yr	CONAGUA 2020
Ratio between operational and design capacity of WWTPs	69.3	%	SALTILLO Gobierno Municipal 2020
Homes with water consumption measurement	100	%	AGSAL 2019
Share of households within the city that are connected to a WWTP	97	%	IMPLAN
Energy demand for wastewater treatment	0.3	kWh/m^3	SALTILLO Gobierno Municipal 2020
Energy produced at the WWTP	7.42	kWh/person equivalent	SALTILLO Gobierno Municipal 2020

Table 1: Indicators for Saltillo's water sector

Key stakeholders, governance structure and policies

Mexico has a diverse set of water resources management challenges and to tackle them, It has developed a complex decentralized structure of managing and funding investments in water resources (CONAGUA 2010).

Since water resource management has long been a priority for Mexico, the legal framework for managing hydric resources emanates from the country's Constitution. The Constitution establishes that the national government is the owner of all water resources (rivers, lakes and groundwater) in Mexico, while local governments are responsible for delivering water and sanitation services. The National Water Law develops this framework by tasking a federal agency called CONAGUA to lead and coordinate water resource management. Any use of national water resources (both abstraction and discharge) requires a permit from CONAGUA (CONAGUA 2010).

CONAGUA is a decentralized agency under the mandate of the SEMARNAT. CONAGUA is the institution with responsibilities for coordinating the water sector, interacting with decentralized river basin organizations and other entities with various sector and regional responsibilities. CONAGUA is in charge of developing the national water policy, administering the rights for water use and wastewater discharge, planning, irrigation and developing drainage systems, managing emergency and natural disasters and managing investment in the water sector.

For a better administration of the basins as well as management and preservation of Mexico's water resources, CONAGUA has sectorized the country into 13 Hydrological-Administrative Regions (HARs) concerning the main river-basin systems and delimited in such a way that fits the territory of whole municipalities so that the jurisdiction is not shared in the limiting borders, thus, avoiding discussions on administration among municipalities (CONAGUA 2016). The limits of the HARs respect municipal divisions to facilitate the integration of socio-economic information. Every HAR is managed by its own "river basin organizations" (Organismos de Cuenca), in which multiple ministries operate through an advisory board. Each of these regions covers a wide range of aquifers. Besides, CONAGUA has 20 local officers in the states in which no river-basin organization has its headquarters and has functional organs integrated by 26 basin councils, 50 basin committees, 36 basin commissions, 88 groundwater technical committees, and 41 clean-beach committees. For example, the river-basin organization responsible for administrating the water concessions for the different users and sectors of the region in which Saltillo is located is named "Río Bravo VI", and the basin council is called "Consejo de Cuenca del Río Bravo" (CCRB 2019).

On the other hand, nowadays, many of the municipal areas in Mexico provide water and sanitation for the population. In the case of Saltillo, since 2001, the municipal water management responsibility was transferred to the private-public company AGSAL. In the last years, AGSAL has made improvements in the city's water supply and sewerage network. The company has gained significant achievements related to commercial efficiency that is reflected in more investment in maintenance of the water supply, distribution and sewerage network and new hydraulic infrastructure with new equipment, all in benefit of the city of Saltillo and its surroundings.

Finally, concerning stormwater management, the responsibility, which includes the overall management, maintenance and cleaning of the stormwater infrastructure, falls entirely under the municipality of Saltillo through the local offices of "Infrastructure and Public Works" and "Environment and Urban Spaces".

Potential for contribution to climate change mitigation and adaptation

As previously mentioned, the most critical risks that Saltillo is facing in terms of water are absolute water scarcity (<500 m^3/cap/a) and, at the same time, flooding events. Both risks will potentially be intensified by climate change since more extensive periods of drought can be expected as well as an increased number of atypical rains per year. Saltillo's authorities show a clear commitment to addressing these risks by building Saltillo´s resilience capacity against climate change before suffering significant consequences.

Concerning water scarcity, the discussion lies on how to increase the percentage of rainwater that goes into the permeable soil so that a major volume reaches the groundwater reservoirs. One method to achieve this is to decrease the impermeable surface area, namely street asphalt or impermeable rooftops, and converting them into permeable surfaces, such as gardens or porous gravel. This would increase the rate at which rainwater is infiltrated and, thus, reduce the amount of surface runoff that eventually reaches the drainage system and the amount of water that is evaporated.

Potential measures for contributing to this transformation include the implementation of nature-based solutions such as green infrastructure all over the city, in the form of rain gardens, green rooftops, vegetated median strips or pedestrian ways, among others. Besides, this type of infrastructure has other benefits than water-related, such as improving the microclimate, thus decreasing the use of energy for air conditioning. Additionally, green infrastructure has the potential to improve air quality, and it offers shaded areas through the canopy cover, which fosters walkability or biking among citizens, allowing a transformation of the mobility sector as well. Green infrastructure also offers social benefits, as the citizens will perceive a nicer and more natural environment, which positively impacts life quality. However, it is essential to clarify that not all types of green infrastructure are suitable for semi-arid climates such as Saltillo's. Therefore, particularly interesting for the city would be to implement the so-called Xeriscape gardens, whose main difference to conventional gardens is that only native vegetation with low water requirements is used.

Xeriscape landscaping can be expanded throughout the city in different schemes, for example, through a strategy of green spaces or sustainable urban corridors, which at a significant scale can have a substantial impact on the reduction of impermeable surfaces, apart from the previously mentioned trans-sectorial benefits.

Alternatively, a combination of grey infrastructure and Nature-based Solutions (NBS) can be implemented (e.g. infiltration wells) strategically located in infiltration zones. This type of measure has a major focus on increasing aquifer recharge and flood prevention and has the advantage of requiring less space than solely green infrastructure. However, they generally offer a lower number of trans-sectorial benefits compared to other solutions.

Another approach for increasing water availability is to decrease the volume of water extracted from aquifers. This can be done by using alternative water resources instead, such as rainwater or treated wastewater. In the case of Saltillo, the reuse of treated water has immense potential, considering the already existing infrastructure of the purple line. The current capacity for reuse of the tertiary treated effluent of the WWTP Principal is up to 400 L/s. Through potential industrial use of this water, combined with reuse in urban public services, this would represent 400 L/s that would not be extracted from aquifers, thus, reducing their depletion rate and the high-energy requirements for water pumping.

For instance, the reuse of treated water can also be done through a decentralized

approach after wastewater treatment in smart buildings. Apart from the potential of recycling water, these innovative buildings aim to reduce water consumption per capita by using efficient systems (e.g., efficient flushing toilets, water-saving nozzles, drip irrigation etc.). Furthermore, smart buildings have other sustainable advantages, such as the potential for harvesting rainwater or reducing the electrical energy consumption due to efficient systems and natural insulation, which reduces the need for air conditioning. Besides, renewable energy production is also common in this type of innovative building (e.g. with solar panels).

NBS represent an interesting and sustainable alternative to grey infrastructure in building resilience capacity regarding flooding risks. Apart from increasing the infiltration rate during rain events, green infrastructure can serve as Sustainable Urban Drainage Systems (SUDS) by intercepting the surface runoff and acting as temporary storage, which is referred to as the “sponge city effect”. This sponge city concept would allow to partially infiltrate water into the aquifers and discharge the reduced runoff at a constant flow into the drainage system (e.g. through floodable parks). As mentioned before, the suitable vegetation for Saltillo would be considered in a Xeriscape approach, which has a lower capacity for storing water than other types of green infrastructure. However, the intended purpose can be reached by appropriately increasing the amount of these natural elements.

Xeriscape landscaping can be expanded throughout the city in different schemes, such as multiple green rooftops (e.g. in sustainable neighbourhoods, on public and smart buildings, on shopping malls, etc.). Here, the major benefit is obtained at strategic locations near areas that have proven to be more likely to be affected.

On-site findings

Saltillo 2050: The responses from the interviewed stakeholders showed a clear common concern regarding water and related topics. While some shared an optimistic point of view, and others a realistic one, there is a consensus in the fact that water scarcity is a critical problem for Saltillo and that it should be addressed for sustainable development of the city that ensures water for all sectors. From their perspective, this could be achieved by promoting the reuse of treated water as an alternative water resource and increasing the exploited aquifers' recharge rate.

Furthermore, the stakeholders identified that to reach the city's expected development and resilience level. It is necessary to elaborate and implement a legal framework that considers sustainability as a cornerstone. This is a framework that includes environmental criteria that should foster greening the city while urban & environmental culture is raised, which would intrinsically increase social engagement with the urban ecology and biodiversity. The stakeholders envisioned the implementation of environmental technologies through urban corridors, sustainable neighbourhoods and cutting-edge public spaces as part of Saltillo’s transition towards becoming a green city with a built-up resilience capacity against flooding and drought events.

Another important element in the future vision of the stakeholders is the development of an attractive, innovative, and industrialized metropolis. Moreover, the interviewees hope to see that Saltillo will find a way to restore its surface waters and incorporate them into the urban environment as a space for recreation.

Challenges: The municipality of Saltillo is located in the southeastern region of Coahuila, where the well-being of its population and economic development is limited by the low availability of water to satisfy future scenarios (González Pimentel 2019).

To determine the main challenges of the water sector in the city, it is important to take into account the hydrography of the metropolitan area. According to the National Institute of Geography and Statistics Information (INEGI), there are no permanent runoffs in the municipal territory; all runoffs are classified as streams. The main runoffs (based on the hydrological order) are the "Salto del Moro" stream (south of the municipal territory), "Los Cuatitos" stream (southwest of the municipal territory), and "San Juan de la Vaquería" stream (west of the territory municipal). In the metropolitan area of Saltillo several streams drain from the Sierra de Zapalinamé (south of the city), and Sierra del Asta (west of the city). The "Pueblo" stream crosses the entire metropolitan area in a northern direction through the western part of the city, the "Ceballos" stream runs through the city in the same northern direction through the centre of the city, while "Del Cuatro" stream does the same in the eastern part of the metropolitan area. Other streams present are "León", "Martillo", "La Esperanza", "Santa Teresa", "San Lorenzo", "Pres Los Narro" and "Blanco". All these runoffs converge outside the municipal territory, shortly before the urbanized area of Ramos Arizpe (ITESM 2015).

Based on what is reported in the 2015 Saltillo Natural Risk Atlas, the main challenges in the city are due to floods in the streams that cross it and problems caused by floods in the flat areas where these runoffs drain. Part of the existing problems in the water sector of Saltillo is related to its geography. However, regarding the metropolitan area, other factors increase the challenges for the city, like human settlements in the proximity of streams and waste disposal into the same ones (ITESM 2015).

Likewise, for this initiative, 21 interviews were carried out with key water sector stakeholders. The main goal was to identify their vision of the water sector in the city and identify the challenges and opportunities for the city. The main challenges identified for the city are listed below:

- Water scarcity and water stress.
- Water security.
- Resilience to climate change and climate variability.
- Risks due to floods and droughts caused by extreme hydro-meteorological events.
- Water supply for different sectors in the city.
- Increased urban expansion in natural areas.
- Excessive and messy urban growth of the city without following public regulations.
- Changes in the surface hydrology within and outside of the city due to the construction of infrastructure.
- Environmental awareness and education to face future environmental challenges.
- Urban planning considering environmental aspects.
- Lack of public policy that encourages the efficient use of water.
- Continuity of projects through different public administrations.
- Increase in clandestine wastewater discharges.
- Increase of human settlements at streams borders.
- Poor development of storm drainage infrastructure.
- Lack of integration of the technical-scientific contribution to solve environmental problems in the city.
- Insufficient funds to develop environmental projects.

The previous results show that, in order to achieve water security in the city, different measures must be implemented to face the challenges previously posed. The actions which could potentially contribute to the solution of Saltillo's water problems are:

- Actions to adapt to climate change.

- Increase environmental awareness and education.
- Incorporate green areas as measures to face the challenges of the city.
- Build synergies between experts from academic institutions and the public and private sectors.
- Reuse of treated water in the industry and residential areas.
- Conduct projects of rainwater water harvesting.
- Take advantage of the natural and urban environment for the implementation of green infrastructure.
- Continue developing treated wastewater reuse projects that already exist in the city (Línea Morada/purple line).
- Vertical growth in a sustainable way to densify the city.

3.7.2 Mobility

Figure 15: Vision, challenges, and solutions in the mobility sector

Sector description

The municipality of Saltillo is characterized by concentrating the greatest tourist attraction in its Historic Centre and its industrial zone. The most important services and economic activities of the municipality are found in these areas. The main areas of origin of the trips are located in the perimeter of the centre of the municipality, where the areas with the highest housing density are concentrated. (IMPLAN 2016a). The Saltillo Metropolitan Area (SMA) is one of the industrial poles of northern Mexico and one of the fastest-growing economic poles in recent decades. In this sense, its dynamic economic activity has driven the expansion of its transport infrastructure.

In the city of Saltillo, as in many other Mexican cities, the accelerated expansion of urbanization has had consequences associated with infrastructure, air quality, and residents' quality of life. Unfortunately, this process leads to a vicious circle in which the expansion of infrastructure stimulates urban growth towards the periphery, increasing car dependency, which requires additional infrastructure development (IMPLAN 2018a, S. 5).

Figure 16: Travel Attraction in the City of Saltillo (IMPLAN 2016). On the right, the black line represents the municipal boundaries, in dark grey are represented the zones that attract more rides (city centre), the yellow lines represent existent bike lanes

Key developments and Status Quo in the sector

According to the findings of the interviews, there is progress in alternative means of transport, but there is still significant resistance due to the widespread belief in a large sector of society that the car reflects superior social status. In addition to this, a very poor service of public transport with units in poor condition, inefficient routes and not multimodal is often seen as one of the last options for mobility. The cycling infrastructure covers a considerable part of the city. It represents a great area of improvement to promote non-motorized mobility; however, it requires maintenance.

The city is dispersed due to the existence of void urbanized land set aside by speculators, who, waiting for a price increase, leave it idle for several years until it can be considered a profitable investment, forcing new developments to take place further from the city centre.

Airport: The city of Saltillo has an international airport called Plan de Guadalupe located in the municipality of Ramos Arizpe. In 2012 it registered an average of 60 flights per day, of which 70% were cargo flights operating around 8,000 tonnes of cargo. The remaining 30% were passenger flights carrying 134,540 passengers (Redes Urbanas y Servicios de Planeación S.A de C.V. 2012).

Railway system: The Saltillo Metropolitan Area is connected by two railway lines: Kansas City Southern and Ferromex, which ease the mobility of cargo from the industrial zone of Saltillo and Ramos Arizpe. Arteaga is not connected to the railway system, but its proximity allows it to use its service when necessary (Redes Urbanas y Servicios de Planeación S.A de C.V. 2012).

Roads: The Saltillo Metropolitan Area has 2987 km of roads - measured by the length of the central axis - and a road density of 411.9 km/100,000 inhabitants. The Municipality of Saltillo has 2594.74 km of roads - measured by the length of the railway - of which 38.8% correspond to primary roads, 38.2% to secondary roads and 23% to toll roads (IMPLAN 2015a, S. 65). 68.5% of city blocks in Saltillo have paved roads. Full access to paved roads is mainly concentrated in the interior of the Municipality, while partial access is widespread on the perimeter of the city, concentrated mainly in the southwest and northeast of the city as shown in Figure 17.

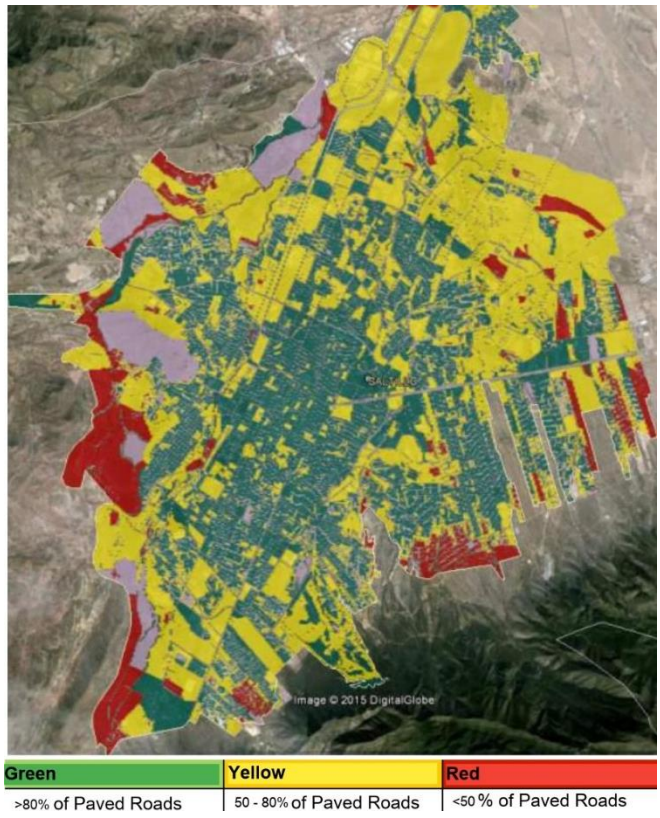


Figure 17: Access to paved roads

Pedestrian facilities: In the municipality of Saltillo, the greatest accessibility to sidewalks is concentrated in the interior of the city and the areas with the highest density of housing. The lowest levels of development of this type of infrastructure are distributed in the periphery of the municipality. In 55.24% of the city blocks, roads have pedestrian accessibility. In 29.98% of them, only some of their streets have pedestrian accessibility (IMPLAN 2015a).

In terms of pedestrian streets and alleys, Saltillo is underdeveloped, with 6.54 km throughout the city, representing 0.90 km / 100,000 inhabitants (IMPLAN 2015a, S. 44) This infrastructure extends mainly in the west and the city centre linked to the commercial areas.

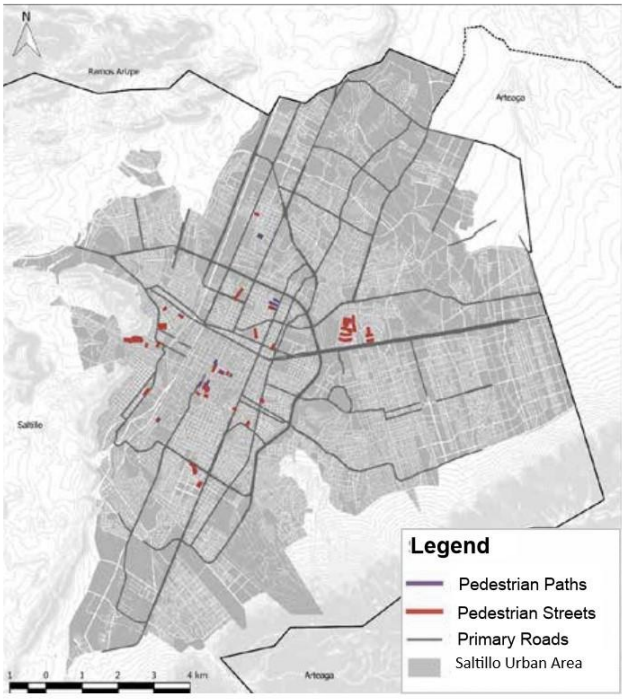


Figure 18: Streets and pedestrian alleys in Saltillo. source: INEGI (2015) in IMPLAN (2015b, p.44)

Finally, in terms of pedestrian infrastructure for disabled people, only 2.58% of city blocks in Saltillo have wheelchair ramps on all roads. The limited infrastructure for disabled people using wheelchairs is mainly concentrated in the northern part of the city centre (IMPLAN 2015a, S. 45).

Cycle paths: The bicycle road infrastructure in the Municipality of Saltillo is 34km long and has been implemented over three phases starting in 2013 as a two-lane (IMPLAN 2018a, S. 13–14). Bicycles represent less than 1% of the city's modal share. In recent years, bicycle users have been decreasing, showing a 60% reduction between 2014 and 2017

(Vanguardia, as cited in IMPLAN 2018a). According to a survey conducted in 2018 in Saltillo, the main motivations of bicycle users to use this vehicle as a means of transport are health and leisure. This survey revealed that in Saltillo, cycling is mainly used to travel to school and work, and trips are mainly made to the north and the city centre. Despite the unfavourable assessment of Saltillo's cycling infrastructure by its users, there is a willingness to switch from using cars or other means of transport to cycling if optimal street conditions exist in terms of infrastructure quality and safety. Finally, Periférico Luis Echavarría, Blvd. Fundadores and Calle Otilio González are the roads that require the most urgent repairs (IMPLAN 2018a, S. 30–34).

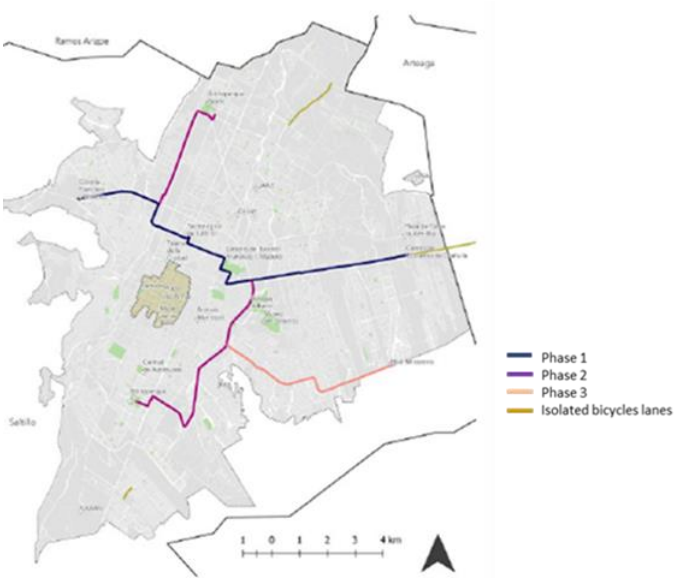


Figure 19: Phases of bike lane implementation in the Municipality of Saltillo. Source: IMPLAN (2018, p.13)

Public transport: Public transport in the SMA is covered by 54 routes operated by 894 buses, which travel an average of 238,000 km daily. Most routes converge in the city centre, generating problems of traffic in the service provided, such as overlapping routes - in some cases up to 20 routes cover the same road -, low-speed levels - the average speed of the routes is 16 km/h - and the supply of transport in some areas of the city (IMPLAN 2015a, S. 20–22). The average journey time by public transport is 39.52 minutes. Out of the total public transport trips, 31% of trips last between 21 and 30 minutes, followed by 19% of them lasting between 11 and 20 minutes, and 13% lasting between 31 and 40 minutes as well as between 51 and 60 minutes (IMPLAN 2015a, S. 41). In terms of the distance travelled each day in the city, it is estimated that the majority of trips - 34% - are between four and seven kilometres (IMPLAN 2015a, S. 34).

Private Transport: The motorisation rate in Saltillo in 2014 was 314 vehicles / 1,000 inhabitants. In 15 years, the vehicle fleet increased by 150,000 cars. Car purchases are concentrated in higher-income segments; however, due to factors such as easy access to credit and the long-life cycle of vehicles, car purchases in low-income

sectors have increased (IMPLAN 2016b, S. 11–12). In Saltillo, car use is still more efficient than public transport in terms of trip duration. The average travel time by car is 25.6 minutes, while the average travel time by public transport is 39.52 minutes (SISTEC, as cited in IMPLAN 2015a, S. 40).

Main indicators for the mobility sector are summarized in the next table.

Indicator	Value	Unit	Source
Modal split: Share of traffic by pedestrian	18	% of total traffic	IMPLAN_Guía de diseño de infraestructura peatonal (2015) Pg. 9
Modal split: Share of traffic by bicycle	.92	% of total traffic	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 36
Modal split: Share of traffic by public transport (including taxi)	34.07%	% of total traffic	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 36
Modal split: Share of traffic by personal vehicles (cars, motorcycles etc.)	38.07	%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 36
Accessibility to public transport stations	16.4	%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 62
Accessibility to ramps for wheelchairs	2.58	%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 45
Total length of road network	411.9	km/100.000 inhabitants	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 64
Percentage of traffic light intersections with total pedestrian crossing in relation to total traffic light intersections	5	%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 42
Road quality	10	%	Accesibilidad a vias pavimentadas - IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 65
Number of cars per person	.18	Cars per person	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 38
Annual Growthrate Total private Vehicles in general	3.78	%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg.39
Travel time by car	25.60	Min/day/person traveltime	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg.40
Travel time by public transport	39.52	Min/day/person traveltime	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 41
Hours spending in congestions	**N/A**	Hours/capita/year	N/A
Transport-related GHG emissions per capita	6.22	Metric tons of CO_2	Inventario de gases y compuestos de efecto invernadero del estado de Coahuila (2016) pp.21
Traffic fatalities	4.97	Rate of traffic fatalities per 100,000 inhabitants	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 74
Transport affordability	22.3	% Portion of household	Encuesta Nacional de Ingesos y Gastos de los Hogares (INEGI, 2018)
Regulatory environment	1	Number of regulatory bodies	IMPLAN

Table 2: Indicators for Saltillo's mobility sector

Key stakeholders, governance structure and policies

The local authorities that supervise the operation of transport in the Municipality of Saltillo are the following:

- Municipal government: Grants concessions for the provision of local public transport services and authorize rates.
- Municipal Transport Institute: Decentralised public entity in charge of public transport services.
- IMPLAN: Decentralised public entity that assists the municipal authority in urban, environmental, economic and social development.
- Directorate of Concessionary Services: Unit through which the municipal government monitors, supervises and controls public transport services and road management.
- Municipal Transport Council: Made up of municipal authorities, concessionaires and citizens, in charge of advising the Municipality on matters concerning the Municipality in the field of transport (IMPLAN 2015a, S. 70).
- Coahuila State Government
- Coahuila Secretary of Environment
- Coahuila Secretary of Public Works and Urban Development
- Federal Government
- Citizenship in general and organised civil society
- Public and private Universities and Research Centres
- Public Transport Concessionaires

The main regulations in the Municipality of Saltillo regarding public transport operation in the city are presented below, addressing different aspects such as its conditions and principles of quality, infrastructure characteristics, subsidies, and accessibility.

- Law of Transit and Transport of the State of Coahuila de Zaragoza (1996): This law establishes the rules that regulate transport services as well as the conditions of concessions. In this regard, it addresses different aspects of the transport operation, such as authorised vehicle schedules, frequencies, routes and years of operation (IMPLAN 2015a, S. 39).
- Sustainable Mobility Law of the State of Coahuila de Zaragoza (2017): This law establishes the general conditions for the operation of infrastructure for persons with disabilities, pedestrians and users of public transport and non-motorised vehicles. It promotes public policies aimed at shifting the use of private vehicles to public transport, establishing the plan for the adoption and replacement of public transport vehicles, and promoting the implementation of subsidies, loans, and provisions to achieve this objective (IMPLAN 2015a).
- Law for the Development and Inclusion of Persons with Disabilities in the State of Coahuila de Zaragoza (2013): This law establishes that the General Department of Urban Management, Water and Planning and the General Department of Infrastructure are in charge of designing, establishing and monitoring compliance with regulations focused on the mobility of persons with disabilities in the city (IMPLAN 2015a, S. 40).
- Traffic and Transport Regulation of Municipio of Saltillo, Coahuila de Zaragoza (2015): This regulation establishes the rules concerning public transport and defines the local authorities in charge of monitoring compliance. Following these provisions, the Municipality is responsible for establishing the rules regarding timetables, fares and rules for the use of public transport vehicles. In addition, the Municipality supervises the locations of

bus stops and terminals in the city and the routes and frequency of public transport (IMPLAN 2015a).

- Saltillo Urban Development Master Plan (2014): This strategic plan sets out the main objectives in terms of mobility, transport, and guidelines for constructing road and parking infrastructure in Saltillo. In terms of mobility and transport, it seeks to solve conflict points in the city's road network, improve connectivity with the Derramadero area and create alternative road options in the east of the municipality. It also aims to improve the average speed of public transport journeys to levels similar to those of private vehicles and aims to develop specific roads for freight transport and alternative mobility. It also seeks to discourage the entry of private cars into strategic areas of the city to benefit the operation of public transport (IMPLAN 2015a, S. 17–18).
- General Law on Human Settlements, Territorial Planning and Urban Development (2016): This law establishes the government's responsibility to ensure the interconnection of roads and shared-use paths with human-scale design. It also promotes the adoption of new urban mobility and accident prevention habits to improve people's travel conditions by encouraging the intensive use of public and non-motorised transport. In addition, it encourages the provision and preservation of spaces for pedestrian and bicycle traffic and connectivity criteria between roads that promote urban mobility (IMPLAN 2016b, S. 5).

Areas of opportunity in mobility for climate change mitigation and adaptation

Expansion and strengthening of cycling infrastructure: In recent years, the city of Saltillo has developed different initiatives to strengthen cycling infrastructure, consolidating a network of bicycle lanes. It is expected to increase the number of bicycle trips in the city's modal share to 7%. To this end, different interventions have been designed as part of the strategic road plan proposed by the Saltillo Urban Development Master Plan, which seeks to redistribute public space efficiently and functionally (IMPLAN 2016b, S. 23).

Public transport restructuring: The municipal administration has focused on the creation of a comprehensive transport system, reorganising its routes and carrying out a regulatory reform in this area. The "Strategic Plan for Corridors and Auxiliary Routes" is considered the starting point of this initiative and was presented in 2016. The same year and based on this contribution IMPLAN and the contracting the Agency IDOM, elaborated a proposal for the organisation of routes. To this end, a model was proposed that can be implemented in several phases, in which there are trunk routes that are configured as corridors and feeder routes that are structured as auxiliary routes. The corridors will cover the areas of greatest demand, and the auxiliary routes will cover the more residential areas. The first phase of this project is planned to start with the public transport network in the western part of the city (IMPLAN 2016b, S. 4–7). In addition, strategies to develop this project include the following:

- Create exclusive bus lanes.
- Optimise the existing bus lane network.
- Incorporate express buses between Saltillo and Ramos Arizpe and between Saltillo and Arteaga.
- Build efficient transfer stations.
- Integrate fares and ticketing.
- Generating complete and accurate information for users (IMPLAN 2016b, S. 9).

***Transport interventions in the consolidation of Saltillo's Historic Centre**:* The municipal government of Saltillo has among its strategic urban projects the recovery of its Historic Centre, which currently has very deteriorated areas in terms of housing infrastructure, commerce, public spaces, and transport. It seeks to develop a Transport-Oriented Development Model (TOD), which incorporates inclusive, equitable, and sustainable mobility proposals. It also proposes the need to invest in constructing large scale transport infrastructure, consolidating and expanding the municipality's integrated transport network (IMPLAN 2018b, S. 24).

The historic centre of the city is an area where there is a great deal of pedestrian activity. In recent times, different roads in the Historical Centre have been intervened, but despite the large number of people who walk daily through this area, the infrastructure conditions are far from ideal for comfortable, accessible and safe movement on most of the roads (IMPLAN 2018b, S. 21). According to IMPLAN studies, two alternatives are identified to reduce the negative impacts of the “oversupply” of public transport: creating exclusive roads for public transport or redistributing existing buses and routes in a balanced way. Neither of these alternatives addresses the causes of the problems in the public transport service, but only displaces them by moving them to other parts of the city centre. Also, some streets could be used as exclusive for public transport and where urban regeneration in favour of public transport, cycling and pedestrian mobility could take place (IMPLAN 2016a, S. 48–49).

Cycling infrastructure within the historic centre of Saltillo is practically non-existent. There are no confined cycle lanes or priority cycling lanes, so cyclists must ride on the road or the sidewalks. Moreover, there are no on-street bicycle parking facilities, and only three public bicycle loan stations are in place (IMPLAN 2016a).

On-site findings

Saltillo 2050: The interviewed stakeholders see Saltillo in 2050 as a compact and integrated conurbation and a multimodal transport system with modern units and the best technology within the municipality's possibilities. The planning and application of public policies focused on sustainable mobility as a priority of municipal authorities, as well as stricter and enforced urban development regulations were also mentioned. The interviewees also see Saltillo in 2050 as a city with numerous functional pedestrian zones and cycling infrastructure. Several stakeholders highlighted the need for preparing the industrial sector of Saltillo for the technological leap, so an industrial sector adapted to the needs of 2050 is something they consider to be preponderant. The future city will have a population balance between the city and the countryside, so there must be opportunities for both segments of the population.

Challenges: Among the main challenges facing Sustainable Development in Saltillo were: Changes of municipal government every 3 years make continuity difficult. Also, due to political or economic interests, consolidating consensus between actors is a challenging task, especially in issues related to public transport, due to the high incidence of politics in the organisations of public transport operators. Due to Mexico's fiscal-administrative structure system, there is a lack of sufficient resources in the municipalities and a high dependence on money from the federal and state governments, which can be affected by political considerations.

Vehicle verification is not mandatory at the state level.

There are unharmonized regulations from different levels of government, which leads to real estate developments that are inconsistent with the urban development plans of the municipality. Centralisation in the design of new social housing developments is also a barrier to sustainable development.

The mountainous geography of the city also plays an important role in mobility plans, as it requires a level of analysis and specific knowledge to carry it out.

Opportunities and Fields to Develop: Among the main areas of opportunity, it was proposed to generate participatory democratic mechanisms so that citizens can influence the allocation of the budget, especially in terms of infrastructure projects in the city as well as integrating social variables in the design of urban development plans. Following are the actions that could potentially contribute to the solution of Saltillo's mobility issues:

- Improve as much as possible the technology of public transport units, e.g. the use of electric-powered vehicles instead of diesel.
- Prepare the industry in Saltillo for the transition to the creation of auto parts for electric vehicles.
- Promote circular economy projects arising from the industrial sector. Likewise, to take advantage of its location adjacent to several tourist spots, to turn it into a base point for tourist visits to the vicinity.
- Expand, redesign, and recondition the bicycle lanes
- Recover pedestrian spaces.

3.7.3 Energy and CO_2 Emissions

Figure 20: Vision, challenges, and solutions in the energy sector

3.7.3.1 Energy Sector

With approx., one million inhabitants and located in one of Mexico´s most industrialized zones, Saltillo´s final energy demand is highly driven by its industrial and transportation sector and, to a lesser extent, by other sectors (residential, commercial, agricultural). This section describes the energy consumption and supply of Saltillo, programs already in place to improve the city's sustainability, key stakeholders in the energy sector, potentials for sustainable energy development and the challenges related to their implementation.

Sector description: Energy demand and supply by sectors

The pivotal role of Saltillo´s industrial sector becomes visible when looking at the distribution of Saltillo´s electricity consumption (Table 3 and Figure 21). The city´s total yearly electricity consumption is about 2100 GWh (CFE, 2021). About 35% of this total electricity consumption stems from "industry" tariffs, 45 % to "general" tariffs, which include both industry and businesses, 17% to the residential sector, 2% to the agricultural sector and 1% to the public sector. Hence, 80% of total electricity use is for the large, medium and small industries and business sectors. The distribution within the industrial sector is also very uneven, visible when looking at the number of users per tariff group.

There are only 14 very large industrial users in Saltillo, which account for 35% of the city´s total electricity use, or an average consumption of 52 GWh per year and user.

	Number of users		**Total consumption**		**CO_2 Emissions**	**Average consumption per user and year**
Sector	**No.**	%	**GWh**	%	**$ktCO_2$**	**kWh**
Residential	254.347	90%	349	17%	165,05	1372
Agricultural	1.710	1%	37	2%	17,54	21680
General	24.820	9%	958	46%	453,31	38613
Industry	14	0%	733	35%	346,57	52335446
Public	1.226	0%	24	1,2%	11,57	20

Table 3: Electricity consumption in Saltillo by sectors (own elaboration based on CFE open data on users and consumption by tariffs) (CFE open data 2021).

To put it in relation, the average consumption of one of these large industrial users is about 40 thousand times the average electricity use of a household in Saltillo. Indeed, Saltillo´s 250 thousand households consume merely an average of 1400 kWh per year. Using the grid CO_2 emission´s factor of around 450 gram CO_2 per kWh, Table 3 also provides an estimate of CO_2 emissions from electricity consumption, which are proportional to the electricity use and thus highlight the role of the industrial sector in climate change mitigation.

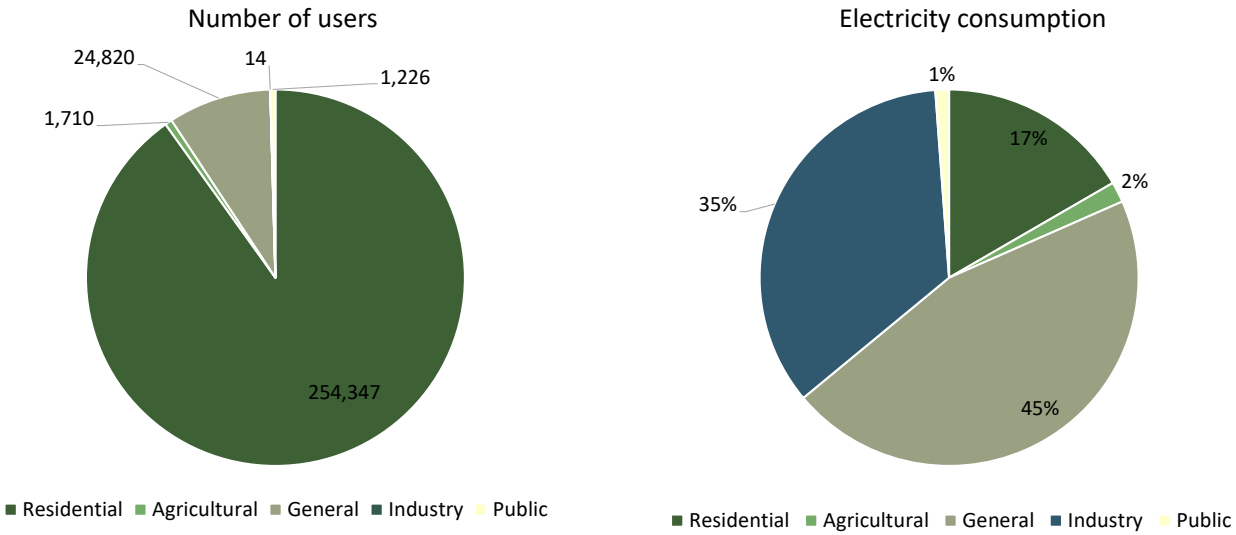


Figure 21: Distribution of electricity users (left) and total electricity consumption (right) in Saltillo by sectors (own elaboration based on CFE open data on users and consumption by tariffs).

Beyond electricity, in terms of Saltillo´s total final or primary energy demand, it remains challenging to provide a reliable picture of the city´s energy balance, as energy data is not collected and published systematically at the sub-national level. Nevertheless, we provide estimates for the total energy consumption of Saltillo´s most relevant energy-consuming sectors. Based on an energy simulation model of the city, implemented in the Low Emissions Analysis Platform (LEAP), the final energy demand for the largest energy-consuming sectors was estimated. For the transportation sector, data from the remote sensor study was used. A recent study was conducted in Saltillo´s metropolitan area to compute the number of circulating vehicles (INECC 2019) and fuel intensities of circulating vehicles. A yearly demand of approx. 5 500 GWh is estimated, with cars representing 35%, taxis 32%, SUVs 17%, pick-ups 10% and public buses 5% of the transport sector's total energy consumption. Of note, nearly the totality (99%) of these vehicles are gasoline vehicles, as freight transportation occurs mainly outside the city and is thus largely omitted in this estimation. Next to the transportation sector, the industrial sector is the largest energy-consuming sector in Saltillo. A total yearly energy demand of approx. 5 700 GWh is derived, hence slightly higher than the transportation sector, which is however omitting freight transport. This number is derived by using value-added data by industries located in Saltillo from the national statistics and geography institute (INEGI) and industry-specific energy intensities and fuel-use breakdowns for Mexico (Ordonez et al 2015). For the residential sector, a yearly consumption of approx. 1 000 GWh is estimated, considering the reported electricity

consumption of the residential sector 350 GWh (CFE, 2020) and applying the average relation of electricity consumption to the total residential energy consumption of Mexican households (Enerdata Global Stat, 2021). Further, based on the energy consumption data of Saltillo´s water company, as well as public tariffs for buildings and lightning, water pumps are estimated to consume about 500 GWh and public buildings and lightning close to 30 GWh each. The agricultural sector plays a negligible role in the city´s energy consumption. An overview of all considered sectors is provided in Figure 22.

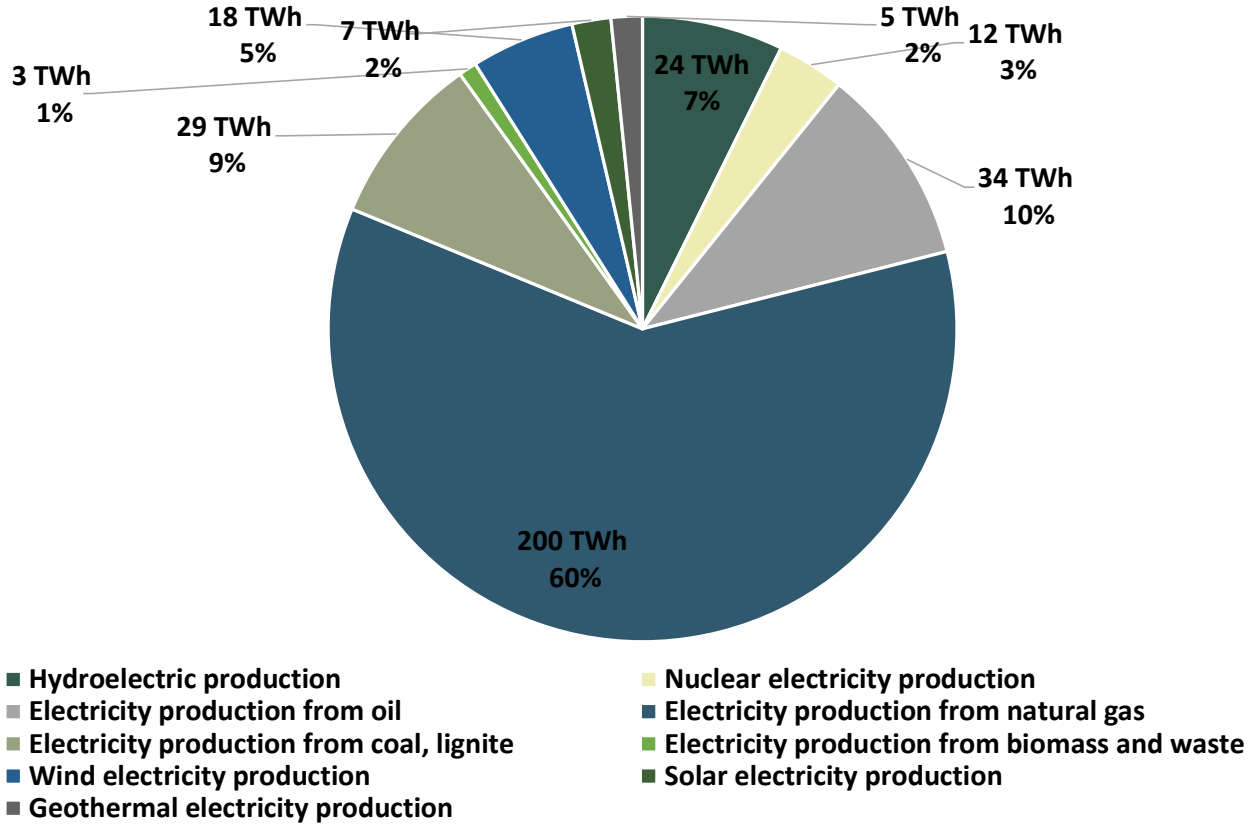


Figure 22: Estimation of the distribution of total energy demand by selected urban sectors (own elaboration)

In terms of supply, Saltillo´s electricity and its oil and gas products are for the most supplied by the Comision Reguladora de Electricidad (CFE), Mexico´s state-owned electricity utility and the Petróleos Méxicanos (PEMEX), Mexico´s state-owned Oil Company. These companies have ever since represented the backbone of Mexico´s energy sector. Indeed, CFE produces more than half of the country's electricity demand, owns over 60% of generation capacity, and until recently, it remained as a sole retail supplier in the country (IEA, 2017). Similarly, PEMEX and its subsidiaries produce and supply domestically a considerable fraction of Mexico´s total oil demand, with a production of approx. 1,65 million barrels per day, contrasting with Mexico's demand of approx. 2 million barrels per day. Mexico´s national grid provides Saltillo´s electricity (see Figure 23), which is primarily based on electricity by fossil fuels, mostly natural gas (60 %), followed by oil (10 %) and coal (9 %). Low carbon, clean electricity sources represent the remainder, with hydroelectric electricity representing 7%, wind 5%, nuclear 3% and geothermal and solar each 2%. Reflecting the large share of gas in the grid, the CO_2 emission factor of grid electricity amounts to 473 grams of CO_2 per kWh.

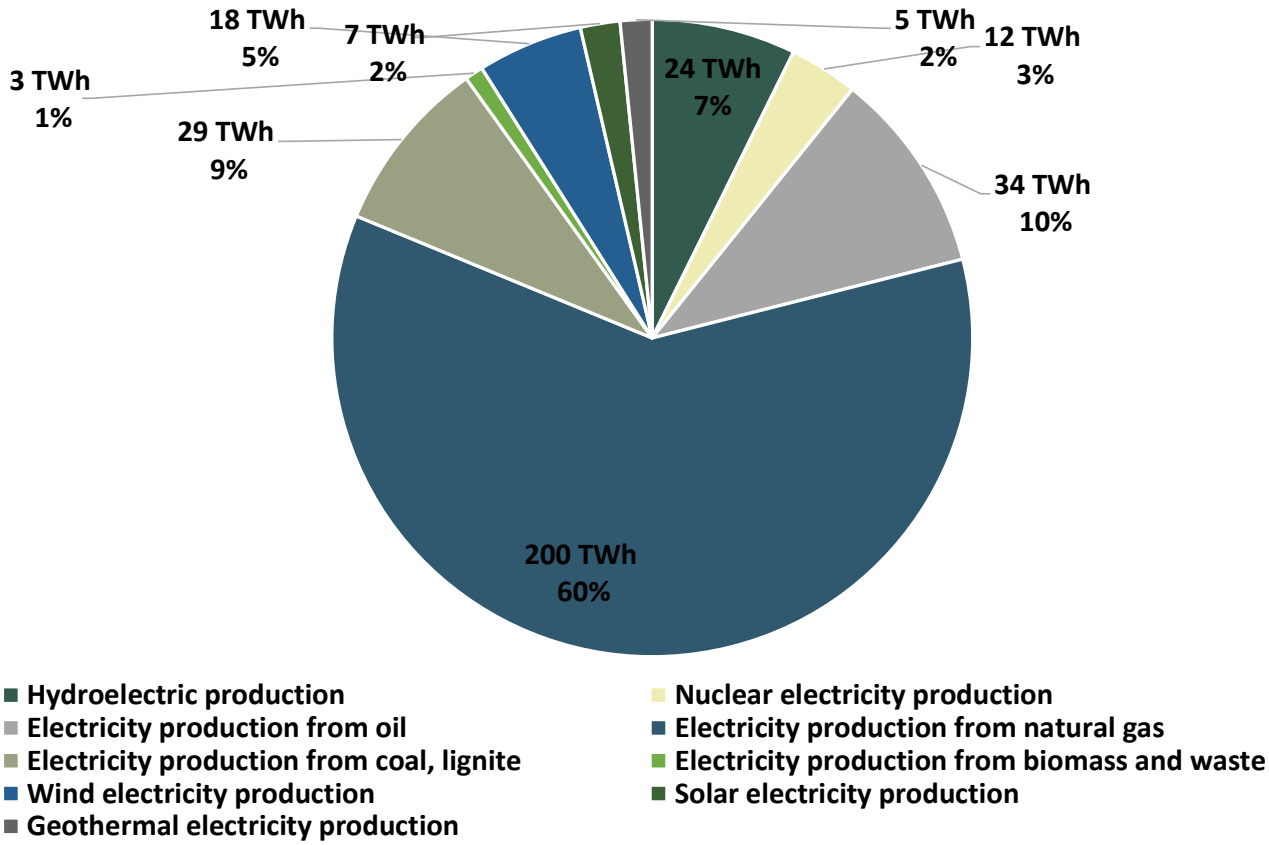


Figure 23: Electricity production by sources (own elaboration based on ENERDATA 2021)

Key developments and Status Quo in the sector

In the energy sector, Saltillo has taken the first steps to improve its sustainability performance. Since 2013, the methane produced in Saltillo's landfill has been used for electricity generation. Since its operation it has generated between 2 and 9 GWh annually. However, this represents only a small fraction (0.1- 0.5%) of Saltillo's final electricity demand (see Table 4 for a selection of relevant indicators for Saltillo in the energy sector).

Similarly, since 2019, Saltillo has implemented several programs to improve energy efficiency. In particular, it has improved the energy efficiency of public lighting by replacing low-efficiency lighting with LEDs, leading to savings of about 0.5 GWh per year. Similarly, it has implemented an energy-savings program in offices, aiming to reduce the annual electricity demand that public buildings consume substantially.

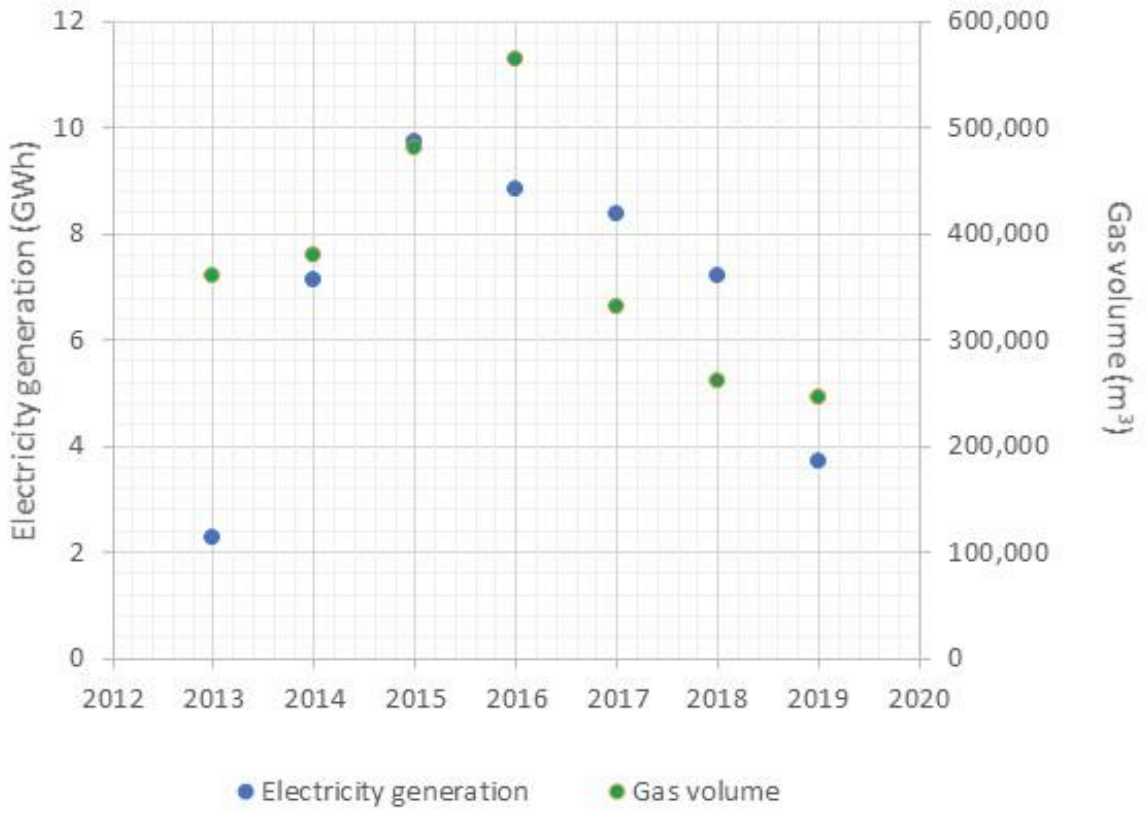


Figure 24: Gas flow and annual electricity generation of the Saltillo´s landfill (Municipality of Saltillo 2020)

Since 2019, Saltillo has been implementing programs to improve the city energy efficiency. One of these programs is called "*Saltillo se Prende*", which has the purpose to increase energy efficiency through the modernization of the public lighting system by replacing its ceramic metal lights with Light Emitting Diodes (LED) technology. By 2020, 81% of the total lights were replaced and is expected an energy reduction of 521 MWh that is equivalent to a 54% reduction of the GHGs (Public Services Municipality of Saltillo 2020). On the other hand, it was estimated that public sector buildings consumed around 30 GWh per year, therefore, the city implemented the Green Office plan, which is a training program offered to government, educational institutions, and state companies, that includes specific actions to improve energy efficiency in buildings where 182 workplaces are involved.

Indicator	Value	Unit	Source
Total energy demand per capita (kWh/a/cap)	10,518	kWh/a/cap	Own estimation based on energy simulation model of the city, considering total energy use of the residential, industrial, transportation and public sector
Total electricity demand per capita (kWh/a/cap)	2,104	kWh/a/cap	CFE public data on electricity consumption
Total electricity demand per capita for residential sector only (kWh/a/cap)	422.98	kWh/a/cap	CFE public data on electricity consumption allows to compute only the residential sector value
Authorized electrical service	100	%	Nearly 100% of households within the urban area have access to electricity.
Cooling units	48	% of total number of housing units	ENCEVI survey by INEGI
Share of electricity demand produced within the city (%)	0.90	% of total electricity demand	Own estimation based on CFE public data and technical data from methane landfill
Share of electricity demand produced by renewable energy sources	17.9	% of total electricity demand	Using 17% national RE elecricity in the grid and 1% of relleno sanitario.

Table 4: Selected indicators for Saltillo's energy sector.

Key stakeholders, governance structure and policies

For the most, Mexico electricity and oil and gas sectors are supplied by the state-owned electricity utility Comision CFE, and Mexico's oil company PEMEX. These companies represent the backbone of Mexico's energy sector. Mexico's energy sector is still governed at the national level, with the federal states and municipalities having no jurisdiction over energy-related matters.

In 2013, Mexico launched a major energy reform aiming to restructure its energy sector away from the monopolistic state-owned enterprises CFE and PEMEX, to a more liberalized market open to private actors. In the power sector, although independent power producers were already permitted to operate under power purchase agreements and captive generation was allowed for industrial consumers, the energy reform unbundled the CFE into separate companies, strengthening further access for the private actors.

In this newly liberalized electricity market, two rounds of energy auctions were held in 2016 and 2017, allowing private sector participants to bid for long-term contracts for the generation and distribution of electricity in the market (Wood 2018). The auctions had record low outcomes. In particular, Mexico's 2017 auction had average prices of 2 US cents per kWh and the lowest bids broke world records. In fact, Mexico ranks globally among the top nations in terms of solar radiation and practical solar PV potential, making this technology particularly affordable if financing conditions are good (Timilsina 2020). Coahuila and Saltillo are among Mexico's best locations in terms of solar radiation, meaning solar PV electricity generation potential is exceptional (Global Solar Atlas 2021, Marcel et al. 2020). However, the development of renewable energies is currently on hold, as President Andres Manuel Lopez Obrador and his administration have taken a critical view of the energy reforms (Eckstein et al. 2020). The Lopez Obrador administration has put much effort into rolling back energy reforms and

private sector participation, based on the belief that state-owned enterprises should be the agents of development (Gastelum et al. (in prep.)). This has created a highly adverse climate for renewable energy development, as the CFE has been instrumentalized to use gas and oil products from the financially struggling PEMEX (Mexico News Daily 2020).

Potential for contribution to climate change mitigation and adaptation

Mexico as a country, and the Coahuila state, in particular, have significant renewable energy sources (IRENA 2015). Most outstandingly, Saltillo has exceptional potentials for the development of solar and wind energy. As a country with an average solar PV practical potential of 4.92 kWh per kWp or 1785 full load hours per year, Mexico ranks globally as one of the most outstanding countries in terms of its practical potential for solar PV development. Saltillo has even better potentials. Its minimum potentials are at 4.92 kWh per kWp, Mexico´s county average, yet more than half of its potentials are above 5.15, and its 25% best potentials are above 5,23 kWh per kWp.

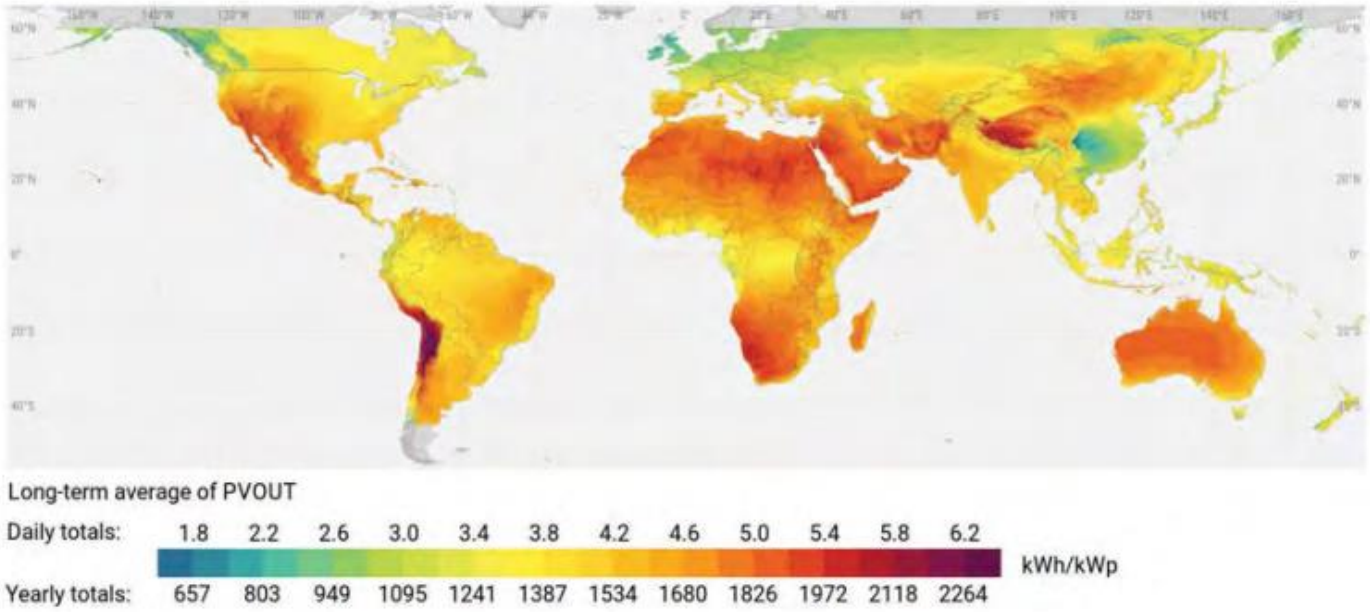


Figure 25: Solar PV potentials (Global Solar Atlas 2021)

Statistics	kWh/kWp	full load hours/year
Average	5,15	1880
Maximum	5,32	1942
Percentile 90	5,3	1935
Percentile 75	5,23	1909
Percentile 50	5,15	1880
Percentile 25	5,08	1854
Percentile 10	4,99	1821
Minimum	4,92	1795

Table 5: Distribution of solar potential in Saltillo (Global Solar Atlas 2021)

According to Atlas of Clean Energy Zones, Coahuila has the potential to install up to 23 GW of wind power and 10 GW of solar projects, respectively (Gobierno del Estado Coahulia de Zaragoza 2018). Considering limitations like the availability of infrastructure and topographic characteristics, it is estimated that the region has a potential for electricity generation of 59 000 GWh per year from wind energy and 18 000 GWh per year from solar energy. This value corresponds to 37 times the total electricity consumption of Saltillo in the year 2017. Currently, there are 34 projects in the zone authorized for the generation of electricity through solar and wind energy in Coahuila, yet the national policy of the Lopez-Obrador administration represents a major barrier to the successful accomplishment of these projects (Gobierno del Estado Coahulia de Zaragoza 2018; Eckstein et al. 2020).

Saltillo also has substantial non-renewable resources. Around 45% of the total shale gas of Mexico is within the Sabinas, Burro, and Picachos basins at the north and centre of Coahuila. It is estimated that these basins have 14 million barrels of equivalent crude oil (Cluster 2018). Furthermore, Coahuila state is the highest producer of coal in Mexico, with more than 90% of the coal reserves, and it has two of the three coal-fired power plants (Río Escondido and Carbón II) of Mexico. For 2017, coal power plants generated 9% (30,557 GWh) of the total electricity of Mexico, where Río Escondido and Carbón II power plants produced 41% of the total (Prodesen 2017).

Next to renewable energies, Saltillo has a great potential to improve its energy efficiency performance. Cities, as opposed to rural areas, are generally distinguished by a high concentration of social and economic activity that takes place within their boundaries, leading to a higher potential for energy efficiency improvements. Saltillo´s economic activity is firmly based on industrial activities, particularly automobile, machinery and steel products manufacturing. More than 40 industrial parks are located in Saltillo's industrial zone, and over 8% of Mexico's automobile manufacturing and 6% of Mexico's metal industry are located in the zone. Thus, being in one of Mexico's most industrialized zones, Saltillo has great potential to reduce its GHG emissions in the industrial sector by improving energy efficiency.

Improving energy efficiency also unlocks enormous benefits to many different stakeholders, which are often overlooked: next to reducing energy consumption and greenhouse gas emissions, it can improve energy security, lower energy prices, improve industrial productivity, reduce household and companies' energy bills, thereby increasing disposable income, increase asset´s values, improve air quality, alleviate public budgets, and many others more. Research comparing measures in cities around the world shows that low carbon investment pays off by its annual savings, with payback periods of few years, thereby contributing to economic growth (IEA 2012).

Finally, noting that the transportation sector is responsible for a bulk of energy consumption of the city, a significant potential for CO_2 emission´s reduction in the sector is identified if the city promotes access to sustainable public mobility (e.g. low energy consumption and emissions vehicles, towards non-motorized mobility like pedestrian zones and bicycle infrastructures) and integrates urban and mobility planning. A detailed overview of measures in the mobility sector is provided in chapter 3.7.2.

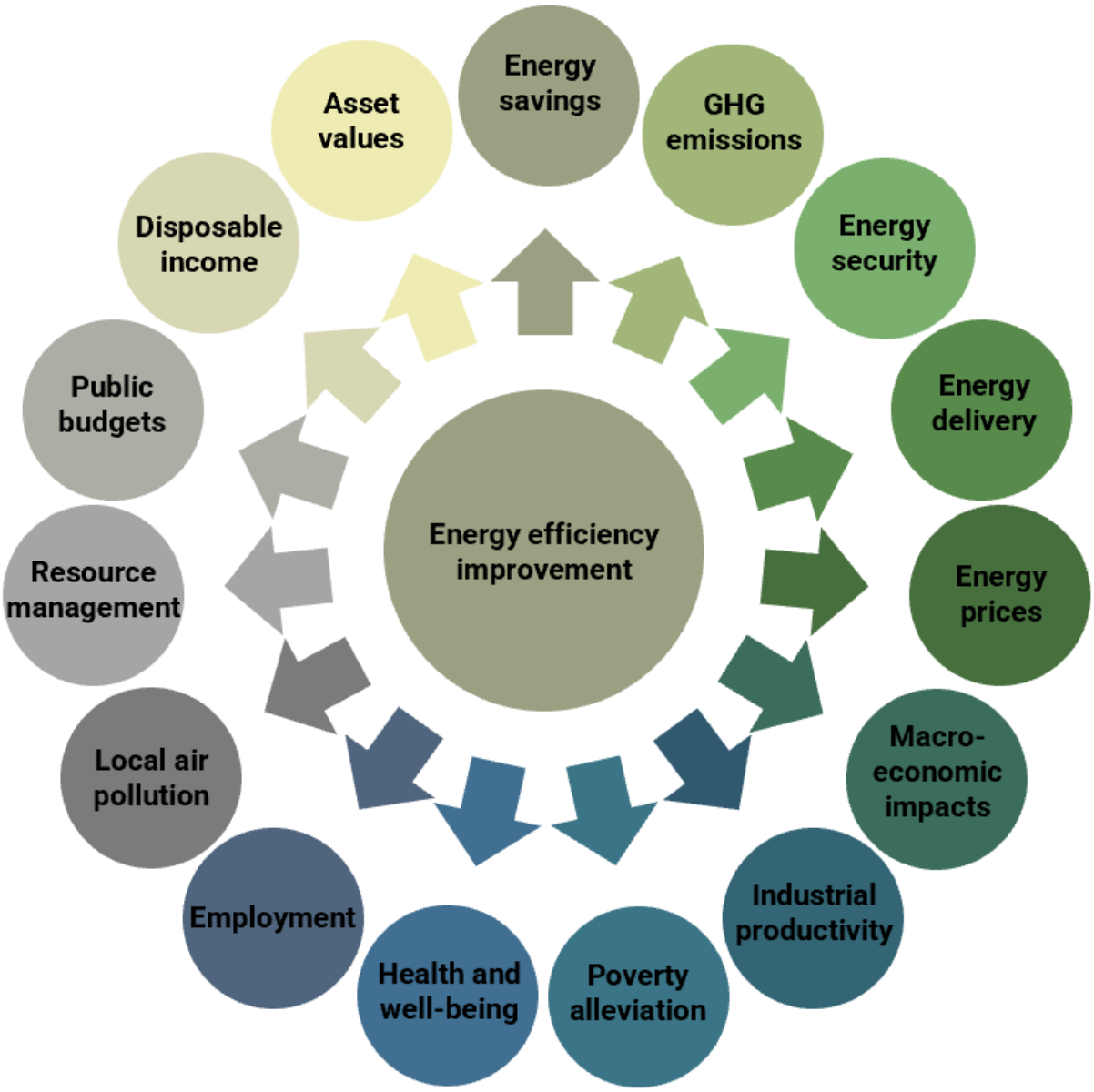
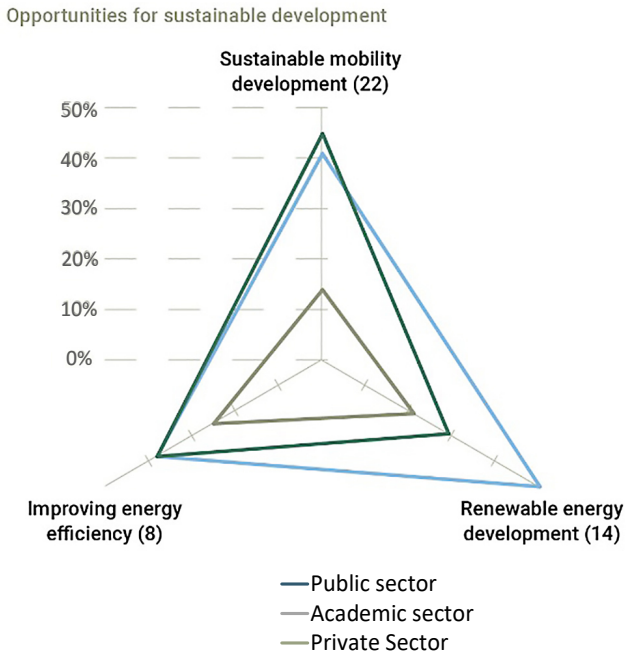


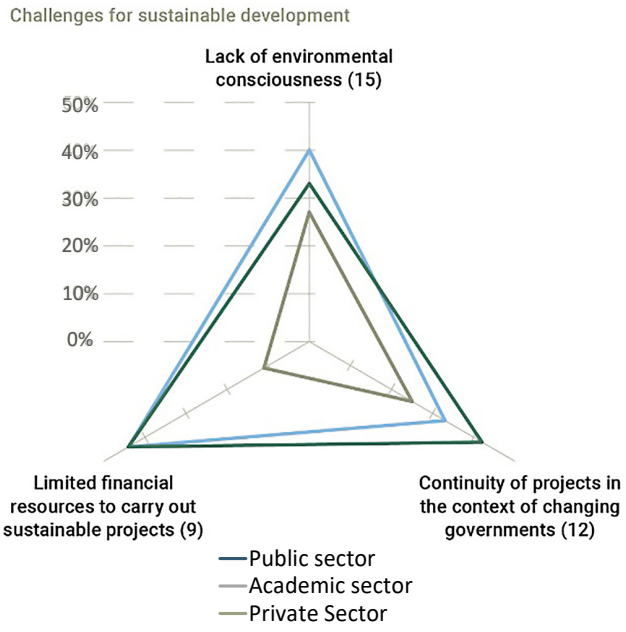
Figure 26: Multiple Benefits of Energy Efficiency (IEA 2014)

On-site findings

Opportunities and challenges for sustainable development were a repeated subject of discussion in over 45 interviews conducted with expert local stakeholders in the academic, public and private sectors and civil society. In terms of opportunities, stakeholders over all sectors mentioned the potential for renewable energy and energy efficiency development, as well as sustainable mobility, as the most important opportunities.

The interviewees also referred to many salient challenges that impede sustainable development. The most important factors that inhibit transformational change in the long term are a lack of environmental consciousness, limited financial resources and the challenge of implementing long-term incentives in the face of changing governments (Figure 27).





The percentages refer to the proportion of mentions from the public, academic and private sectors against the total number of mentions (in parenthesis). Own representation based on 46 expert interviews with key stakeholders from the public, academic and financial sectors.

Figure 27: Challenges and Opportunities of sustainable development in Saltillo. Numbers in parenthesis represent the number of mentions in the interviews, shares represent the share of total mentions (own elaboration based on interviews).

3.7.3.2 CO_2 Emissions

Mexico´s NDC and the role of cities

Mexico's NDC was submitted in advance of the 2015 United Nations Framework Convention on Climate Change. This specifies mitigation targets for the reduction in GHG emissions relative to a Business-as-Usual (BAU) scenario. In the BAU scenario, GHG emissions increase by a factor of 1.5 from 665 to 973 $MtCO_2eq$ by 2030. The unconditional scenario corresponds to a decrease in GHG emissions of 22% (reaching 762 $MtCO_2eq$) by 2030 compared to the BAU. Transport sector emissions in the unconditional scenario correspond to a decrease in GHG emissions of 18%, industry emissions of 5%, residential and commercial emissions of 18%, and waste emissions of 29% (Figure 28). These sectors typically represent the majority of energy-related emissions of cities. These sectoral reductions could serve as a guide for Saltillo to reach the national GHG emission reduction targets, as stipulated in Mexico's NDC.

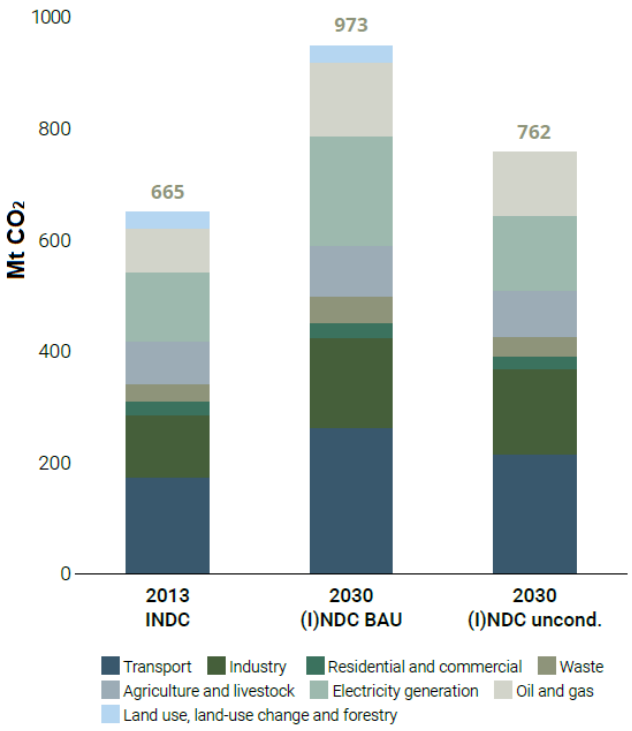


Figure 28: Mexico´s historical CO_2 emissions, its 2030 baseline development and its 2030 NDC´s mitigation targets by sector (Eckstein et al. 2020)

Cities are distinguished by the concentration of social and economic activity that takes place within their boundaries. The IPCC has estimated cities, within their boundaries, directly account for 44% of global GHG emissions, and, when considering their final consumption of electricity (generated outside the city yet supplying urban centres) the share can be as high as 71–76% (IPCC 2014). Numerous analyses have even suggested that when wider indirect effects are taken into account the share of global energy-related CO_2 emissions attributable to cities would be higher. In this view, cities can and must substantially contribute to the achievement of climate targets. Considering Saltillo´s excellent renewable energy potentials, and the fact that its industrial and transportation sectors are overrepresented as compared to the national average, Saltillo should drive transformation away from fossil fuels in these sectors.

To assess the contribution of Saltillo to the goals of the Paris Agreement, energy and CO_2 simulation model of the city was developed in the LEAP. This integrated tool portrays the energy demand and supply of Saltillo in four scenarios:

1. A business-as-usual scenario, assuming the historical trend in energy use CO_2 emissions continues into the future.
2. A generic energy efficiency scenario, portraying the effect of energy savings across Saltillo´s most relevant sectors of 2% and 4% every year
3. A renewable energy scenario, assuming Saltillo´s electricity supply is covered by CO_2 free electricity, e.g. by the use of solar PV or other renewables.
4. A combined scenario, assuming a combination of the energy efficiency and renewable energy scenarios.

The model comprises Saltillo´s most relevant sectors, the transportation, industrial and residential sector, as well as the water supply sector, public buildings and public lighting. According to data availability at the national and local levels, a mix of methodologies was applied in each sector. For the transportation sector, the energy was estimated considering the city vehicle fleet, the fuel efficiency, and kilometers travelled by vehicle category. This information was contrasted and validated with the amount of fuel sold in the city. For the industry sector, value-added data of the industries located in Saltillo was combined with typical energy intensities and fuel breakdowns, as estimated for the national average (Ordonez et al. 2016). For the residential sector, the socio-economic data of Saltillo was combined with appliance and devices consumption data and national statistics. Publicly available electricity consumption data by users was used to validate and calibrate the estimations.

Box 1: Carbon neutrality by the second half of the century

Complying with the goals of the Paris Agreement will require achieving a carbon-neutral economy by the second half of the century, as achieving any climate stabilization target will require retaining cumulative CO_2 emissions within a constrained carbon budget. The Intergovernmental Panel on Climate Change´s Fifth Assessment Report provides an estimate for achieving a 1.5°C and a 2°C temperature stabilization targets. The Sixth Assessment Report *reaffirms with high confidence the AR5 finding that there is a near-linear relationship between cumulative anthropogenic CO_2 emissions and the global warming they cause. Every 1000 GtCO_2 of cumulative CO_2 emissions is assessed to likely cause a 0.27°C to 0.63°C increase in global surface temperature with the best estimate of 0.45°C.* The remaining carbon budget as of 2020 for achieving a 1.5°C temperature stabilization target above pre-industrial levels is approx. 400 Gt of CO_2eq, while the remaining budget for a 2°C temperature target is 1150 Gt of CO_2eq. As every year of increased GHG emissions consumes a piece of the remaining budget, the longer decided action is taken, the more radical yearly reductions must be to achieve a given stabilization target

Achieving substantial emission reductions will require a fundamental transformation, away from a fossil fuel-based economy and society. To achieve this goal, two fundamental strategies can deliver a large share of emission reductions, paving the way towards a Paris compatible trajectory. Figure 29 shows the global CO_2 emissions in the International Energy Agencies' 2018 new policies scenario, as well as in the sustainable development scenario. At a global level, energy efficiency improvements with the use of existing efficient technologies combined with the abolishment of the misaligned incentives towards a higher energy consumption resulting from subsidized energy, can deliver around 37% of GHG emission reductions. Similarly, the large-scale implementation of renewable energies, as well as the reduced use of carbon-intensive and inefficient coal-fired power plants can deliver an approx. 36% of emission reductions as compared with the new policies scenario. Together, energy efficiency and renewable energies account for the bulk of CO_2 emissions savings.

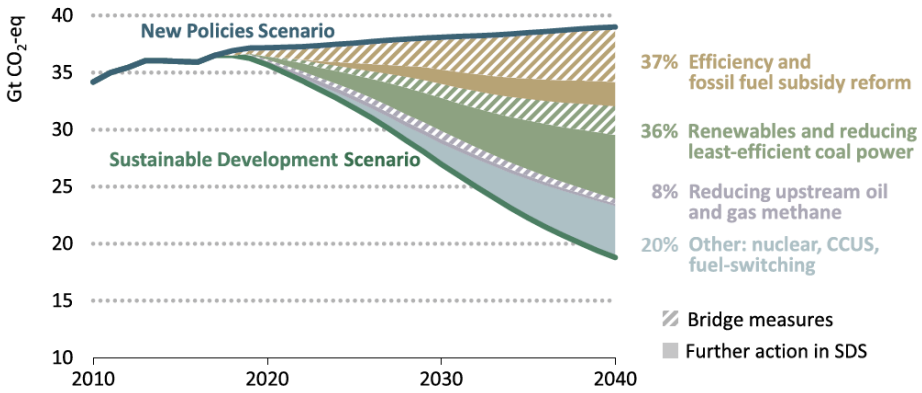


Figure 29: The global role of energy efficiency and renewable energies in a Paris compatible trajectory. (Source: (IEA 2019))

Energy efficiency savings

Based on a BAU scenario of Saltillo's energy development, which uses historic growth rates of final energy demand to estimate future energy consumption by sectors and fuels, an energy efficiency scenario was developed.

The scenario assumes efficiency measures across the industry, mobility, residential and public sector to achieve annual saving rates of 2 % and 4% in a variation, respectively, for the final energy consumption these sectors.

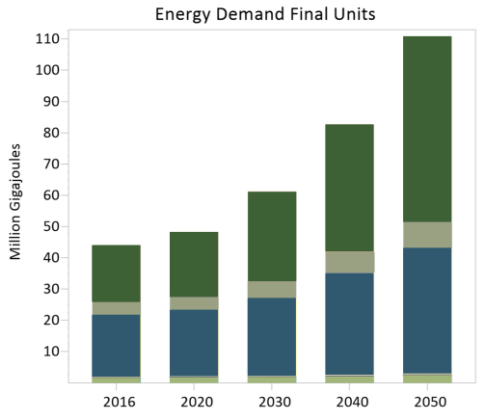
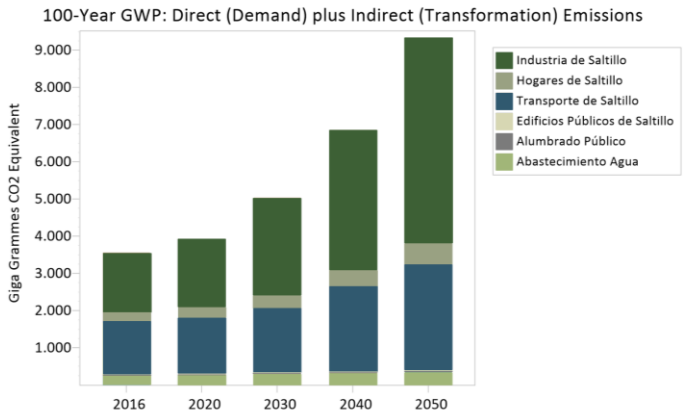
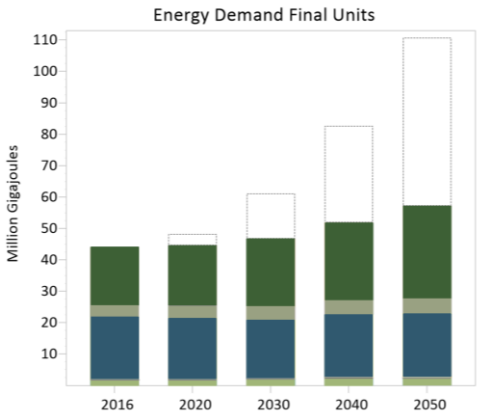
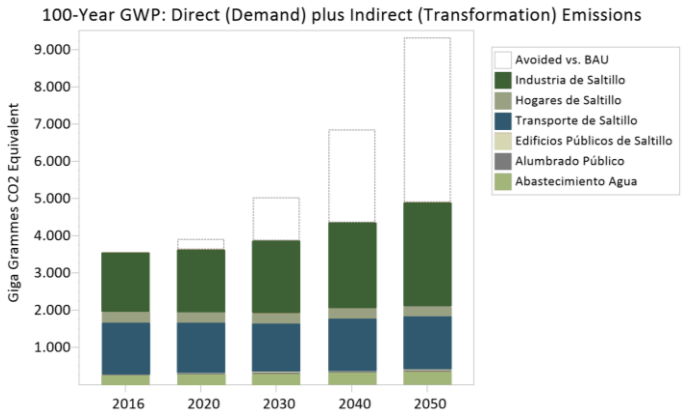
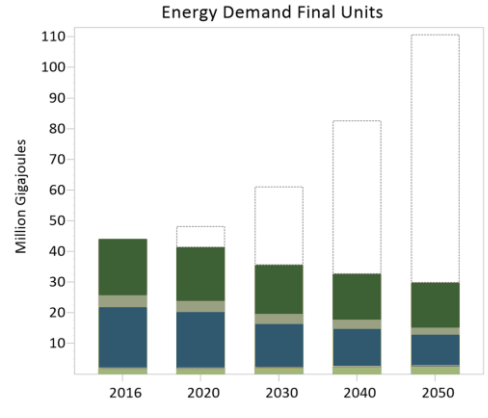
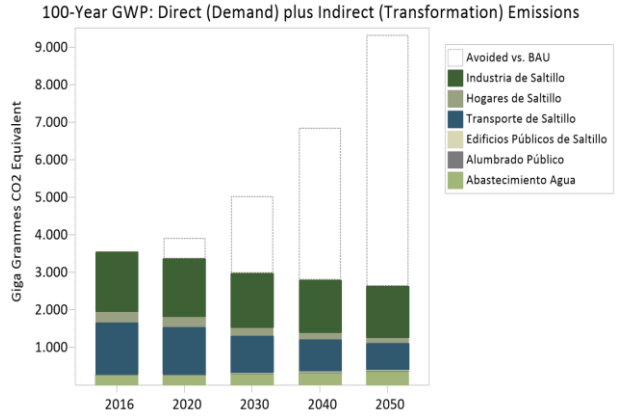
Sce-nario	Energy Demand by Sectors	Energy-Related Emissions (CO_2) by sectors
BAU		
-2 %		
-4 %		

Figure 30: Energy demand and energy-related emissions by scenarios and sector in the timeframe 2016-2050.

As shown in Figure 30, the final energy demand and CO_2 emissions in Saltillo would more than double until the year 2050 in a BAU scenario if no measures are implemented. In contrast, energy efficiency measures achieving a yearly saving of 2% across the transport, industry, residential and public sectors could slow down the increase in final energy demand significantly. In this scenario, the final energy demand and CO_2 emissions in 2050 are only 30 % higher than in 2016 and just half of the value in 2050 in the BAU scenario.

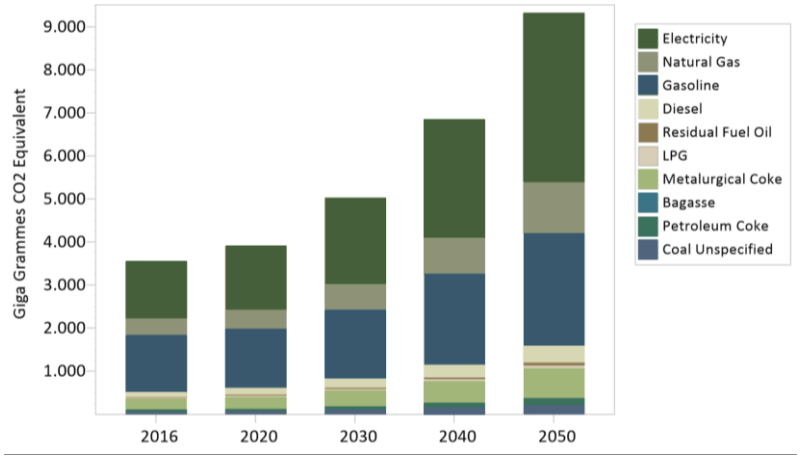
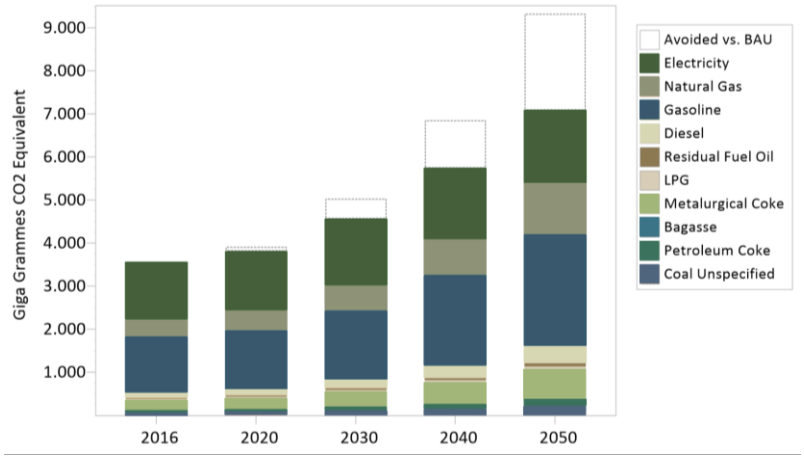
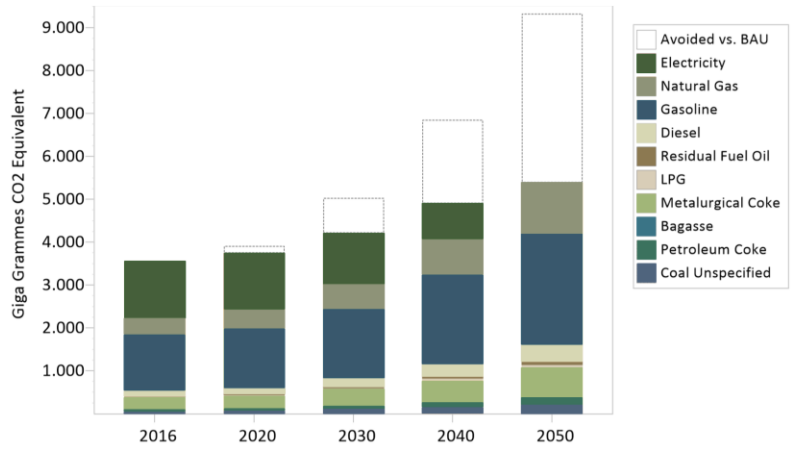
Scenario	Energy Related Emissions (CO_2) by fuels
BAU	
Clean	
Green	

Figure 31: CO_2 emissions by fuels between 2016 and 2050 for different scenarios.

Assuming even more ambitious energy efficiency measures, achieving yearly savings of 4 %, the energy demand and CO_2 emissions in 2050 are one third lower than in 2016 and just a quarter of the BAU value. Thereby assuming unchanged emission factors for fuel combustion, as defined in the IPCC tier-one methodology, greenhouse gas emissions would be reduced proportionally to energy consumption.

Renewable energies

In addition to energy efficiency measures, achieving carbon neutrality by the second half of the century will require the decarbonization of the power sector within the coming decades. The business-as-usual scenario of the developed energy and CO_2 emissions model uses the current emission factor of around 460 gCO_2/kWh, corresponding to the Mexican grid electricity mix. The electricity sector is one of the main contributors to the overall CO_2 emissions in Saltillo, followed by gasoline use in the transportation sector and gas use in the industry (Figure 31, top). Based on this business-as-usual scenario, two renewable energy alternatives were developed as renewable energy scenarios. For the "*Clean Electricity*" a reduction of the emission factor to 200 gCO_2/kWh in 2050 is assumed. As shown in Figure 31 (centre), this would be necessary to keep the overall emissions of the power sector constant over time, despite the growth in electricity demand. The "Green Electricity" scenario assumes a gradual transformation to a 100 % renewable power sector by 2050 and thus no CO_2 emissions related to electricity generation by that year (Figure 31, bottom).

Combining renewable energies and energy efficiency

Combining energy efficiency and renewable energies would lead to even stronger GHG emission reductions, as energy efficiency also reduces the electricity demand. This leads on the one hand, to fewer emissions in the power sector, and decarbonizing the electricity sector emissions is thus easier, as less renewable power plants are required to cope

with electricity demand. Depending on the energy efficiency measures taken, different total demands for renewable electricity are necessary. Assuming solar PV power plants with a capacity factor of 20%, a rather conservative value considering the excellent potentials in Saltillo, the renewable electricity demand can be transferred directly into the total installed capacity needed.

The combination of green electricity and no implemented efficiency measures results in the highest demand for installed solar PV capacity: 4.22 GW in 2050.

Clean electricity and 4 % yearly energy intensity reduction on the other side lead with 0.78 GW to the lowest demand in 2050.

The yearly capacity addition from 2021 to 2050 results, therefore, depending on the combination of scenarios between 26 MW/year and 141 MW/year.

The results for the different combinations of scenarios are summarized in the following plots and table.

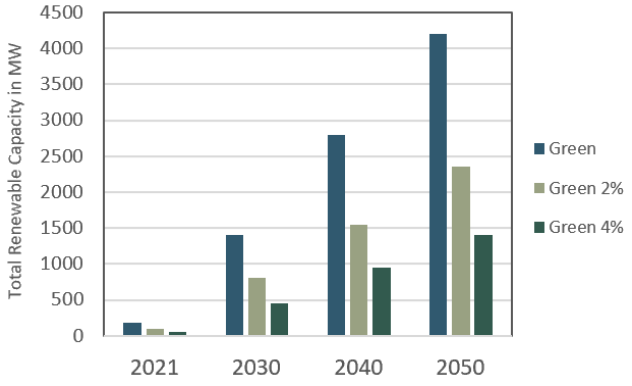


Figure 32: Required solar PV power capacity in the timeframe 2021-2050 to transform Saltillo´s power supply to 100% carbon-free under different energy efficiency saving rates.

	Clean Electricity			*Green Electricity*		
	BAU	***2 %***	***4 %***	***BAU***	***2 %***	***4 %***
Total power capacity in 2050	*2.4 GW*	*1.3 GW*	*0.8 GW*	*4.2 GW*	*2.3 GW*	*1.4 GW*
Yearly capacity addition until 2050	*80 MW*	*44 MW*	*26 MW*	*141 MW*	*78 MW*	*46 MW*

Table 6: Total installed Solar PV power capacity in 2050 and yearly capacity additions to until 2050 in a scenario assuming that half of Saltillo´s electricity demand is provided by solar PV (clean electricity) and 100% of electricity demand is provided by solar PV (green electricity) under different energy efficiency saving rates.

Finally, Figure 33 shows the development of CO_2 emissions in Saltillo for all scenarios and combinations. The business-as-usual trajectory would lead to a massive increase in greenhouse gas emissions until 2050. However, the combination of energy efficiency measures and green electricity allows lowering the emissions significantly and therefore contribute to the achievement of the goals of the Paris Agreement on climate change. Likewise, Figure 33 shows that just decarbonizing the power sector is not enough, as even if electricity is generated from 100% renewables in 2050 (Green electricity scenario), without energy efficiency measures, total CO_2 emissions will continue to increase compared to 2016.

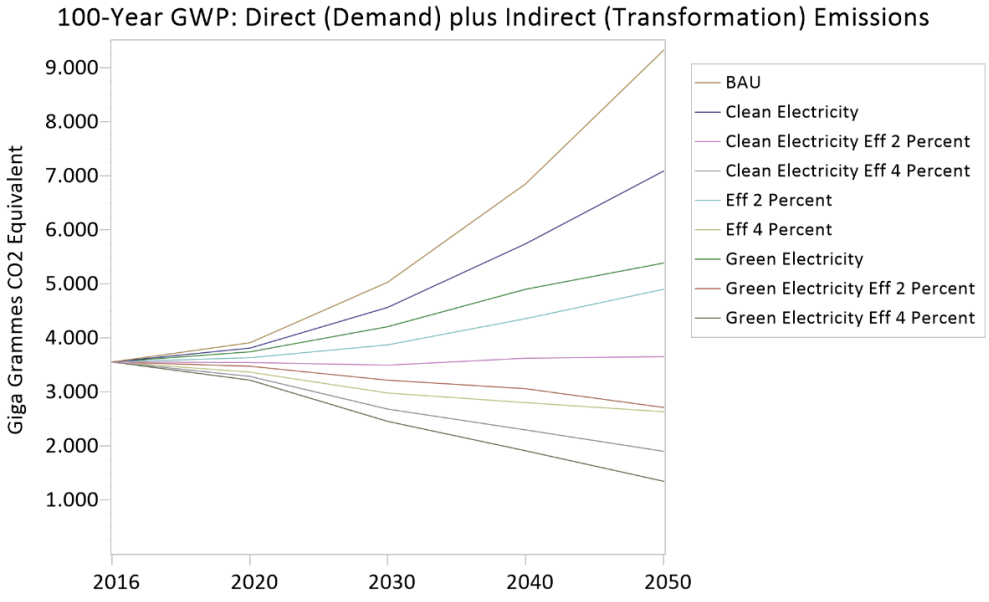


Figure 33: CO_2 emissions by scenarios in the timeframe 2016-2050.

3.8 Sensitivity Analysis of Saltillo

Based on more than 40 interviews with local stakeholders from different sectors, the on-site assessment of Saltillo revealed a total amount of 39 impact factors that exert substantial influence upon the development of the city. These impact factors only represent a partial set of variables that impact a complex system like an entire city. Nevertheless, for analytical reasons, following the Sensitivity Model of Frederic Vester, it was necessary to distil the most important factors out of this list for further processing.

The cross-impact analysis of factors allows distinguishing between four different categories of factors:

1) Drivers: these factors have a high impact on other factors and receive little influence from other factors. They have the potential to drive change and to stay stable over a long time. Often, they are difficult to change.

2) Levers: These factors have a high impact on many other factors, and many other factors also influence them. These are the crucial factors that one needs to address to transform the system in the desired direction. Levers need to be designed carefully because their consequences in the system may be challenging to oversee.

3) Indicators: These are variables that have little influence over other factors but are strongly influenced by other factors. They show the change in the system. Therefore, they can be used as indicators of the transition of a system.

4) Buffers: These are factors that are rather inactive in any direction. They do not influence many other factors, and many other factors do not influence them. One should not try to change the system by working with buffers.

A comprehensive analysis of the prioritized action fields and the most crucial impact factors gave rise to the following fields of intervention for the city system of Saltillo:

- Highly industrialized zone
- Industrial parks
- Automobile manufacturing cluster
- Extense city
- High migration rate
- Environmental consciousness
- High university density

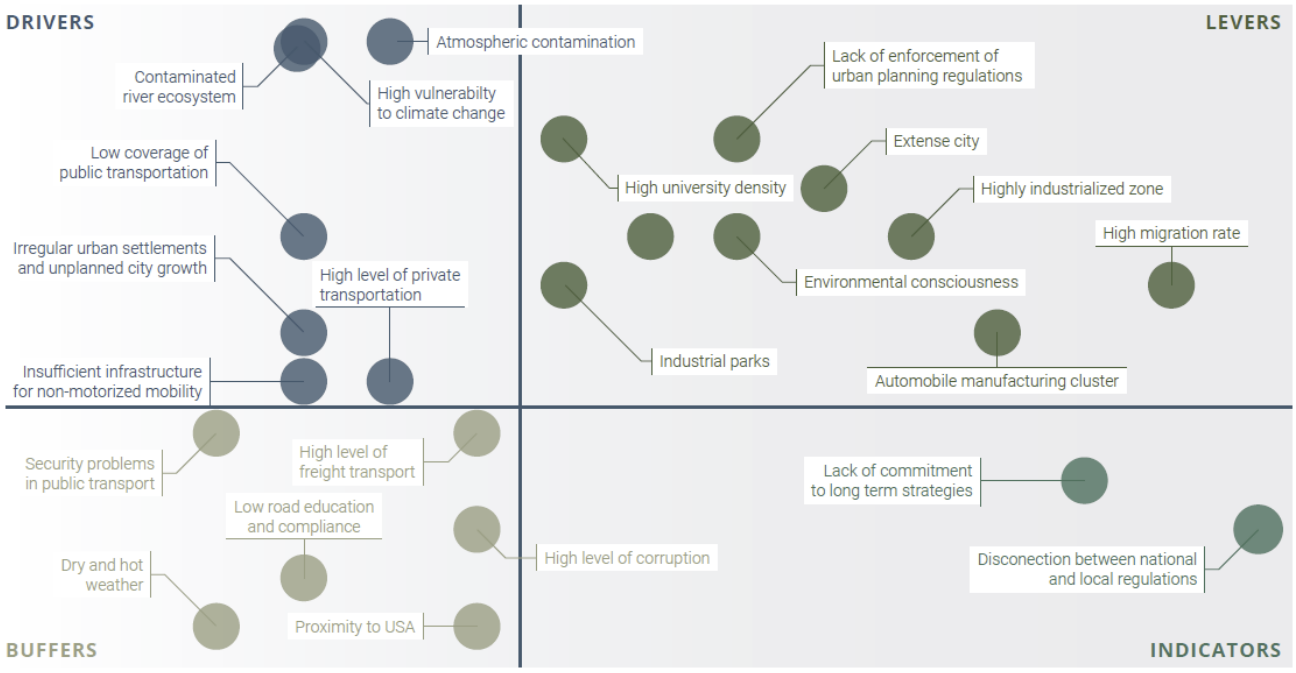


Figure 34: Impact Factor Analysis Outcomes

4 Roadmap

4.1 Overview of the Suggested Measures

The integration of the City Systems Analysis and the Sensitivity Analysis carried out during the project, along with workshops and discussions, generated a list of 26 project ideas for the city of Saltillo across the three sectors of work. The ideas were presented at the virtual stakeholder´s workshop on February 11th, 2021.

Based on the feedback, the following steps were to combine project ideas when applicable and to assess them with the help of the Morgenstadt Project Ranking Tool, which is explained next.

The list of 26 project ideas was reduced to 13 taking into account the evaluation criteria and the requirements of the BMU to fund the pilot project. This chapter presents these 13 project ideas which are believed to have a strong impact on the sustainable development of Saltillo. The list of projects shows a good mixture of topics, and they are based on the existing initiatives in the city as well as the information received during on-site interviews, incorporating features and proposals not discussed in Saltillo so far. The list of projects and descriptions is presented in chapter 4.3. More detailed documentation of each of them can be found in Annex III.

4.1.1 Project Ranking Tool – Selection Criteria

The experts and the city lab team analysed the presented 26 project ideas based on the 11 criteria listed below. The purpose of this analysis was to examine which project ideas have the highest potential to fulfil the needs of Saltillo, as well as satisfy the requirements of the MGI project.

1. **Alignment with city goals:**
Defines whether the project idea aligns with the city strategy, enabling the security of political, institutional and financial support
2. **Stakeholder Engagement:**
Indicates to what extent the stakeholders showed interest in the project idea, based on the onsite interactions (interviews, workshops, meetings)

3. **Replicability potential:**
Indicates whether the proposed measure has the potential to be replicated in other cities, a state and/or national level as well as the knowledge transfer to a broader audience of stakeholders beyond the MGI project partners and stakeholders.

4. **Regulatory Constraints:**
Helps determine whether local regulations could pose a significant risk for project implementation

5**. GHG mitigation potential:**
Signifies the MGI project KPIs; the project ideas must meet the pre-determined GHG mitigation potential until 2030.

6. **Climate change adaptation potential:**
Signifies the MGI project KPIs; the project ideas must meet specific climate change adaptation indicators.

7. **Need for public sector funding support**

8. **Likelihood of securing public funding in support of the project**

9. **The interest of private-sector financial support involvement**

10. **Risk of project approval:**
Indicates the complexity of the project approval process through various levels of government agencies, posing a significant risk for the successful and timely implementation of the project

11. **Risk of project approval:**

Extent of resettlement and rehabilitation issues associated:

Each of the criteria is assigned a weighting, which indicates the relevance of that criterion (see Annex 0). The assessment criteria and the weightings have been derived, considering the criteria used in previous City Labs (e.g. City lab Coimbatore), as well as the KPIs of the MGI project. The criteria have been revised and agreed on by the MGI project partners.

4.1.2 Additional selection criteria for project ideas

Besides the analysis with the project ranking tool, a second step was to consider the requirements of the BMU, as project donor, to fund the pilot project. In this regard, the pilot project is expected to be a tangible intervention rather than studies or development plans. These criteria removed from the selection the following project ideas:

- City densification – 15-minute city
- Strengthening urban development plans and citizen participation
- Strategic alliances between universities, business and government
- Mandatory vehicle verification programme (OBD/RSD)
- Water master plan
- Restriction of car use in the historic centre
- Smart Cities strategies with IoT
- Industrial policy to transform Saltillo into a cluster for IT, artificial intelligence, automation, computing and other industries of the future.
- Mobility study

Despite not being considered as a potential pilot project under the MGI initiative it is recommended to the city further develop and execute these projects in the interest of sustainable and resilient development. The relevance of such studies or actions is quite high as they could represent significant improvements across different areas with a desirable impact. For instance, some of the

project ideas could represent a significant reduction of greenhouse gas emissions with low investment and reduced logistic efforts (e.g. vehicle verification programme).

To conclude this section, it is worth mentioning that the implementation of a single project is hardly sufficient to facilitate an integral sustainable development in Saltillo. Therefore, the commitment and active involvement of key stakeholders should be maintained after the end of the project. The development of a long-term vision would benefit the city to achieve its sustainability goals.

4.2 Roadmap: Strategy and Measures

The strategy roadmap was developed from the analysis and assessment in the first three phases of the project, as depicted in Figure 1 at the beginning of this report. It is a portfolio of projects that aim to address the challenges identified and contribute to achieving a long-term vision in the different sectors. The roadmap is a graphical representation of the projects and depicts the complexity of the relationships between them and other essential instruments in the city, such as master plans or similar measures. The graph illustrates that the implementation of the projects is neither linear nor isolated.

The roadmap in Figure 35 presents the project ideas arranged in a possible implementation time frame, i.e., short and medium-term. At the same time, the projects are organized into three categories. The first category includes projects that involve physical-tangible interventions. These are depicted in the oval-shaped boxes. The second category corresponds to projects of a regulatory nature, such as measures, studies, master plans or events, which are, in some cases, relevant for implementing projects within the first category. The second category is represented by the rectangle-shaped boxes. Third, projects or plans that the city is already developing are depicted in diamond-shaped boxes. A short description of the projects in the first category can be found in Annex III.

The projects located on the left-hand side of the graph are those that, in general terms, can be more easily implemented in a short period. For instance, it is worth mentioning the annual awards for best practices in energy efficiency – a project that, by its nature as a yearly event, can be easily organized, does not require significant initial investments and could bring onboard stakeholders from different sectors to commit to energy efficiency in their daily business. The project itself could be replicated in other areas and with other areas of focus, such as water efficiency, which plays a significant role in Saltillo.

Another example of this type of project is the mandatory vehicle verification program (OBD/RSD6), whose objective is to reduce emissions for in-use vehicles by ensuring that owners provide proper mechanical maintenance to their vehicles. The project itself is easy to implement and could result in a considerable improvement in the air quality of the city by prioritizing safer and less costly methods, such as OBD and RSD for vehicle verification. It would require the support and cooperation of key stakeholders, such as the public transport providers, private car owners and the secretary of mobility of Saltillo, among others.

The projects on the right-hand side of the graph require more time, resources, and infrastructure for their execution. This is the case for the sustainable industrial park, which involves parties from different sectors, addresses diverse matters, such as water and energy efficiency, green mobility and circular economy principles, among others, and therefore requires more time, organization and economic resources for its implementation.

The roadmap serves as a guideline for the city to execute the projects in a timely and articulated manner, thus achieving the long-term visions through interventions that cover the different needs and areas in the city.

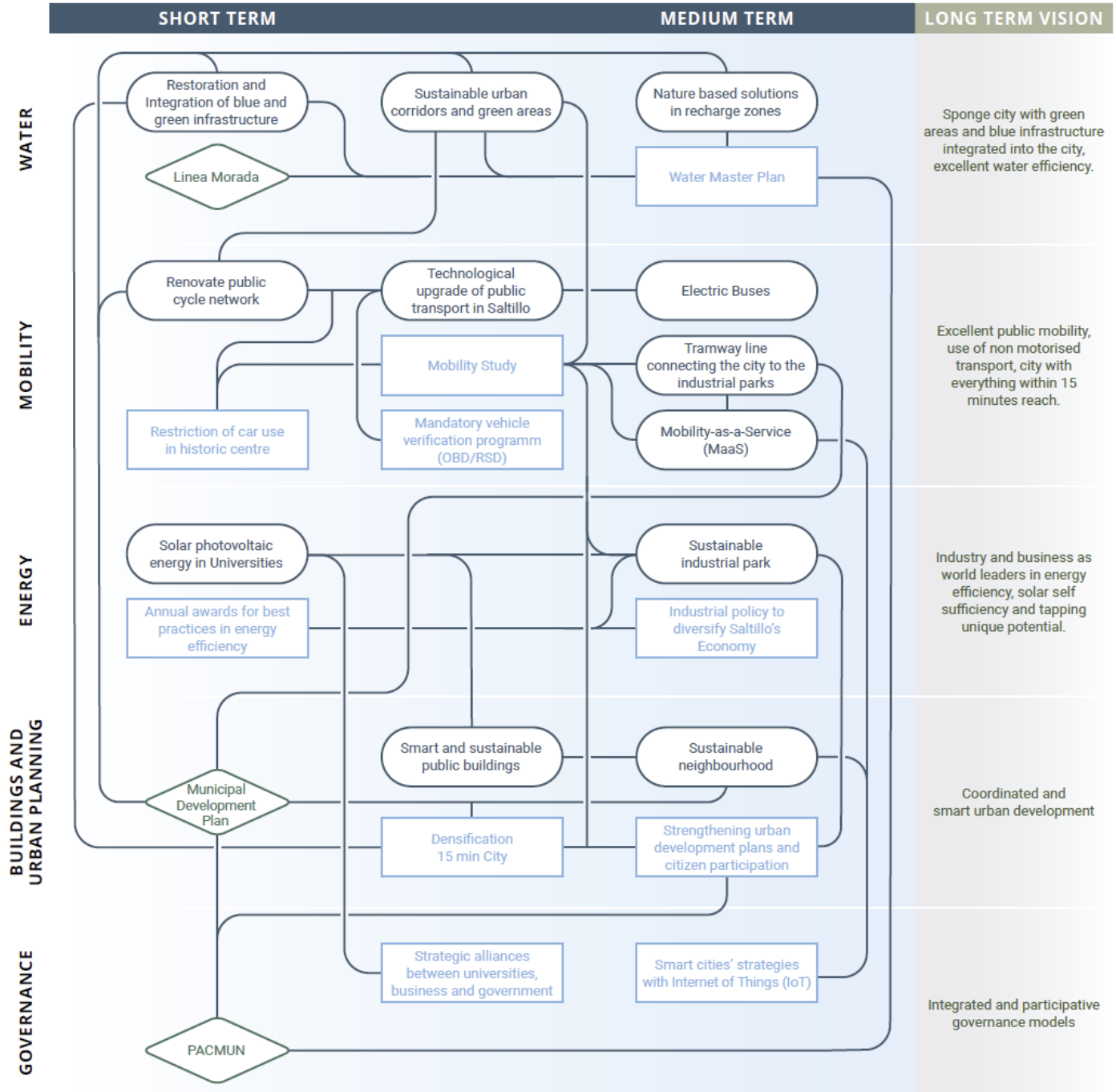


Figure 35: Roadmap

4.3 Suggested measures

This section presents the list of concrete ideas developed within this project to improve the sustainability of the city within the sectors of water, mobility, and energy. These measures were developed based on the challenges identified in each sector, the possible solutions and the long-term sustainability to be achieved. Together with the participation of external stakeholders, two workshops were conducted for co-creating and refining the project measures. Sectoral discussions and voting sessions were held, together with an objective evaluation of the different criteria (e.g., GHG emission reduction potential, climate change adaptation potential, project financial viability, etc.), to identify the most promising ideas. The project ideas presented below are organized according to their score from the assessment with the project ranking tool. More detailed documentation of each of them can be found in Annex III.

Energy Efficiency, Renewable Energy and Sustainable Water Use Awards
Achieving substantial reductions in energy use and GHG emissions requires the active involvement of the industrial and commercial sectors that, compared to the national average, are overrepresented in Coahuila and Saltillo. However, regulation of the energy and industrial sector is largely in hands of the national government. The municipality still has an opportunity to contribute to sustainable development in these sectors through awareness-raising events. A well-known practice is the hosting of sustainability awards. These awards could be given to best practices in, e.g., energy-efficiency improvements, renewable energy integration or sustainable water use. The awards can have different criteria (e.g., greatest absolute impact, greatest relative impact, most innovative, etc.) and different participant categories (very large, large, medium, and small industrial users, commercial users, public users, etc.). Awards should be given in such a way that visibility is maximized to encourage best practices across the pertinent user groups. These kinds of awards are carried out in other countries and regions and have shown to be very impactful at low costs. Notable examples are the German energy-efficiency awards of the German Energy Agency or the ASEAN sustainability awards of the ASEAN Centre for Energy.

Sustainable Urban Corridors and Green Areas
This project aims to implement diverse and native green infrastructure (such as xeriscape gardens, trees, green rooftops, etc.) within a strategic corridor to achieve multiple environmental, social and economic benefits. The main expected impact is the improvement of the drainage system through a so-called SUDS, which is achieved by the capacity of vegetation to retain and absorb water and allow it to infiltrate the soil. The envisioned corridor would also encourage walking and cycling by offering an attractive green street with an improved microclimate through shading and evapotranspiration from the vegetation. As the number of people moving by foot or bike increases, the number of people moving by car is expected to decrease, along with the related CO_2 emissions. A further decrease in emissions is expected to be achieved through the lower need for air conditioning, as green infrastructure can decrease the UHI effect.

Restoration and Integration of Blue and Green Infrastructure
This project aims to restore a section of one of the main creeks in Saltillo so that its fluvial capacity is restored, while also converting the riverbank into a recreational area that offers environmental, social and even economic benefits. The main expected impact is an improvement to the drainage system, not only from the recovered fluvial capacity of the creek but also through a so-called SUDS. The latter is achieved by the capacity of vegetation to retain and absorb water and allow it to infiltrate the soil. When implemented on a larger scale, this green infrastructure can be analogically viewed as a vast sponge that can significantly improve the capacity of the city to avoid flooding events while also offering multi-sectorial benefits.

Smart and Sustainable Buildings
With the current climate challenges, it is necessary to have adequate technologies for the efficient generation and use of water and energy resources. This project aims to install different technologies and identify best practices to be implemented and tested in a public building for the sustainable use

of water and energy, emphasizing off-grid solutions and monitoring and control instruments. In addition, these buildings will promote sustainable development models for the city that can be used as urban living labs. The plan would be to use public buildings in a pilot project.

Sustainable Neighbourhood

Creating a sustainable neighbourhood in Saltillo aims to reduce water and energy consumption, reduce the heat island effect, and mitigate floods. This can be achieved through the implementation of best water and energy management practices, green technologies and ecotechnologies. The initiative includes green walls and roofs, rainwater harvesting, collection systems, solar energy generation, implementation of technologies for the treatment and reuse of wastewater (for garden irrigation) as well as adapting green spaces with green infrastructure (rain gardens) or functional recreational areas (to reduce the effects of heat islands).

Renovation of the Public Cycle Network

Although Saltillo has a public cycle network, the external perception is that it has not been adequately promoted or properly planned. This is due to the perception of insecurity in the population when it comes to using this means of mobility. On the other hand, in other cities in Mexico, such as Mexico City, Guadalajara, as well as in Latin America, these systems have been successful due to their properly defined implementation, scope and use. Therefore, a renewal of the existing system in the city is proposed so that it operates solidly, consolidating the formation of an integrated public system using various modes of transport. The cycle network should be inclusive, with the citizens being the primary beneficiaries.

Nature-Based Solutions in Recharge Zones

Hydrological basins have elements of vegetation and soil in their ecosystems that promote hydrological environmental capabilities. The soil fulfils the functions of storage and filtration of water and influences the quality and recharging of aquifers. The vegetation in the hydrological cycle, on the other hand, intercepts and retains the rain, allowing it to infiltrate the soil through its roots, thus opening the pores in the soil. Vegetation, water and soil must be conserved and managed to ensure their ecological functionality in the natural recharge zones. This proposal aims to implement conservation and rehabilitation strategies for natural recharge sites, namely the Sierra de Zapalinamé, and create priority infiltration zones through the implementation of NBS. The proposal seeks to contribute to the re-charging of aquifers, reduce the erosive water processes that cause sediment dragging, reduce runoff speed and reduce the maximum flows that can cause flooding in the low-lying areas of the region. In addition, carrying out this type of project is expected to improve the area's environmental, social, and landscape conditions or the natural reserves. This project will help achieve the goal of Saltillo to become a sponge city. It will contribute to the recharging of aquifers and compensate for the pressure of water stress in the region.

Tramway Line Connecting the City with the Industrial Parks

Saltillo's mobility requirements are largely determined by the individual transportation of its workforce to its 40 industrial parks and numerous other industrial facilities. After the industrial sector, the mobility sector is one of the most energy-consuming and GHG-emitting sectors, both in Saltillo as well as in the whole of Mexico. Achieving substantial emission re- ductions in the transport sector will require the expansion of public mobility services and the provision of infrastructure for non-motorized transport (e.g., pedestrian and bicycle lanes), as well as a technological transformation away from internal combustion vehicles. Among the most promising technological options is the electrification of mobility, which would allow vehicles to be powered by (low carbon) electricity and thereby reduce emissions. A tramway line would substantially expand public mobility by offering a huge transportation alternative between the city of Saltillo and its industrial parks. The tramway would be powered by electricity, enabling effective decarbonization of Mexico's economy by coupling the electricity sector with the transportation sector. Such a project implies a massive infrastructural investment and thus could only be realized in the medium to long term.

Mobility-as-a-Service (MaaS)

Mobility-as-a-Service (MaaS) combines the different current mobility trends with the public transport offer without considering a dependence on the private vehicle. This establishes a challenge

and opportunity for the evolution of traditional mobility services and actors in the city, representing an opportunity for new ideas and participants. In Latin America, there are several providers of this service in the main cities on the continent that have demonstrated success in the results obtained using these platforms. The implementation of MaaS is a global trend that transforms mobility through technological innovation. This new way of thinking of transport and new methods of collaboration is fundamental for guaranteeing a continuous urban flow using more efficient alternative modes of transport. MaaS is based on the connectivity, access and affordability of the different transport options present in the region of interest.

Sustainable Industrial Park

To a large extent, Saltillo's manufacturing industry is located in its approximately 40 industrial parks in the metropolitan area and beyond. A single large industrial company might consume as much energy as 40 thousand households. The clustering of industrial companies in physical proximity to each other provides an opportunity to improve the sustainability profile of Saltillo's industry by addressing industrial parks as organizational units. The decarbonization of industrial parks by implementing best-in-class energy-efficiency measures and renewable energy self-supply, in particular solar PV, offers great potential for reducing energy consumption and GHG emissions while improving industrial competitiveness. Indeed, many energy-efficiency measures in Saltillo have reportedly paid off within short periods (a few months) by amortizing investments with cost savings in energy expenditures. Additionally, solar PV equipment has seen substantial cost reductions in recent years, and the vast solar radiation potential in Coahuila makes self-supply a viable option. As mentioned, Mexico has the potential to achieve very low prices for solar PV electricity, as demonstrated during the third round of auctions for clean energy in 2017. The decarbonization of a pilot industrial park could serve as a showcase for tangible sustainability options and enable the project to be replicated in other industrial parks. In this way, Saltillo could become the heart of the transition towards a low-carbon economy in the industrial sector, becoming a first-mover nationally and an example for Latin America and the world.

Solar Photovoltaic Energy in Universities as a Real Laboratory

Saltillo has numerous universities, four of which explicitly offer sustainable energy as a study track. Although solar PV and wind energy are technically mature and can already compete with fossil fuel-based electricity alternatives, the main challenge hindering their implementation is often variability in supply. Solar PV depends on radiation conditions, while wind energy depends on available wind resources. This project proposes using universities as laboratories with high expertise in achieving a balance between supply and demand. Thus, the proposal is to install solar PV panels at universities for real-life investigations of supply patterns, storage opportunities and flexibilization of demand. Universities could become solution providers for industrial, commercial and residential users in Saltillo and thus be crucial actors in enabling the transformation towards a low-carbon energy system.

Technological Update of Public Transport in Saltillo

Saltillo's current bus fleet is technologically obsolete with high energy consumption and GHG emission release while offering poor quality for its users. The policy for modernizing public transport is based on technical instrumentation to improve performance indicators and user perceptions. These renewed systems must include information technology and the permanent monitoring of all units that meet current emissions standards. The main impacts include the reduction of pollutants, GHGs, noise and traffic and should be more efficient than the traditional services. For the development of these initiatives, government support is essential and should focus on the user: improving quality, various mobility options, integrated fares, exclusive-use lanes and modern and adequate infrastructure.

Electric Buses

The electrification of the mobility sector offers a tangible opportunity for decarbonizing the transport sector. Electric vehicles are already being used for urban transportation in leading Asian and European cities, despite the high initial cost of implementing this technology. There are several car manufacturers worldwide who are interested in promoting its application. The operating environment must be analyzed based on

energy consumption during the actual operation of traditional buses to ensure that the proposed fleet meets actual demand due to the autonomy of electric vehicles. In addition, a feasibility analysis is required for the proposal of various scenarios of a pilot project on specific routes. Economic efficiency analyses must be subsequently conducted to measure the benefits of this project.

Results in other cities and countries show economic benefits after five years of implementation. The city of Saltillo would benefit significantly from this type of infrastructure by getting more of its citizens to use the public transport system.

5 Outlook

This City Profile report presents the results of the City Lab Saltillo as one of three pilot cities within the Morgenstadt Global Initiative project. It describes the status quo of Saltillo concerning its sustainability performance in the mobility, energy and water sectors, presenting the most salient challenges, solutions and a sustainability vision for each of them. Furthermore, it presents a list of concrete project ideas developed for the city of Saltillo or other interested stakeholders to develop and move towards the defined sustainability vision.

The integrated analysis, the evaluation of challenges and potential for improvement in each sector, and the list of 15 concrete project measures to improve the sustainability of the sectors of scope was developed based on the holistic Morgenstadt City Lab methodology. This methodology is based on quantitative and qualitative methods, with a focus on the participation of local stakeholders from the public, private and academic sectors through expert interviews and workshops. This co-creation and participative approach ensure tailored solutions and a high degree of local ownership. As the capital city of the state of Coahuila de Zaragoza, Saltillo has the potential to become a role model for sustainable development for other cities in the region.

In the **water sector**, the city can tackle water scarcity and flooding events by integrating green and blue infrastructure into the urban space, improving the city's soil permeability and the recharging of already overexploited aquifers through creating a sponge city effect.

In the **mobility sector**, the city can reduce the use of individual transportation and traffic congestion by substantially improving public mobility services and developing infrastructure for non-motorized transportation. Integrating urban and mobility planning would provide a great opportunity for densifying the city and designing it in such a way that the basic needs of the citizens are within easy reach, without the need for extensive travel.

In the **energy sector**, the city can self-supply its electricity requirements by developing solar PVs. Coahuila is considered a region with an excellent solar radiation potential, and its abundant solar resources make solar electricity a feasible and viable alternative. In one of Mexico's most industrialized zones, improving energy efficiency is a great opportunity to not only reduce energy use and GHG emissions of industries, households and commerce, but also to reduce costs, improve industrial and business competitiveness, improve air quality and create employment opportunities, among many other co-benefits that can be harvested at local level.

Saltillo has already begun tackling the sustainable development challenges faced by salient mid-size urban settlements of the Global South. The city has issued an Environmental Agenda, highlighting its interest in and commitment to improving the sustainability of its urban environment. It has also begun implementing sustainable projects, such as the use of landfills for electricity generation, the public lighting and buildings efficiency program, as well as a public bicycle network, among others. Key stakeholders in the public, private and academic sectors, who actively contributed to this project, also highlighted the extraordinary commitment of Saltillo's society to sustainable development.

Nevertheless, achieving the sectorial sustainability visions developed in this project and beyond will require a long-term commitment to sustainable development. As the first step in this direction, Saltillo has anchored the results of this project into official planning documents, such as its Urban Development Plan and the Municipal Climate Action Plan PACMUN. Indeed, institutionally anchoring sustainable development and defining clear future targets is considered the way forward to cope with the challenge of continuity in the face of changing governments. Additionally, it will be crucial for the city to allocate financial resources for implementing sustainable development projects. It is also essential that the city defines its monitoring schemes for improved sustainable urban development and decision-making. Two prioritized project measures from the suggested roadmap in this report, 1) the energy efficiency awards, and 2) the integration of green and blue infrastructure to the urban environment are already on their way to being implemented. The project measures are and are currently being analysed in terms of their technical and financial components, feasibility, and corresponding climate change mitigation and adaptation impacts. Further projects on the list of project ideas and the roadmap developed in this project offer great potential for fostering the transformation of Saltillo into a sustainable city of the future.

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7 Annex

I. List of Interviews

No.	Organization
Onsite Interviews	
1	IMPLAN
2	UAdeC Dirección de Investigación y Postgrado
3	San Lorenzo
4	Planta Tratadora de Aguas Residuales (PTAR)
5	COPERES (Consejo para la Planeación Estratégica a Largo Plazo de la Región Sureste del Estado de Coahuila de Zaragoza)
6	Consejo Ciudadano Agenda Ambiental
7	Dirección de Medio Ambiente y Espacios Publicos
8	Secretaria de Medio Ambiente. Subdireccion de Cambio Climatico, energia, calidad de aire, RETC)
9	Comisión Estatal de Aguas y Saneamiento (CEAS)
10	Aguas de Saltillo (AGSAL)
11	CANACINTRA
12	Secretaria de Medio Ambiente.
13	PROFAUNA
14	COPARMEX
15	Sierra de Zapaliname

16	UAdeC
17	Consultora de las emisiones del aire
18	Parque Industrial Alianza
19	Desarrollo Urbano
20	Tecnologico de Saltillo
21	Bouss Energy
22	UAdeeC
23	Secretaria de Economía
24	UTS
25	Cluster de Energia
26	Recursos Tecnologicos Mundiales
27	ULSA
28	COECYT
29	Universidad Carolina
30	Aggregatum Solar
31	UTC
32	Salud Pública
33	Instituto Municipal de Transporte
34	Instituto Municipal de Transporte
35	UAdeC

36	Rueda Limpio
37	Universidad Carolina
38	Consejo Ciudadano de Convivencia y Movilidad Sustentable (CCCMS)
39	Secretaria de Transporte y Movilidad
40	UAdeC
41	Comisión (cabildo)
42	Gas Natural Industrial
43	E-Drive
Climate risk and resilience interviews	
44	Instituto Municipal de Planeación de Saltillo (IMPLAN)

II. Climate risk and resilience expert survey response values

The climate change risk and resilience assessment for Saltillo followed the below-mentioned framework (See Figure 36). 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.

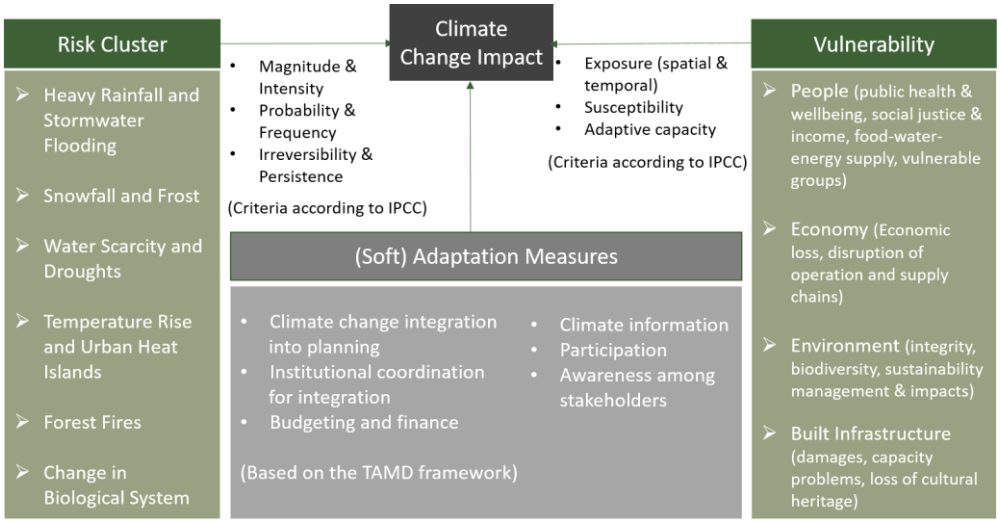


Figure 36: Risk and resilience assessment framework

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 how likely and often a hazard will occur.

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

Exposure (temporal & 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).

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 latter was conducted by 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 focus 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 IMPLAN experts conducted in May and June 2021.

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%

Table 7: Heavy Rainfall and Stormwater Flooding

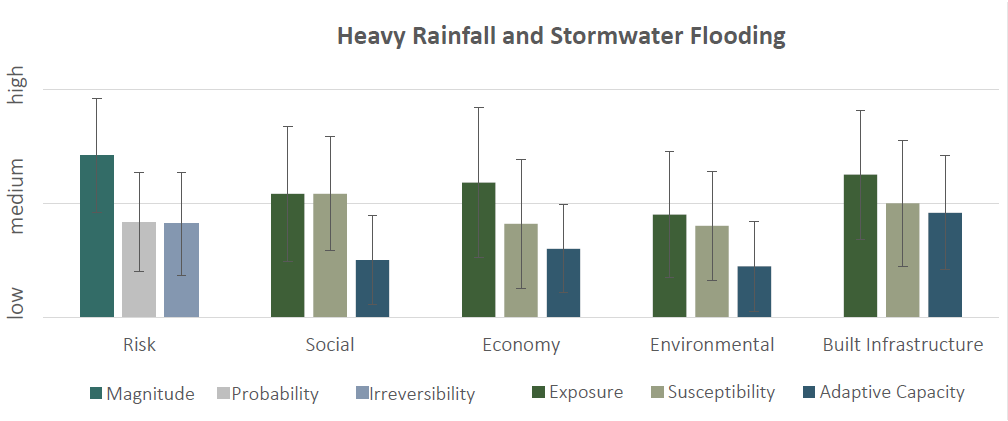


Figure 37: Expert evaluation for the risk cluster "heavy rainfall and stormwater flooding" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental and built systems in the city. Survey results with 12 participants from different local institutions and city lab on-site experts. Standard deviation is shown as black bars.

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%

Table 8: Temperature Rise and Urban Heat Island

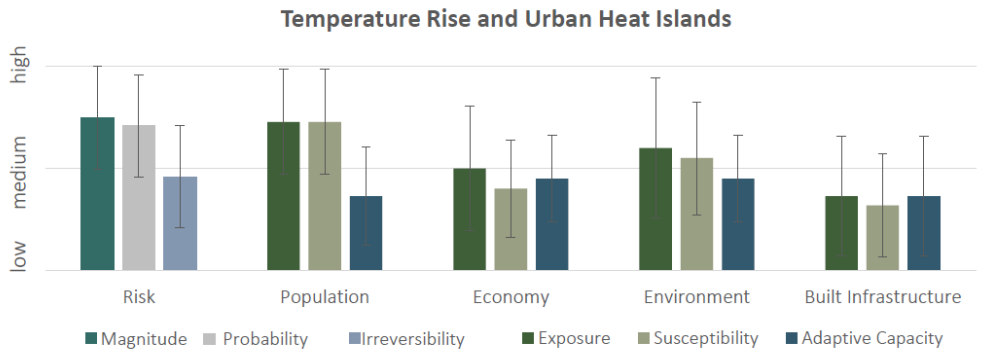


Figure 38: Expert evaluation for the risk cluster "Temperature Rise and Urban Heat Islands" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental and built systems in the city. Survey results with 12 participants from different local institutions and city lab on-site experts. Standard deviation is shown as black bars.

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%

Table 9: Water Scarcity and Droughts

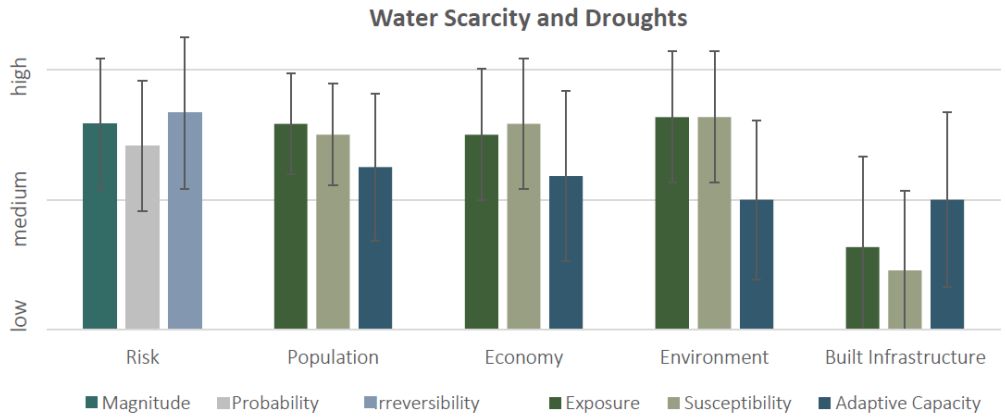


Figure 39: Expert evaluation for the risk cluster "Water Scarcity and Droughts" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental and built systems in the city. Survey results with 12 participants from different local institutions and city lab on-site experts. Standard deviation is shown as black bars.

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%

Table 10: Forest Fires

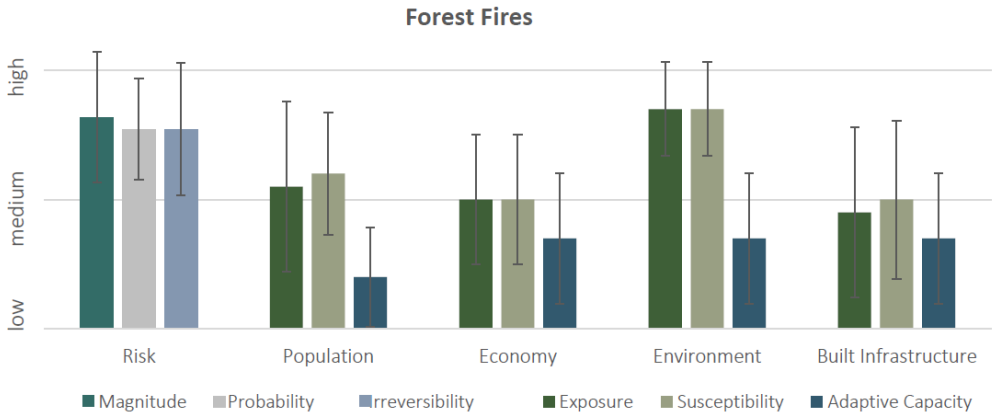


Figure 40: Expert evaluation for the risk cluster "Forest Fires" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental and built systems in the city. Survey results with 12 participants from different local institutions and city lab on-site experts. Standard deviation is shown as black bars.

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%

Table 11: Snowfall and Frost

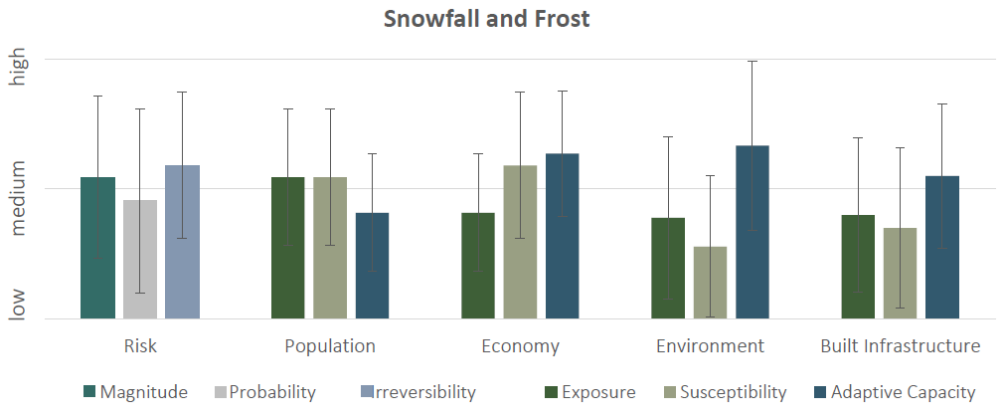


Figure 41: Expert evaluation for the risk cluster "Snowfall and Frost" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental and built systems in the city. Survey results with 12 participants from different local institutions and city lab on-site experts. Standard deviation is shown as black bars.

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%

Table 12: Changes in the Biological System

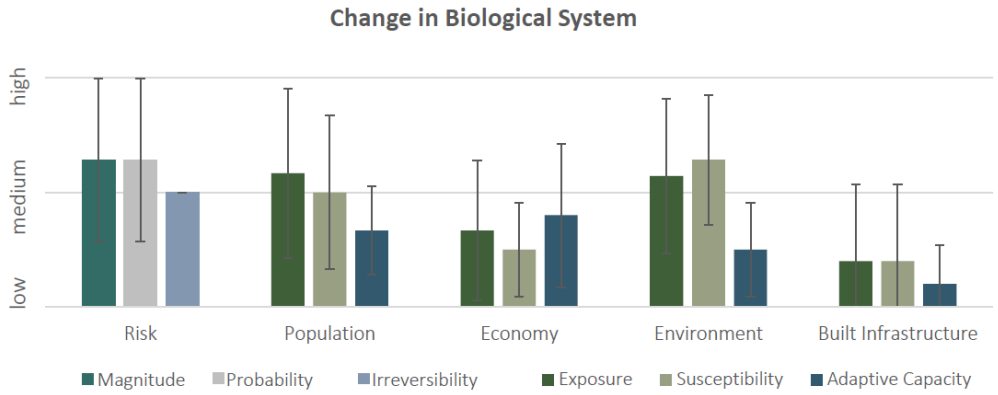


Figure 42: Expert evaluation for the risk cluster "Change in Biological System" for the city of Saltillo, including general risk factors and the vulnerability of the social, economic, environmental and built systems in the city. Survey results with 12 participants from different local institutions and city lab on-site experts. Standard deviation is shown as black bars.

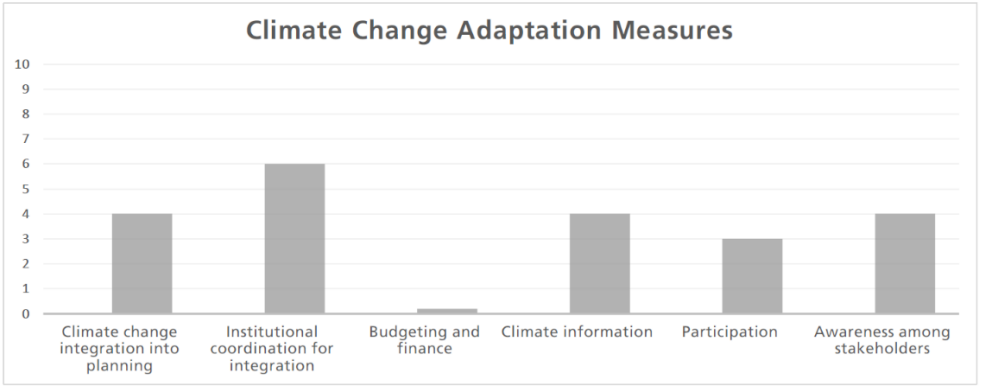


Figure 43: Climate change adaptation assessment according to the TAMD framework (iied 2014). Each indicator consists of 3 to 5 questions, which amount to a maximum score of 10.

III. Detailed Project Ideas

Annual awards for best practices in energy efficiency

The annual awards for best practices in energy efficiency has the main objective of recognize organizations and companies that demonstrate remarkable commitment to achieve best practices in energy efficiency. This initiative has a not significant initial investment and foster the implementation of energy efficiency measures among diverse and wide range of stakeholders within the commercial and industrial sector of Saltillo. The recognition allows to demonstrate the economic, social, and environmental benefits of energy efficiency and promotes the replication of good practices in companies with similar processes and infrastructure. This project requires a team that design the rules and categories of participation, as well as create and coordinate an evaluation system to define the winners by category.

Objectives

Recognize organizations and companies that demonstrate remarkable commitment to achieve best practices in energy efficiency.
Foster the implementation of energy efficiency measures in industry and commerce in Saltillo.
Exhibit economic, social, and environmental benefits of energy efficiency

Description

This initiative proposes to recognize organizations and companies that demonstrate their commitment for reducing energy consumption, through the implementation of energy efficiency measures in their processes and infrastructure. The recognition is an annual award for best practices in energy efficiency that includes diverse categories. This is a flexible project that includes not only organizations within the Saltillo city but also companies located in the Coahuila state. The annual awards are an alternative to foster the implementation of energy efficiency measures demonstrating their economic, social, and environmental benefits, which can be replicable among diverse stakeholders.

Alignment with city goals

Medium

The Saltillo municipality has already implemented initiatives to reduce the energy consumption in buildings, and this project converge with these initiatives.

Key project outputs

The outputs and benefits of the project could be the following:

- The project requires a low initial investment
- The initiative can help to accelerate the reduction of the energy consumption in Saltillo

A wide spectrum of stakeholders can be motivated to implement energy efficiency measures.

Minimum feasibility/Conditions

The project requires the political will to formalize the program and a clear and detailed description of the participation rules and award.

Replicability potential

High

This project could be replicable among a wide range of stakeholders, once the economic, social, and environmental benefits be demonstrated.

Impact

GHG Emission reduction potential

High

Energy efficiency is, next to the development of renewable energies, a key strategy to reduce CO_2 emissions. This project contributes with the reduction of GHG emissions due to the improvement of energy efficiency and the reduction of the energy consumption of the industry sector. With Saltillo characterized by the existence of very large industrial users, the impact of this project will crucially depend on the participation of these and other large industries involved.

Climate change adaptation potential

Low

The adaptation is not the focus of this solution.

Extent of resettlement and rehabilitation issues

Low

The main goal of the project does not impact the resettlement and rehabilitation issues.

List of stakeholders

- Private consultants
- Commerce
- Industry
- IMPLAN

Engagement

High

Universities have the willingness to cooperate in projects that promotes the sustainability in the city, and four of them have the building capacity through their environmental programs to implement this solution.

Target groups

Energy leaders of private companies from the commercial and industrial sector.

Persons reached

All people interested in learning about best practices in energy efficiency.

Regulatory constraints, risks, and barriers

Regulatory constraints

Low

There are not restrictions for the implementation of this initiative

Risk of project approval

Low

The project does not interfere with the city goals and is attractive for the municipality

Other barriers and risks

-

Project Financials

The proposed project intends to institute an award. Therefore, a corpus of fund is needed to be formed to provide annual awards from the fund.

Quantification possible at this stage? ***No***

Need for public sector funding support

Low

In principle, a wide range of actors could sponsor/finance the Awards. The proposed project idea will not need funds from public sector.

Likelihood of securing public funding in support of the project

High

Not applicable (in principle there will not be any need for public funding as such)

Interest of private sector financial support involvement

High

It is expected that the private sector will be willing and able to contribute to the corpus of fund for the award.

Cost Benefit Analysis

The proposed pilot project proposes to institute an award to recognize high achievement in the area of implementation of energy efficiency improvement measures in industrial establishments).

The central value of the project consists of promoting good energy efficiency practices as a mechanism for reducing energy consumption in the industrial and commercial sector, directly and indirectly impacting the reduction of greenhouse gases.

Costs:

- One time cost to raise funding for award (to form a corpus of fund).
- Operation costs (audits, evaluation of winners, etc.)

Social Benefits:

- Lower energy consumption and lower level of GHG emissions
- Make visible and disseminate good practices to be replicated in energy efficiency issues.
- It reduces the economic expenses associated with energy consumption in the commercial and industrial sector.
- The project's impact area may extend to the outskirts of the city of Saltillo
- Does not require a significant initial investment

Quantification possible at this stage? ***No***

Investment Plan

The proposed project is expected to be funded out of private sector donors.
It is expected that private sector investors to fund up to 100% of the cost of the project.

Quantification possible at this stage? ***No***

Major Assumptions

- Not Applicable

Envisaged Activities and Technologies

Envisaged Activities	Timeframe
Design of the energy efficiency best practices program.	4 months
Dissemination and outreach to stakeholders to motivate their participation.	4 months
Opening of the system for receiving proposals	2 months
Evaluation of participating proposals	1 month
Preparation of award ceremony	1 month
Award ceremony	1 day

Preconditions
Political will

Technologies/Products
Not required

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
Energy	Total energy use per capita	< 12000 kwh Per person per year	Implementation of LEAP model https://leap.sei.org/
Energy	CO_2 emissions per capita	3.7 tons CO_2 per person	Emission factor methodology https://www.ipcc-nggip.iges.or.jp/EFDB/main.php

Sustainable Urban Corridors and Green Areas

This project aims to implement diverse and native green infrastructure (such as xeriscape gardens, trees, green rooftops, etc.) within a strategic corridor, to achieve multiple environmental, social and economic benefits. The main impact for the water sector is the improvement of the drainage system, through a so-called sustainable urban drainage system (SUDS), which is achieved by the capacity of vegetation to retain, absorb and infiltrate water. When implemented at a big scale, this green infrastructure could be analogically seen as a huge sponge, which can notoriously improve the capacity of a city to avoid flooding events while also offering multi-sectorial benefits.

The envisioned corridor would also foster walkability and bicycling, by offering an attractive green street with an improved microclimate through shading and evapotranspiration from the vegetation. As the number of people moving by foot and/or bike increases, the number of people moving by car is expected to decrease, along with their related CO_2 emissions. A further decrease of emissions is expected to be achieved from the lower need of air conditioning, as green infrastructure has the capacity of decreasing the Urban Heat Island (UHI) effect.

Objectives

Design and implement a green corridor which can successfully achieve the expected benefits and will contribute to the city's vision of being a sustainable city. The success of the project will be measured through a series of indicators that are expected to show positive changes in the water, mobility, environmental, and even economic sector. To fulfil the objective is important the selection of adequate spaces and vegetation, mainly native species which will require relatively low amounts of irrigation water. The main goal from the water sector perspective is to achieve a sponge city effect through the vegetation that would act as sustainable urban drainage system.

Description

The idea is to implement diverse and native green infrastructure (such as xeriscape gardens, trees, green rooftops, etc.) within strategic pedestrian streets to achieve multiple environmental, social and economic benefits. Ideally, some extra elements such as bike lanes, surveillance cameras or reclaimed water can be added, but their implementation requires the support of third parties. Particularly interesting for the water sector would be to use reclaimed water for irrigation, as the benefits of higher infiltration rate can be surpassed by the drinking water usage for irrigation. Even though the vegetation to be implemented would be native, with low water requirements, the opportunity to use reclaimed water and build a more resilient system following a circular economy model should be considered. Water-intensive vegetation could also be considered, as long as it is located in a strategic area where the major number of people can be benefitted from it.

The main impact for the water sector is the improvement of the drainage system, through a so-called sustainable urban drainage system (SUDS), which is achieved by the capacity of vegetation (even low water-retaining plants) to retain, absorb, and infiltrate water. When implemented at a big scale, this green infrastructure could be analogically seen as a huge sponge, which can notoriously improve the capacity of a city to avoid surface runoff and flooding events. To a lesser extent, it would contribute to decrease the municipality's water shortage, because even though the percentage of rain that would infiltrate the aquifer can be considerably increased, the limiting factor is the low annual rainfall.

Within the social impacts, there are multiple health impacts attributable to the integration of natural elements within the urban environment. In addition, the stress of vehicular traffic can be avoided for those who decide to take advantage of the corridors, either by walking or cycling. Not less important is the potential to reduce crime in neighbourhoods where these types of corridors are to be implemented, as there will be greater attendance and ideally greater police presence (including surveillance cameras and environmental police).

The envisioned corridor would foster walkability and bicycling, by offering an attractive green street with an improved microclimate through shading and evapotranspiration from the vegetation, as well as an improved air quality. This has social and environmental benefits, as the number of people moving by foot and/or bike increases (improving health), and the number of people moving by motorized vehicles is expected to decrease, along with their related CO_2 emissions. A further decrease of emissions is expected to be achieved from the lower need of air conditioning, as green infrastructure has the capacity of decreasing the urban heat island (UHI) effect considerably.

An increased coverage of green areas in the city will positively influence life quality, as they will perceive a nicer and more natural environment. Besides, an adequate amount of green areas in an urban context helps to improve air quality

by increasing humidity, and filtering pollutants and dust. Moreover, implementing this type of nature-based solutions (NBS), allows increasing biodiversity, as it provides food and shelter to many species.

Finally, the local economy would benefit from having a greater flow of customers. By replicating and expanding the project, work hours lost due to traffic congestion can also be importantly reduced.

Alignment with city goals

Full

There is a need to create green corridors, linear parks, and green rings, taking advantage of streams, associating nature spaces in the city with periurban and rural natural spaces, favouring their use by citizens is aligned with the municipal urban development plan 2020.
The Environmental Agenda proposes the conservation and restoration of green areas.

Key project outputs

The project focuses on the following points:
One of the main environmental impacts that the project would have would be on the pluvial drainage system to prevent flooding events. Another problem strongly attacked would be that of CO_2 emissions and air quality. To a lesser extent, it would contribute to decrease the municipality's water shortage, because even though the percentage of rain that would infiltrate the aquifer can be considerably increased, the limiting factor is the low annual rainfall.

Within the social impacts, there are multiple health impacts attributable to the integration of natural elements within the urban environment. In addition, the stress of vehicular traffic can be avoided for those who decide to take advantage of the corridors, either walking or cycling. No less important is the potential to reduce crime in neighbourhoods where these types of corridors are implemented, as there will be greater attendance and ideally greater police presence (including environmental police).

Finally, the local economy would benefit from having a greater flow of customers. By replicating and expanding the project, work hours lost due to traffic congestion can also be reduced.

In summary, the impacted indicators are:

- Urban storm drainage coverage
- Water security
- Sustainability
- % Of treated water reuse * (ideally)

The impacted actions fields are:

- Flood protection
- Active implementation of green infrastructure
- Urban regeneration through the greening of public space
- Pollution control and improvement of urban water and air quality
- Reduction of heat stress and improvement of health
- Management of the urban water cycle
- Smart and resilient infrastructure in the urban water system

The considered impact factors are:

- City located in semi-arid region
- Insufficient sustainability awareness
- Air pollution
- Drop in aquifer levels
- High vulnerability to climate change

Location

Strategically selected street(s) to benefit the greatest number of people.
For the pilot project, which will probably have a limited budget, it is reasonable to select a small area that could benefit the higher number of people. A location showing those characteristics might be found in the city center or nearby areas.

Street's redesign might be required as such corridors are currently not common. An option is to modify an existing conventional street with car lanes, by eliminating one or both lanes so that it is only a one-way street or even better, a street without access to motorized vehicles. By doing so, the space for implementing the pedestrian/bike lanes will be notoriously increased.

Minimum feasibility/Conditions

- An important condition is to consider and fulfill the needs, concerns and recommendations of civil society and integrate different perspectives.
- To have a more robust system with a greater number of benefits, it is recommendable to have a diversification of vegetative species, for instance by limiting the percentage of one species to 5%.
- It is also important that the area designated for green infrastructure is carefully determined to ensure that the benefits are obtained.
- It must also have a department in charge of the care of public space and the safety of citizens.
- A bicycle lane and points to park bicycles and areas that facilitate the temporary stop of cyclists.
- Finally, it is important that there are enough benches and trashcans (ideally one for each type of waste stream to encourage recycling).
- Ideally, the pedestrian and/or biking lanes will be constructed with permeable pavement

It is recommended to have:

- Air quality measurement stations to allow monitoring of the effects of the project.
- Surveillance cameras and help buttons.
- Points to rent bicycles.
- Ornamental fountains to contribute to the urban landscape and to improve the microclimate (or better yet, small ponds if possible)
- Endemic vegetation with low water requirements. In addition, there is the possibility of taking advantage of the GBU WWTP's treated water for the maintenance of green areas.
- A prohibition or a significant limitation on car access.
- WIFI connection points

It could have:

- A space for environmental education. In addition, this space can include photos and texts describing the floods that have already affected the city in the past, with the purpose of serving as a reminder of the impacts that climate change can bring and, therefore, of the importance of a more responsible lifestyle with the environment and society. One could also include the issue of streams that are currently neglected and make a comparison with cities where streams have been integrated into the urban environment.
- Waste collection centers to encourage recycling.
- Vertical gardens
- Public lighting with solar panels.
- Small workshops for basic bicycle repair / maintenance
- A Citizen Council in charge of making the link between civil society and the municipality with respect to the urban corridor.

Replicability potential

High

As part of the Environmental Agenda, the city and the IMPLAN promoted the largest reforestation campaign carried out in different areas of the city. The program Mi plaza, mi casa (My square, my house) improved the conditions of public spaces.

Impact

GHG Emission reduction potential

Medium

The heat island effect can lead to high temperatures in urban centers. With increasing standard of living, air conditioners for climatization become more important, representing a large share of electricity consumption in the residential, commercial and public buildings. Vegetation integrated to the urban environment can substantially lower the heat island effect, and thus reduce electricity demand for climatization substantially, thereby considerably reducing CO_2 emissions from electricity generation. However, a substantial greening of the city will be necessary for a temperature decrease to be noticeable.

Climate change adaptation potential

High

The potential is high as green infrastructure will contribute to build a resilient city that is better prepared to avoid floods. In addition, it could slightly contribute to reducing the water shortage in Saltillo, which is currently critical, as the percentage of permeable area would be increased, and with it the percentage of water infiltrated into the aquifers would be increased.

If implemented successfully, the reduction in CO_2 emissions can also be noticeable by reducing the need to use cars and by reducing the local temperature, which in turn, reduces the use of air conditioning. At the long term, CO_2 reduction will also be achieved through vegetative CO_2 sequestration.

Extent of resettlement and rehabilitation issues

Low

The spaces to be intervened are multiple, therefore there are no resettlement issues foreseen. For instance, examples of suitable locations are the Sierra de Zapalinamé, a protected natural area, as well as the green areas determined in the urban planning.

List of stakeholders

- IMPLAN: Coordination of the project at the local level. Proposals for areas with implementation potential. Facilitate the development of the vegetation portfolio to be implemented.
- Department of Environment and Urban Spaces: Relevant permits
- Civil Society: Approval and recommendations mainly from the neighbors in the area where the project would be implemented.
- Urban Development Department: Relevant permits.
- Environmental Police: Supervision and care of the corridor.

Engagement

High

Citizen participation in reforestation and green area recovery campaigns is high. More than 10,000 people have participated in the mega reforestation.

Target groups

The locals will be the most benefitted from this project as they will acquire a new recreational space, while obtaining a major cover of green spaces and increasing their capabilities to move without motorized vehicles. Further on, the risk of being affected by flooding events or heat waves is expected to be significantly reduced.

Regulatory constraints, risks, and barriers

Regulatory constraints

Medium

Some urban spaces that could be intervened, such as vacant lots, cannot be used due to their legal status. However, this can be solved by taking advantage of the spaces designated by the urban development plan, which have the use of land permit assigned for green areas and urban recreation.

Risk of project approval

Low

As this is an activity that is already being carried out by the administration, the project has a good chance of being approved.

Other barriers and risks

An important possible barrier would be the disapproval of the neighbors, as civil society has the capacity of preventing projects to be developed (this happened in Mexico City with the proposed Chapultepec Green Corridor)

Another risk is that an adequate balance between low water-retaining plants and high water-retaining plants is not met, and thus, obtaining a deficient “sponge city effect”.

Additionally, the risk of people misusing these spaces (e.g. vandalism) should be considered and mitigated by implementing sufficient police surveillance.

Project Financials

Approx. costs of the project

Total CAPEX will be estimated based on the Project Design Document Cost of the project is estimated as follows:

Capital Expenses (CAPEX) components
Cost Heads
Land
Construction (Building)
Road Construction (Pedastarian / Bicycle track) EUR per Km
Plantation (trees)
Urban heat island reduction measures
Other equipment
Pre-operative expenses
Total CAPEX

Operating Expenses (OPEX)
Cost Heads
Salaries of core staff
Materials and consumables
Energy Expenses
Other utilities
Maintenance
Total Operating Expenses / year

Total CAPEX will be estimated based on the Project Design Document (Cost of a similar project **EUR 38 million**.)

Need for public sector funding support

High

The proposed pilot project involves substantial infrastructure development cost. On the other hand, there is no revenue generation. Therefore, the project will need high percentage of public funds.

Likelihood of securing public funding in support of the project

Moderate

The pilot project will be additional responsibility of the local government and will need substantial convincing. However, the pilot project envisages positive impact on climate change over a long period. Thus, the likelihood of securing public funding improves to moderate level.

Interest of private sector financial support involvement

Medium

The proposed pilot project idea does not generate any revenue. Secondly the project has infrastructure development cost. Private sector may show interest if appropriate cash incentives are provided (e.g. advertisements allowed around the project area, new real estate development on a piece of land provided elsewhere in the city). It is expected that some private sector companies may be interested as project is promoting climate change cause (such companies may invest through corporate social responsibility initiatives.

Cost-Benefit Analysis

The pilot project proposes to Implement Green infrastructure on pedestrian streets to promote non-motorized mobility in the city and reduce CO_2 emissions related to this sector. In addition, the project also envisages promoting the infiltration of water into local aquifers.

As the key information for a financial cost-benefit assessment are yet to be worked out at this stage of the project preparation, the following costs and benefits could be anticipated:

Financial costs:

- Cost of construction of corridors
- Cost of planting trees
- Cost of implementing heat island effect reduction measures.

Social costs:

- Frequent flooding of city
- Water shortage
- High traffic density

Social Benefits:

- Better environment and better quality of life
- Better availability of water
- Pedestrians and cyclists who choose to use the corridors can avoid the stress of vehicular traffic.

Quantification possible at this stage? ***No***

Investment Plan

The proposed pilot project idea can be financed by Municipal Corporation of Saltillo, IMPLAN, Department of Urban Development and Department of Environment.

Indicative investment plan is as follows:

Indicative Means of Financing	% Share
Saltillo Municipality	55%
Deptt. Of Environment	20%
Deptt. Of Urban Development	20%
IMPLAN (in-Kind)	5%
Total	**100%**

Quantification possible at this stage? ***No***

Major Assumptions

- The proposed project does not envisage any revenue generation.
- Total cost of the project is yet to be ascertained hence **investment plan mentioned is an indicative**.
- The pilot project involves construction / modification of existing road and adding a bicycle track.
- Financing of the project is mainly through **grant** funding.

Support from NGOs can be explored for financing studies.

Envisaged Activities and Technologies

Activities	Timeframe
• Identify areas with high potential to develop the envisioned corridor. An area with high potential will be one that offers a connection between two or more important points in the city. In addition to being close to places that are more prone to flooding, so that the sponge city effect has a greater impact.	4 – 6 weeks
• From the list of areas with potential identified, select one to implement the pilot project.	2 – 3 weeks
• Carry out all necessary technical studies (e.g. soil analysis).	1 – 2 months
• Approach the neighbors, in order to explain the project clearly and in detail. Ideally this approach would be carried out by some group with which people are already familiar and have a good reputation to generate greater confidence in what is explained (e.g. PROFAUNA)	3 – 4 weeks (constant communication)
• Make a list of all the elements that must / should be included: E.g. vegetation, public lighting, containers for solid waste, etc.	2 – 3 weeks
• Define the indicators that will be used to measure the success of the project in the short and long term.	1 –2 weeks
• Propose the design of the corridor, including distribution of spaces. In other words, define the percentage of the area destined for green infrastructure.	2 – 3 months
• Development of the vegetation portfolio to be used.	2 – 4 weeks
• Find investors. Select one	May vary

Preconditions

- Identification of places with implementation potential
- Site selection for pilot project
- Achieve public acceptance
- Building permits
- Selection of suitable vegetation
- Urban design

Technologies/Products

- Nature-based solutions, such as green infrastructure (xeriscape type) that will serve as a sustainable urban drainage system (SUDS) and shelter for local biodiversity.
- Permeable pavement for the required pedestrian and/or bicycles lanes
- Air quality monitoring stations

- Potential to include charging points for e-bikes and/or electric cars.
- Potential to include WiFi
- Potential to include IoT

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
AM (Action Mitigation): Reduced greenhouse gas emissions and expansion of carbon storage in the project / program field	1. Cycle traffic percentage 2. Percentage of pedestrian traffic 3. Percentage of people avoiding the use of motorized cars 4. Bicycle sales increase	1. 0.92% 2. 18% 3. Unknown 4. Unknown	1. IMPLAN_Sistema Indicadores Movilidad urbana (2015) Pg. 36 2. Encuestas ciudadanas
AP (Action People): Number of people directly supported by the project regarding adaptation to the consequences of climate change or regarding ecosystem conservation	1. Water security 2. Sustainability 3. % Of treated water reuse 4. Urban heat island 5. Annual number of local floods	1. 119 m3/cap/a 2. -16 Hm3/a 3. 7% 4. Unknown 5. Depends on the selected location	1. CONAGUA – Disponibilidad media anual de acuíferos 2. Consejo de Cuenca Río Bravo 3. Dirección de medio ambiente y espacios urbanos

Restoration and Integration of Blue and Green Infrastructure

The project aims to restore a section of one of the main creeks in Saltillo so that its fluvial capacity is recovered, while also converting the riverbank into a recreational area that will offer environmental, social and even economic benefits.

The main impact for the water sector is the improvement of the drainage system, not only from the recovered fluvial capacity of the creek but also through a so-called sustainable urban drainage system (SUDS), which is achieved by the capacity of vegetation to retain, absorb, and infiltrate water. When implemented at a big scale, this green infrastructure could be analogically seen as a huge sponge, which can notoriously improve the capacity of a city to avoid flooding events while also offering multi-sectorial benefits.

The envisioned system would also foster walkability and bicycling, by offering an attractive green corridor with an improved microclimate through shading and evapotranspiration from the vegetation and during rainy seasons also from the stream itself. Thus, the number of people moving by car could be decreased, if the location is strategically selected, along with their related CO_2 emissions. A further decrease of emissions is expected to be achieved from the lower need of air conditioning from the people living nearby, as green/blue infrastructure has the capacity of decreasing the Urban Heat Island (UHI) effect.

Objectives

The main objective of this project is to restore a section of one of the main creeks in Saltillo, firstly by cleaning and then by enhancing through the incorporation of pedestrian and/or bicycling lanes in combination with green infrastructure.

In other words, the aim of the project is not just to recover the fluvial capacity of the selected stream, but also to convert it into a recreational area that will offer a new natural landscape within the city and that will offer multi-sectorial benefits.

Description

The idea is to restore a section of one of the main creeks in Saltillo so that its fluvial capacity is recovered, while also converting the riverbank into a recreational area that will offer environmental, social, and even economic benefits. In the long term, this concept can be expanded along the same creek or replicated to other streams, which would increase the obtained benefits.

The main impact for the water sector is the improvement of the drainage system, not only from the recovered fluvial capacity of the creek but also through a so-called sustainable urban drainage system (SUDS), which is achieved by the capacity of vegetation to retain, absorb, and infiltrate water. Therefore, there will be an improved capacity to control and decrease the runoff reaching the city, which will in consequence, decrease the risk of flooding events while also offering multi-sectorial benefits.

Other environmental benefit would be the improvement of local air quality, achieved through the reduction of car use, but also from CO_2 sequestration by green infrastructure and by filtering pollutants and dust particles. Moreover, the green infrastructure to be implemented within the corridor could potentially increase urban biodiversity, as local species can use this space for food and shelter.

Within the social impacts, there are multiple health impacts attributable to the integration of natural elements within the urban environment. In addition, the stress of vehicular traffic can be avoided for those who decide to take advantage of the corridors, either by walking or cycling. Not less important is the potential to reduce crime in the areas nearby to the creek, as there will be greater attendance and ideally greater police presence (including surveillance cameras and environmental police). Furthermore, the project has the potential to contribute to environmental education and awareness through murals installed along the corridor.

The envisioned system would also foster walkability and bicycling, by offering an attractive green corridor with an improved microclimate through shading and evapotranspiration from the vegetation and during rainy seasons also from the stream itself. Thus, the number of people moving by car could be decreased, if the location is strategically selected, along with their related CO_2 emissions. A further decrease of emissions is expected to be achieved from the lower need of air conditioning from the people living nearby, as green/blue infrastructure has the capacity of decreasing the Urban Heat Island (UHI) effect.

Alignment with city goals

Full

According to the Urban Development Plan, linear parks are proposed to promote the conservation of the city's creeks, and the Environmental Agenda proposes green infrastructure interventions for these areas too to increase rainwater recharge to the aquifers.

Key project outputs

The project focuses on the following points:
One of the main environmental impacts that the project would have would be on the pluvial drainage system to prevent flooding events. Another problem strongly attacked would be that of CO_2 emissions and air quality. To a lesser extent, it would contribute to decrease the municipality's water shortage, because even though the percentage of rain that would infiltrate the aquifer can be considerably increased, the limiting factor is the low annual rainfall.
Within the social impacts, there are multiple health impacts attributable to the integration of natural elements within the urban environment. In addition, the stress of vehicular traffic can be avoided for those who decide to take advantage of the corridors, either walking or cycling. No less important is the potential to reduce crime in neighbourhoods where these types of corridors are implemented, as there will be greater attendance and ideally greater police presence (including environmental police).
Regarding the economic benefit, by replicating and expanding the project, work hours lost due to traffic congestion can also be reduced.

In summary, the indicators to be monitored to determine the success of the project are:

- Urban storm drainage coverage
- Water security
- Sustainability
- % of treated water reuse * (ideally)
- Saprobic index and ecological status to evaluate the quality of the aquatic ecosystem of streams.
- In the long term, achieve a correlation between the increase in green areas in the city and the increase in the health of the inhabitants.
- Compare the frequency of flood events in the area to the frequency before implementing the corridor.
- Compare the local temperature in the area before and after implementation.
- Continue to closely monitor local aquifer water levels to determine if there was an increase after implementation.
- Define whether in the long term there was a decrease in the city's CO_2 emissions.
- Measure local air quality
- Increase in the use of renewable energies
- Increase in biodiversity in the city
- Increase in the percentage of citizens avoiding the use of motorized vehicles
- Increase in bicycle sales
- Reduction in local energy consumption (attributable to reduced use of air conditioning)
- NDVI: Normalized Difference Vegetation Index

The impacted actions fields are:

- Flood protection
- Active implementation of green infrastructure
- Urban regeneration through the greening of public space
- Pollution control and improvement of urban water and air quality
- Reduction of heat stress and improvement of health
- Management of the urban water cycle
- Smart and resilient infrastructure in the urban water system

The considered impact factors are:

- City located in semi-arid region
- Insufficient sustainability awareness
- Air pollution

- Drop in aquifer levels
- High vulnerability to climate change

Location

The ideal location for the pilot project is that one that offers the major benefits. It has been identified that the areas near to the creeks Pueblo and Ceballos are constantly suffering of flooding events, thus, making them a potential point for implementation. A further argument for choosing the Ceballos creek, is its closeness to the WWTP Gran Bosque Urbano, whose treated effluent could be used for irrigation and for the replenishment of the creek during dry seasons.
Alternatively, the creek Charquillo can also be a potential location, since there are already feasibility studies for a similar project in this area.

Minimum feasibility/Conditions

A very important condition to be met is to take into account the needs, concerns and recommendations of civil society and integrate different perspectives.
In order to have a more robust system with a greater number of benefits, it is recommendable to have a diversification of vegetative species, for instance, limiting the percentage of one species to 5%.
It is also important that the area designated for green infrastructure is carefully determined to ensure that the benefits are obtained.
It must also have a department in charge of the care of public space and the safety of citizens.
A bicycle lane and points to park bicycles and areas that facilitate the temporary stop of cyclists.
Finally, it is important that there are enough benches and trashcans (ideally one for each type of waste stream to encourage recycling).
Ideally, the pedestrian and/or biking lanes will be constructed with permeable pavement.

It is recommended to have:

- Air quality measurement stations to allow monitoring of the effects of the project.
- Surveillance cameras and help buttons.
- Points to rent bicycles.
- Ornamental fountains to contribute to the urban landscape and to improve the microclimate (or better yet, small ponds if possible)
- Endemic vegetation with low water requirements. In addition, there is the possibility of taking advantage of the GBU WWTP's treated water for the maintenance of green areas.
- A prohibition or a significant limitation on car access.
- WIFI connection points

It could have:

- A space for environmental education. In addition, this space can include photos and texts describing the floods that have already affected the city in the past, with the purpose of serving as a reminder of the impacts that climate change can bring and, therefore, of the importance of a more responsible lifestyle with the environment and society. One could also include the issue of streams that are currently neglected and make a comparison with cities where streams have been integrated into the urban environment.
- Waste collection centers to encourage recycling.
- Vertical gardens
- Public lighting with solar panels.
- Small workshops for basic bicycle repair / maintenance
- A Citizen Council in charge of making the link between civil society and the municipality with respect to the urban corridor

Replicability potential

High

The Environmental Agenda proposes that each local university adopt a stream for conservation. This will increase the coverage of the intervened area.

Impact

GHG Emission reduction potential

Medium

The heat island effect can lead to high temperatures in urban centers. With increasing standard of living, air conditioners for climatization become more important, representing a large share of electricity consumption in the residential, commercial and public buildings. Vegetation integrated to the urban environment can substantially lower the heat island effect, blocking sunlight from heating paved areas and thus reducing air temperature and electricity demand for climatization, thereby considerably reducing CO_2 emissions from electricity generation. However, a substantial greening of the city will be necessary for a temperature decrease to be noticeable.

Climate change adaptation potential

High

The potential is high as the blue-green infrastructure will contribute to a resilient city that is better prepared to avoid floods. In addition, it can slightly contribute to reducing the water shortage in Saltillo, which is currently critical, since the percentage of permeable surfaces would be increased while the impermeable ones would be reduced. Furthermore, the creek itself could also infiltrate more water to the aquifers as its fluvial capacity improves.

If implemented successfully, the reduction in CO_2 emissions can also be noticeable by reducing the need to use cars and by reducing the local temperature, which in turn, reduces the use of air conditioning. At the long term, CO_2 reduction will also be achieved through vegetative CO_2 sequestration.

Extent of resettlement and rehabilitation issues

Low

Due to the characteristics of the project, which does not affect the course of the stream, only the riverbank will require special permits that do not jeopardize the implementation of the project.

List of stakeholders

- Civil Society: Approval and recommendations mainly from the neighbors in the area where the project is to be implemented.
- IMPLAN: Coordination of the project at the local level. Proposals for areas with implementation potential. Facilitate the development of the vegetation portfolio to be implemented. If needed, sharing the performed studies for the Charquillo project.
- Municipality of Saltillo: General support.
- Department for Environment and Public Spaces: Required permits
- Ministry for the Environment: Required permits
- Ministry for Urban Development: Required permits
- CONAGUA:
- Environmental police: Surveillance of the corridor along the creek. Ensuring that the spaces are correctly used and taken care of.

Engagement

High

There is a high level of commitment from educational institutions to participate in stream conservation activities, students and teachers, as well as the community in general.

Target groups

The locals will be the most benefitted from this project as they will acquire a new recreational space, while obtaining a major cover of green spaces and increasing their capabilities to move without motorized vehicles. Further on, the risk of being affected by flooding events or heat waves is expected to be significantly reduced.

Persons reached

-

Regulatory constraints, risks, and barriers

Regulatory constraints

Medium

Due to the characteristics of the project, which does not affect the course of the creeks, only the riverbank will require special permits that do not jeopardize the implementation of the project. It requires an executive project to have the federal approval for the intervention.

Risk of project approval

Low

As this is an activity that is already being carried out by the administration, the project has a good chance of being approved.

Other barriers and risks

An important barrier could be the required times for obtaining the pertinent permits for construction. The necessary studies (e.g. soil analysis) could also pose a risk for delay.
An important possible barrier would be the disapproval of the locals, as civil society has the capacity of preventing projects to be developed (this happened in Mexico City with the proposed Chapultepec Green Corridor)
Another risk is that an adequate balance between low water-retaining plants and high water-retaining plants is not met, and thus, obtaining a deficient "sponge city effect".
Additionally, the risk of people misusing these spaces (e.g. vandalism) should be considered and mitigated by implementing sufficient police surveillance.

Project Financials

Approx. costs of the project

The CAPEX and OPEX for this project will comprise the following main elements:

Capital Expenses (CAPEX) components
Cost Heads
Land
Construction (Building)
Equipment Cost (as applicable)
Plantation (Green area development + trees)
Wetland development (Green / Blue infrastructure development)
Road Construction EUR per Km (if applicable)
Urban heat island reduction measures
Re-settlement and Rehabilitation expenditure
Other expenditure
Pre-operative expenses
Total CAPEX

Operating Expenses (OPEX)
Cost Heads
Salaries of core staff
Materials and consumables
Energy Expenses
Other utilities
Maintenance
Total Operating Expenses / year

Total CAPEX will be estimated on the basis of the Project Design Document.

Need for public sector funding support

High

The proposed pilot project involves substantial infrastructure development cost. On the other hand, there is no revenue generation. Therefore, the project will need high percentage of public funds.

Likelihood of securing public funding in support of the project

Moderate

The pilot project will be additional responsibility of the local government and will need substantial convincing. However, the pilot project envisages positive impact on climate change over a long period. Thus, the likelihood of securing public funding improves to moderate level.

Interest of private sector financial support involvement

Medium

The proposed pilot project idea does not generate any revenue. Secondly the project has infrastructure development cost. Private sector may show interest if appropriate cash incentives are provided (e.g. advertisements allowed around the project area, new real estate development on a piece of land provided elsewhere in the city). It is expected that some private sector companies may be interested as project is promoting climate change cause (such companies may invest through corporate social responsibility initiatives.

Cost Benefit Analysis

The main purpose of the pilot project is Integration of natural areas such as local streams and green elements into the urban environment. These spaces will serve as recreational and landscaped areas, while also serving as nature-based solutions (e.g., against flooding and heat stress). In addition to having the potential to improve the mobility system (pedestrian and cyclist). The pilot project proposes restoring the streams, which will help natural drainage function with greater efficiency than at present.

Apart from climate change benefits as mentioned above, we expect better living conditions and stability to the community could help long term well-being.

As the key information for a proper financial cost-benefit assessment are missing at this stage of the project preparation, the following **qualitative costs and benefits** could be anticipated:

Financial / economic costs:

- Road construction and area development (as applicable)
- Wetland development
- Urban heat island reduction measures
- Resettlement and rehabilitation (or project affected population)
- Other associated costs

Social Costs:

- Losses due to flooding
- Excess load on existing drainage system
- Existing streams in poor condition can lead to inefficient drainage

Social benefits:

- Increased coverage of green areas in the city
- Lower flooding possibilities due to sponge city effect
- Recovery of natural systems through river restoration
- Reduction of urban heat island effect

Quantification possible at this stage? ***No***

Investment Plan

The proposed pilot project is expected to be mainly financed out of the budget of Saltillo Municipal Corporation and private sector investors and construction companies. It may be observed that the private developer is expected to recover its costs from inhabitants of the building.

Indicative investment plan is as follows:

Indicative Means of Financing	% Share
Saltillo Municipality	50%
Deptt. Of Environment	20%
Deptt. Of Urban Development	20%
IMPLAN	5%
CONAGUA	5%
Total	**100%**

Quantification possible at this stage? ***No***

Major Assumptions

- The proposed project does not envisage any revenue generation.

Total cost of the project is yet to be ascertained hence **investment plan mentioned is an indicative**.

Envisaged Activities and Technologies

Activities	Timeframe
• Identify areas with high potential to provide the expected benefits. An area with high potential will be one that offers a connection between two or more important points in the city. In addition to being close to places that are more prone to flooding, so that the sponge city effect has a greater impact.	4 – 6 weeks
• Analyze the potential and feasibility of following up/collaborating with the "arroyo Charquillo" project.	2 – 3 weeks
• From the list of areas with potential identified, select one to implement the pilot project.	2 – 3 weeks
• Carry out all necessary technical studies, for implementation, such as hydraulic, hydrological, soil analysis, etc. For this purpose, it will probably be necessary to find and contract experts.	2 – 3 months
• Submit the performed studies and analysis to the pertinent authorities (e.g. CONAGUA, SEMA, etc.)	1 – 2 weeks
• Approach with the locals, in order to explain the project clearly and in detail. Ideally, this approach would be carried out by some group with which people are already familiar and have a good reputation to generate greater confidence in what has been explained (e.g. PROFAUNA).	3 – 4 weeks
• Make a list of all the elements that must / should be included: E.g. vegetation, public lighting, containers for solid waste, etc.	2 – 3 weeks

• Determine the indicators that will be used to measure the success of the project in the short and long term.	1 – 2 weeks
• Propose landscaping design, including distribution of spaces. For example, define the percentage of the area designated for green infrastructure, for recreation area and for cycle lane.	2 – 3 months
• Development of the vegetation portfolio to be implemented.	2 – 4 weeks
• Find investors. Select one	May vary

Preconditions

- Financing
- Legal permits
- Lack of technical studies (hydrological and hydraulic)
- Multidisciplinary synergies
- Continuity of projects through the different administrations

Technologies/Products

- Nature-based solutions, such as green infrastructure that will serve as a sustainable urban drainage system (SUDS) and shelter for local biodiversity.
- Permeable pavement for the required pedestrian and/or bicycles lanes
- Potential to include charging points for e-bikes and/or electric cars.
- Air quality monitoring stations
- Potential to include renewable energy for public lightning, and/or for irrigation systems.
- Potential to include WiFi
- Potential to include IoT

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
AM (Action Mitigation): Reduced greenhouse gas emissions and expansion of carbon storage in the project / program field	1. Cycle traffic percentage 2. Percentage of pedestrian traffic 3. Percentage of people avoiding the use of motorized cars 4. Bicycle sales increase	1. 0.92% 2. 18% 3. Unknown 4. Unknown	1. IMPLAN_Sistema Indicadores Movilidad urbana (2015) Pg. 36 2. Encuestas ciudadanas
AP (Action People): Number of people directly supported by the project regarding adaptation to the consequences of climate change or regarding ecosystem conservation	1. Water security 2. Sustainability 3. % Of treated water reuse 4. Urban heat island 5. Annual number of local floods	1. 119 m3/cap/a 2. -16 Hm3/a 3. 7% 4. Unknown 5. Depends on the selected location	1. CONAGUA – Disponibilidad media anual de acuíferos 2. Consejo de Cuenca Río Bravo 3. Dirección de medio ambiente y espacios urbanos

Smart and Sustainable Buildings

Cities have high demand and little availability of water and energy, so it is necessary to have adequate technologies to make efficient use of these resources and to be able to generate them. This project aims to install different technologies and best practices to be implemented and tested in a building for the sustainable use of water and energy with an emphasis on off-grid solutions, monitoring and control instruments. In addition, these buildings will promote sustainable development models for the city, as they can be used as an Urban Living Lab.

Objectives

- Reduce the drinking water demand in buildings
- Reduction of water pressure on the city's supply sources
- Reduction of water leaks
- Clean energy production
- Reduction of greenhouse gas emissions
- Set a building as an Urban living Lab for promoting sustainable development models for the city

Description

Saltillo is in a water stress area, for this reason the use of alternative sources for water supply, the reuse of wastewater and the reduction of water leaks are measures that should be considered for reducing the pressure on the overexploited groundwater reservoirs of Saltillo.
Moreover, this project can also reduce greenhouse gas emissions by using renewable sources for power generation.

This project aims to install different technologies and best practices to be implemented and tested in a building for the sustainable use of water and energy with an emphasis on “off grid” solutions, monitoring, and control instruments. In addition, these buildings will promote sustainable development models for the city, as they can be used as an Urban Living Lab.

Alignment with city goals

No

Smart buildings are not currently included in the city's planning documents.

Key project outputs

- Implement technologies with an emphasis on off-grid solutions
- Rainwater harvesting
- Capture and use of humidity from the environment to produce drinking water
- Generation of clean energy by installing solar panels
- Savings in water and energy consumption.
- Reuse of wastewater
- Have better monitoring and control of the water system and thus minimize losses due to leaks

Location

It is planned that the smart building will be implemented in a public building, this building will be considered as an Urban Living Lab, from which results and lessons learned can be extrapolated to other buildings in the city.

Minimum feasibility/Conditions

It must take into account:

- Technologies for the generation, capture, use and saving of water and energy (bathrooms, accessories, lighting, energy efficiency)
- Implement good practices for the sustainable use of resources in the building

It is recommended to have:

- Rainwater harvesting, collection and systems for its direct use
- Atmospheric water generator system
- Gray (and ideally black) wastewater treatment plants and reuse systems

- Control, micro-measurement and monitoring of the water system (automation, system control and leak detection)
- Solar panels

It could have:

- Green roofs
- Photovoltaic glasses
- Solar concentrators
- Piezoelectric tiles

Replicability potential

High

Developing a building model would be easily replicable.

Impact

GHG Emission reduction potential

Medium

Sustainable buildings can reduce the energy and fuel consumption for residential, commercial and public uses, such as water heating, climatization, electricity devices, etc. Additionally, cities of high urban density (higher inhabitants per area) tend to have lower energy consumption and CO_2 emissions than cities of low urban density, in particular due to reduce transportation and climatization requirements.

Climate change adaptation potential

Medium

It has a medium impact because, although there are measures that contribute to adaptation and mitigation to climate change, the impacts of this project will be noticeable mainly in the execution area given the scale of implementation.

Extent of resettlement and rehabilitation issues

Low

As this project is being carried out on private property, these elements would not apply

List of stakeholders

- Municipal government: Should allow the implementation of such innovative measures in a local public building.
- Municipal Department for Urban Development: Should issue the permits for implementation.
- IMPLAN: Coordination at local level
- Ministry of Environment: Interest in eco-friendly infrastructure measures
- Federal state government: Ideally, potential to replicate the model in other cities
- Academia: Further development and improvement of the system.
- AGSAL: The overexploitation of aquifers demands a higher effort of the company, as their production pumps have to descent deeper to reach the water table.

Engagement

Medium

Target groups

The municipal entity in charge of the building will be the most benefited parties, as one reduces their operational efforts for water production and the other one reduces its water and energy consumption, resulting in an economic impact.

At a broader scale, the whole city is impacted in the long term, as it could increase its water availability if the model is replicated sufficiently.

Persons reached

- Citizens and citizen groups

Regulatory constraints, risks, and barriers

Regulatory constraints

Medium

The limitations would be few because the real estate, in most cases, belongs to the municipal administration.

Risk of project approval

Low

If there is a budget, there would be no restrictions as the authorized works are intended to directly benefit the population.

Other barriers and risks

The time for selecting an adequate technology for the treatment of the grey wastewater might represent an issue as some specialized studies must be carried out before. Even when the most suitable technology has been selected, the time for acquiring it might also be larger than expected.
Finally, the integration of the envisaged technologies within the selected building might be problematic, depending on the antiquity of the building and the necessity to implement new pipelines for instance.

Project Financials

Approx. costs of the project

Total Cost of the Project exact estimates will be made in the basis of a detailed project report. CAPEX and OPEX breakdown associated with the project is as follows:

Capital Expenses (CAPEX) components
Cost Heads
Land (if applicable in the case of a new building)
Solar PV electricity generation (Roof top)
Rooftop farming (OR cool-roof paint)
Rain water harvesting systems
Water recycling system and Waste water treatment
Atmospheric water generator system
Modification of air conditioning (OR passive / sustainable air conditioning)
Total CAPEX

Operating Expenses (OPEX)
Cost Heads
Salaries of core staff
Materials and consumables
Energy Expenses (Net of generation)
Other utilities
Maintenance
Total OPEX

Quantification possible at this stage? ***No***

Need for public sector funding support

Low

The proposed green building project has many different elements such as retrofit measures, greening measures, solar electricity generation. It is expected that private sector investors may provide large share of finance and hence need for public funding is low.

Likelihood of securing public funding in support of the project

Moderate

Overall lower quantum of public funding requirement may result into relative ease of securing public funding needed.

Interest of private sector financial support involvement

High

Green buildings is an emerging area for private construction companies and hence it is expected to receive attention. Private sector investors are likely to invest in the pilot project. Considering that retrofit measures are to be implemented, the funding requirement will be moderate.

Cost Benefit Analysis

The proposed pilot project envisages implementing several green features as retrofit measures to existing residential building. Main steps in the project include installation of various retrofit measures including solar PV electricity generation, rainwater harvesting, waste-water treatment and water recycling systems. The pilot project would result into reduction of GHG emissions and improve sustainability.

Financial Costs:

- Cost of installation of retrofit measures and systems
- Construction cost as applicable
- Equipment and other material
- Rating fees (cost of green rating service)

Social costs:

- Higher operating expenses (utility costs)
- Higher GHG emissions

Social Benefits:

- Lower cooling load
- Sense of pride
- Reduced water leakage

Quantification possible at this stage? ***No***

Investment Plan

The proposed pilot project is expected to be mainly financed out of the budget of Saltillo Municipal Corporation and private sector investors and construction companies. It may be observed that the private developer is expected to recover its costs from inhabitants of the building. Indicative investment plan is as follows:

Indicative Means of Financing	% Share
Saltillo Municipality	30%
Private Sector Investors	70%
Total	**100%**

Quantification possible at this stage? ***No***

Major Assumptions

- The proposed project may generate **revenues** through **solar PV** electricity generating system**.**
- Total cost of the project is yet to be ascertained hence **investment plan mentioned is an indicative**.
- The project is expected to be financed out of funds from municipal body and debt from investors.

Solar PV systems could be financed by building occupants.

Envisaged Activities and Technologies

Activities	Timeframe
1. Carry out a feasibility analysis to identify and select the public building in which technologies will be installed and good practices will be implemented for the sustainable use of water and energy.	5 –7 weeks
2. Develop a Technology Roadmap to select the technologies and practices to be implemented	2 – 3 weeks

3. Design of strategies for the implementation of technologies and good practices	3 – 4 weeks
4. Collect the data generated in the building (water and energy consumption)	Constantly
5. Development of lessons learned.	After completion

Preconditions

- Have the permission of the corresponding authorities for the intervention of public buildings.
- Have a feasibility analysis to select the buildings suitable for intervention.

Technologies/Products

- Rainwater harvesting and collections systems
- Atmospheric water generator system
- Green roofs
- Water and energy saving technologies (bathrooms, accessories, lighting, energy efficiency)
- Treatment and reuse of grey and wastewater (circular economy)
- Control, micro-measurement, and monitoring of the water (and energy) system (automation and system control)
- Leak detection
- Solar panels
- Photovoltaic glasses

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
AP (Action People): Number of people directly supported by the project regarding adaptation to the consequences of climate change or regarding ecosystem conservation	3. Households practicing stormwater harvesting 4. Ratio of reused water to total water consumption %/m3/a 5. Water security m3/a/cap 6. Sustainability Hm3/a	2. Unknown 3. 7.09 4. 119 5. -16	2. Desarrollo Urbano, Comisión Estatal de Aguas y Saneamiento (CEAS), Aguas de Saltillo 3. Municipio , Director de la PTAR Luis Carlos Ríos

Sustainable Neighbourhood

By creating a Sustainable Neighbourhood, it is intended to reduce water and energy consumption, heat island effects, as well as mitigate floods, which will be achieved through the implementation of the best water and energy management practices, green technologies and ecotechnologies. Punctually, this initiative includes green walls and roofs, rainwater harvesting, collection systems, solar energy generation, implementation of technologies for the treatment and reuse of wastewater (for garden irrigation), as well as adapting green spaces with green infrastructure (rain gardens) or functional recreational areas (to reduce the effects of heat islands).

Objectives

- Reduce water pressure on the city's groundwater sources (overexploitation of aquifers)
- Reduce the vulnerability of the city to floods due to extreme hydrometeorological events
- Decrease in urban heat islands
- Reduction of greenhouse gases emissions
- Development of the "sponge city" effect

Description

The prosperity of Saltillo and its surroundings is directly related to the ability to manage water resources.

Water in Saltillo emerges as a good that we generally consider scarce because it is unequally available throughout its territory and over time. When it appears in abundance, it causes disasters such as floods, causing material and non-material damage to society and when it is totally absent, it causes droughts, which leads to less water availability.

Through the implementation of this project, it is intended that the city will be more resilient to the precarious situation of water resources in the area, so the following is desired:

- Reduce water pressure on the city's groundwater sources (overexploitation of aquifers)
- Reduce the vulnerability of the city to floods due to extreme hydrometeorological events
- Decrease in urban heat islands
- Reduction of greenhouse gases emissions
- Development of the "sponge city" effect

It is important to note that cities contribute greatly to greenhouse gases emissions due to mobility, the use of energy from fossil sources and industrial activity, so this project also intends to implement measures to reduce greenhouse gases through the implementation of solar and green technologies. In the long term and indirectly, the energy for water production from the local company, AGSAL, could also be reduced as their pumps could require less power for groundwater extraction as the city’s water demand decreases.

Alignment with city goals

Partial

In the Saltillo urban planning update, some elements of sustainable neighbourhoods are considered. The densification of the city as one of the priorities.

Key project outputs

- Reduction of surface runoff and attenuation of maximum flows.
- Achieve a sponge effect that contributes to the recharge of aquifers and increases the drainage capacity.
- Increase water availability in the medium and long term.
- Improve the environmental, social and landscape conditions of the intervention areas.
- Adaptation and mitigation to climate change.
- Greenhouse gases reduction.
- Use and capture of rainwater and/or generation of water from the humidity of air.
- Treatment and reuse of waste and grey wastewater (ideally also black wastewater).
- Energy generation

Location

The city may choose an existing residential area or adequate the envisaged technologies within an existing complex. A location with potential of harnessing the most benefits is one which is prone to flooding events and/or has been identified as a focalized point for urban heat islands.

Minimum feasibility/Conditions

It must take into account:

- Green walls and roofs
- Sustainable urban drainage systems (SUDS)
- Rainwater harvesting systems
- Rain gardens
- Wastewater treatment and reuse systems
- Control and monitoring of water in residential homes and at the residential area level
- Runoff control through green infrastructure
- Power generation systems
- Led lighting with solar panels

It is recommended to have:

- Photovoltaic glasses,
- Energy saving systems
- Solar Hybrid Systems (Heat Concentrators)
- Photocatalytic Paints
- Bikeways

It could have:

- Electric buses
- Water generation from the humidity in the environment
- Wind energy production systems

Replicability potential

High

By developing a sustainable neighbourhood model, it could be replicated by construction companies in the region.

Impact

GHG Emission reduction potential

Medium

Sustainable buildings can reduce the energy and fuel consumption for residential, commercial and public uses, such as water heating, climatization, electricity devices, etc. Additionally, cities of high urban density (higher inhabitants per area) tend to have lower energy consumption and CO_2 emissions than cities of low urban density, in particular due to reduce transportation and climatization requirements.

Climate change adaptation potential

Medium

The lighthouse project itself would have a medium impact in CC adaptation but if replicated throughout different points of the city, it could have a high impact. Reason for this is that a single sustainable neighbourhood can indeed increase local water availability as the resource would be efficiently used through ecotechnologies and can also noticeably decrease the affectations from heat stress suffered by the locals. However, the benefits will mainly be reflected at a local level, while when sufficiently replicated, it can substantially increase the impacted area to nearby neighbourhoods as well.

Extent of resettlement and rehabilitation issues

Low

No resettlement issues as the intervention would aim to benefit the current residents of the area.

List of stakeholders

- Civil Society: The project should take into account and include the concerns of the locals and they should be efficiently informed about the objectives and relevance of the project in order to obtain their approval
- Municipal Department for Urban Development: Should issue the permits for implementation.
- IMPLAN: Coordination at local level
- Ministry of Environment: Interest in eco-friendly infrastructure measures
- Federal state government: Ideally, potential to replicate the model in other cities
- Academia: Further development and improvement of the system.
- AGSAL: The overexploitation of aquifers demands a higher effort of the company, as their production pumps have to descent deeper to reach the water table.

Engagement

Low

Citizen participation would be minimal

Target groups

The neighbors and AGSAL will be the most benefited parties, as the locals obtain an economic benefit from reducing their water (and energy consumption) and improve their life quality thanks to the green infrastructure, while the second one reduces their operational efforts for water production

Ideally, at a broader scale, the whole city is impacted in the long term, as it could increase its water availability if the model is replicated sufficiently.

Persons reached

- Citizens and citizen groups

Regulatory constraints, risks, and barriers

Regulatory constraints

Low

Not present

Risk of project approval

Low

It would depend on private investment and housing developers.

Other barriers and risks

If the project is to be implemented in a new residential complex, it might be challenging to comply with the expected times within the City Lab framework.
On the other hand, the integration of the envisaged technologies within existing residential areas might be problematic, depending on the antiquity of the buildings and the necessity to implement new pipelines, for instance.
The time for selecting an adequate technology for the treatment of the grey wastewater might represent an issue as some specialized studies must be carried out before. Even when the most suitable technology has been selected, the time for acquiring it might also be larger than expected.

Project Financials

Approx. costs of the project

The CAPEX and OPEX for this project will comprise the following main elements:

Capital Expenses (CAPEX) components
Cost Heads
Land
Garden development
Rooftop Solar PV electricity generation system
Plantation (Green area development + trees)
Heat island effect reduction measures
Rain water harvesting systems
Waste water recycling systems
Pre-operative expenses
Total CAPEX

Operating Expenses (OPEX)
Cost Heads
Salaries of core staff
Materials and consumables
Energy Expenses
Other utilities
Maintenance
Total Operating Expenses / year

Reference Costs	Amount in EUR	Unit of Measure	Details
River Restoration elements			
floodplain-related restoration measures	22,734.00	EUR/ha	Euro per hactare
Wetlands connection	25,000.00	EUR/ha	Euro per hactare
Dike Modification / removal	21.60	EUR/cubic metre	EUR per volume of cubic meter
Upstream Longitudinal Connectivity	70,000.00	EUR/m	EUR per metre height
Weir removal	5,473.00	EUR/m	EUR per metre height
Remove bed and / or bank fixation	55.12	EUR/m	EUR per meter of restored watercourse
Re-meandering of Watercourse	137.00	EUR/m	EUR per metre of river stretch recovered
Sediment Control through Reforestation	1,819.00	EUR/ha	
https://www.reformrivers.eu/system/files/1.4%20Inventory%20of%20restoration%20costs%20and%20benefits.pdf			

Total CAPEX will be estimated on the basis of the Project Design Document.

Need for public sector funding support

High

The proposed pilot project has several infrastructure development and construction elements. These increase the total cost of the pilot project. Besides, the project is expected to generate limited revenue (electricity generation from solar PV). Therefore, the need for the public sector funding is higher side.

Likelihood of securing public funding in support of the project

Moderate

The Saltillo Municipal Corporation (SMC) has to implement this project in addition to its regular budgeted projects. However, this project may have high level of visibility and hence may increase likelihood of securing public funding.

Interest of private sector financial support involvement

High

The proposed project has many elements such as development of a garden (Urban regeneration through the greening of public space), rainwater harvesting systems, etc. which may provide private sector companies higher visibility and can be seen as contributors to climate actions. On the other hand, **solar PV generation** is a revenue generation activity. These factors may increase interest of private sector to support project.

Cost Benefit Analysis

The proposed pilot project proposes to reduce water and energy consumption, heat island effects, as well as mitigate flooding. These objectives will be achieved through the implementation of best practices in water and energy management, through the implementation of green technologies and eco-technologies (green walls and roofs, rainwater harvesting and rainwater harvesting systems, solar energy generation, implementation of technologies for the use and reuse of wastewater (for garden irrigation), as well as the adaptation of green spaces with green infrastructure, rainwater harvesting systems and implementation of technologies for the use and reuse of wastewater (for garden irrigation)

This is a comprehensive project and as the key information for a financial cost-benefit assessment are yet to be worked out at this stage of the project preparation, the following **costs and benefits** could be anticipated:

Financial costs:

- Garden development
- Rooftop solar PV systems
- Rainwater harvesting systems.
- Other costs associated with different measures.

Financial benefit:

- Revenue generation from solar PV electricity generation.

Social Costs:

- Higher energy and water consumption
- Water shortage
- City's vulnerability to flooding - resultant costs and damages

Social Benefits:

- Reduction of water stress
- Runoff and / or flood control
- Reduction of heat islands effect
- Reduction of greenhouse gas emissions due to the generation of energy from renewable energy sources
- Contribution to the "sponge city" effect

Quantification possible at this stage? ***No***

Investment Plan

The proposed project is expected to be financed as follows:

Indicative investment plan

Indicative Means of Financing	% Share
Saltillo Municipality	40%
Private Sector Investors	40%
Deptt. Of Environment	10%
Deptt. Of Urban Development	10%
Total	**100%**

It is expected that private sector investors to fund up to 40% of the cost of the project.

Quantification possible at this stage? ***No***

Major Assumptions

- The proposed project envisages **limited revenue generation**. (Solar PV electricity generation)
- Total cost of the project is yet to be ascertained hence **investment plan mentioned is an indicative**.

The pilot project involves development of different measures and infrastructure elements making the cost of the project on the higher side.

Envisaged Activities and Technologies

Envisaged Activities	Timeframe
• Involvement of main actors and establishment of a technical implementing Council.	3 – 8 weeks
• Review of the regulatory framework of the territory (natural areas, reserves, among others) to carry out interventions.	2 – 3 weeks
• Identification of the intervention area	2 – 3 weeks
• Definition of the vision, objectives and scale of the intervention	2 weeks
• Definition of strategies and actions, portfolio of technologies to be implemented.	4 – 6 weeks
• Planning and design of the intervention.	4 – 8 weeks
• Establishment of budget, funding and financing.	Constant monitoring and maintenance
• Planning of implementation activities.	
• Evaluation and monitoring.	
• Maintenance	
• Development of lessons learned for their replicability	Upon completion

Preconditions

- Planning framework review (regulatory framework)
- Identification of the project or area to intervene,
- Definition of project vision
- Definition of the scale of the project

Technologies/Products

- Green walls and roofs
- Sustainable urban drainage systems
- Rainwater harvesting systems
- Rain gardens
- Wastewater treatment and reuse systems
- Control and monitoring of water in residential homes and at the residential area level
- Runoff control through green infrastructure
- Power generation systems
- led lighting with solar panels
- Photovoltaic glasses,
- Energy saving systems
- Solar Hybrid Systems (Heat Concentrators)
- Photocatalytic Paints
- Bikeways

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
AM (Action Mitigation): Reduced greenhouse gas emissions and expansion of carbon storage in the project / program field			
AP (Action People): Number of people directly supported by	1.Households practicing	1. Unknown 2. 119 m3/cap/a 3. 7%	1. CONAGUA – Disponibilidad media anual de acuíferos

the project regarding adaptation to the consequences of climate change or regarding ecosystem conservation	stormwater harvesting 2. Water security 3. Sustainability 4. % Of treated water reuse 5. Urban heat island 6. Annual number of local floods	4. 7.09 5. Unknown 6. Depends on the selected location	2. Consejo de Cuenca Río Bravo 3. Dirección de medio ambiente y espacios urbanos

Renovation of the Public Bicycles System

Saltillo has a public bicycle system to promote the use of this alternative mean of transport, however, the external perception of this system is that it has not had the adequate promotion nor the planned use. This is due to the high perception of insecurity that exists in the population according to the use of this mean of mobility. On the other hand, in other cities in Mexico, such as Mexico City, Guadalajara, Playa del Carmen, etc., as well as in Latin America, these systems have been successful due to their properly defined implementation, scope and use. Therefore, it is proposed to renew the existing system in the city so that a modern one can operate solidly and thus consolidate the formation of an integrated public system with various modes of transport. This must be inclusive where the main actors are citizens, financed by external providers with zero investment by the municipality.

Objectives

- Update and expand the current public bicycle system
- Promote the use of bicycles as a mobility alternative in Saltillo.
- Integrate this mode of transport into the public transport network available in the city

Description

Actions:

- Perform diagnostics of the current system
- Design renovation and expansion plan
- Re-design the operation and financing strategy
- Implement gradually with the participation of key stakeholders such as civil associations, service providers, municipality.

Well implemented public bike systems will improve mobility indicators, reduce vehicular traffic and the negative environmental impact of the transport sector
The public bicycle system will allow the citizens of Saltillo to make use of sustainable mobility systems integrated with other transport networks

Alignment with city goals

Partial

The Municipal Development Plan proposes to promote a mobility campaign for the use of alternative means of transportation, as well as to make the necessary adjustments to urban infrastructure in order to facilitate the mobility of citizens by alternative modes of transportation, but the public bicycle system is not explicitly mentioned.

Key project outputs

The project focuses on the following points:
Benefits:

- Reduction of vehicular traffic and emissions
- Inclusive project with all social classes.
- Low cost compared to other alternatives.
- Integration with the public transport system.
- Contribute to the generation of sustainable communities
- New transportation alternatives for the citizens of Saltillo.
- Promote a more active lifestyle by cycling as a means of traveling between areas of the city

Related indicators:

- Modal share by bicycle
- Modal share by public transportation
- Hours spending in congestion

Action Fields:

- Promoting soft mobility modes (Cycling, pedestrian, etc.)
- Intermodality and sharing systems
- Development of goals and guidelines for a sustainable district development.
- Operability of Public transport

- District Management - small-scale use-mix in local districts
- Transport Oriented Development

Impact factors

- Apply innovative and sustainable urban distribution tools
- Free access to information
- Awareness of sustainability in Saltillo
- Build capabilities in smart mobility. Consortium between academia - private companies – government
- Organize the public transport service (accessibility, infrastructure, costs, service, coverage)
- Promote the use of non-motorized modes of transport

Location

Zona centro – Distrito República

Minimum feasibility/Conditions

- Reduction of polluting emissions and noise
- Improve mobility indicators and increase their index.
- Improving people's health

Replicability potential

Medium

The system could be replicated if it has a sustainable financial model.

Impact

GHG Emission reduction potential

Low

While non-motorized mobility represents an important element of the transition to a low-carbon mobility, public bicycles in a city with a low urban density such as Saltillo can only marginally reduce energy use and emissions in the transport sector.

Climate change adaptation potential

High

Extent of resettlement and rehabilitation issues

Medium

Rehabilitation of roads to make them bicycle-friendly involves budget.

List of stakeholders

The key stakeholders are:

- Municipality
- Public bicycle service provider
- IMPLAN
- Citizen groups
- University and research centers

Engagement

Medium

There is interest from cycling groups, however, road culture should promote respect for cyclists.

Target groups

- Citizens and citizen groups
- Municipality
- Public transport providers

Persons reached

- Citizens and citizen groups

Regulatory constraints, risks, and barriers

Regulatory constraints

Medium

It would be necessary to adapt the regulations for the operation of this system.

Risk of project approval

Moderate

Insufficient infrastructure and investment in public works could be one of the risks to implement the project.

Other barriers and risks

- Perception of insecurity
- Insufficient infrastructure
- Operation costs (must be affordable for everyone)
- Financing

Project Financials

Approx. costs of the project

The Capital Expenses (CAPEX) for this project will comprise the following elements:

Capital Expenses (CAPEX) components
Cost Heads
Bicycle with GPS
Electric bicycles
Shipping expenses (Bicycles)
Stations (to park bicycles)
Solar PV (Rooftop of stations) if applicable
App development cost
Software cost
Anchors and Bases
Membership cards
RFID Readers (if applicable)
Associated civil construction (minor items)
Awareness and education (one time expenses)
Pre-operative expenses
Total CAPEX

Operating Expenses (OPEX)
Cost Heads
Salaries of core staff
Materials and consumables
Energy Expenses
Software maintenance and app upgrades
Repairs and Maintenance of bicycles
Other maintenance
Administrative expenses
Total Operating Expenses / year

As such, total CAPEX will depend on the technologies chosen, scope, number of units to be purchased, among others. Total CAPEX is estimated to be higher than EUR 50.000 and can be in the range of EUR 1 million for more than 500 bicycles.

Need for public sector funding support

Low

It is expected that there will be considerable private sector interest in the proposed pilot project. Private sector partner organizations can bring in their contribution to the project. This will reduce need for public sector funding support.

Likelihood of securing public funding in support of the project

Moderate

In view of the observations made above, there will be need for minimum support from the public funding for the proposed pilot project. Thus, likelihood of securing public funding in support of the project will be medium.

Interest of private sector financial support involvement

High

The proposed pilot project will have very high level of visibility and also it is an environmentally friendly one. Therefore, the private sector partners are expected to show keen interest in participating in this project. (It is mentioned in the project profile that the project objective is to operate without any government subsidies).

Cost Benefit Analysis

The pilot project will upgrade and expand the current public bicycle system (There is already a public bicycle system in Saltillo). The proposed pilot project will perform diagnosis of the current system, design renovation and expansion plan and re-design the operating and financing strategy.

As the key information for a proper financial cost-benefit assessment are missing at this stage of the project preparation, the following **qualitative costs and benefits** could be anticipated:

Costs (Financial / Economic Costs):

- Cost of bicycles (both conventional and electric)
- Station infrastructure (renovation)
- All software and app related costs
- Membership cards
- Awareness and media expenses

Operating costs will include salaries of core operational staff, repairs and maintenance, materials and consumables and other overheads.

Social Costs:

- Higher transportation costs to individuals
- Higher environmental costs (higher CO_2 emissions in the absence of bicycles and due to more vehicles running)

Financial benefits / Revenues:

- Membership fees
- Solar PV electricity generation (if applicable)
- Advertising review (display of sponsor names on bicycles) (if applicable).
- Lower travelling costs for individuals (more savings).

Social benefits:

- Lower vehicular traffic and hence lower exhaust emissions (lower GHG / CO_2 emissions)
- Lower transportation hassles and worries.
- Better ecosystem
- Active lifestyle promotes better health

Quantification possible at this stage? ***No***

Investment Plan

The project is expected to be financed by Saltillo Municipality, IMPLAN (in-kind or in cash), private sector bicycle purchase sponsor / Bicycle service provider, citizen groups and University / Research centers.

Indicative share of financing / Investment Plan:

Indicative Means of Financing	% Share
Saltillo Municipality	15%
IMPLAN	5%
Private Sector Organisations	70%
University / Research groups	5%
Citizen Groups	5%
Total	**100%**

Quantification possible at this stage? ***No***

Major Assumptions

- Total cost of the project is yet to be ascertained hence investment plan mentioned are indicative.
- No quantitative data is available at this stage and **hence qualitative cost-benefit analysis** has been presented.
- As the infrastructure for bicycle stations exists, it is expected that the cost of construction of station will mainly include modification and renovation. Bicycles include both electric and conventional and are fitted with GPS system.

New app for users will be developed. New IT infrastructure will be added and old will be phased out. Training of new staff will be carried out. New online payment system will be designed.

Envisaged Activities and Technologies

Activities	Timeframe
• Evaluate the city's current Bicycle System	1 month
• Propose alternatives for improvement and expansion: Physical infrastructure (cycle paths) Operation of public bike systems. Integrate conventional and electric bikes Integrate the Bicycle System into a Comprehensive Transportation System (MaaS) Payment method integrated with public transport	6 months
• Generate an ecosystem of public bicycle operation Include key stakeholders Develop local supply chain for bicycle components. Grant the administration of the System	3 months
• Training at different levels on the proper use of public bicycle systems, safe bicycle management and social awareness about the environmental impact.	3 months
• Start with a pilot project and expand it progressively.	12 months

Preconditions

Current public bicycle system in operation.

Technologies/Products

- Automatic bike stations
- Modern conventional and electric bicycles.
- Payment method integrated into the public transport system.
- Use of mobility as a service platform.
- Monitoring of system for expansion and improvement.

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
Modal split	Modal share by bicycle	0.92%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 36
Modal split	Modal share by public transport	32.06 %	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 36
Mobility	Time spending in congestion	NA	
Mobility	Public investment	0 %	IMPLAN Team.

Nature-based Solutions in Recharge Zones

Hydrological basins have elements such as vegetation and soil in their ecosystems that promote the generation of hydrological environmental services. The soil fulfils the functions of storage and filtration of water and influences the recharge of aquifers and its quality. And the vegetation in the hydrological cycle, intercepts and retains the rain and infiltrates it through its roots, opening the pores of the soil. These elements must be conserved or intervened to ensure their ecological functionality in the natural recharge zones.
This proposal aims to implement conservation and rehabilitation strategies for natural recharge sites, namely the Sierra de Zapalinamé, as well as to create priority infiltration zones through the implementation of Nature-Based Solutions (NBS). This proposal seeks not only to contribute to the recharge of aquifers, but also to reduce the water erosive processes that cause sediment dragging, as well as the reduction of the runoff speed and the attenuation of the maximum flows that could cause flooding in low areas of the region. In addition, carrying out this type of projects is expected to improve the environmental, social and landscape conditions of the areas or natural reserves. This project will achieve the goal of Saltillo as a sponge city, it will be contributed to recharge aquifers and compensate for the pressure and water stress in the region.

Objectives

Through the implementation of NBS in recharge zones, such as the Sierra de Zapalinamé, this project aims to face the challenges of water scarcity, reduce the abatement of aquifers and mitigate the impacts of flooding by implementing strategies to create infiltration zones that allows the capture and infiltration of water runoff, to recharge the main supply sources of the city, while also reducing the amount of surface runoff reaching the city.

Description

Water in Saltillo is scarce because it is available unevenly throughout its territory and over time. When it appears in abundance, it causes disasters such as floods, and when it is totally absent, it causes droughts.

This generates problems that impact various dimensions such as environmental, social, and economic. For example, when water is absent, there is a shortage of the vital liquid and greater pressure and water stress reflected in low availability of the resource. In turn, the distribution to satisfy the demands becomes a challenge, bringing an overexploitation of aquifers. Therefore, causing acquifer depletion, desertification, loss of wetlands, desiccation of water bodies and unproductive economic activities, among others.

On the other hand, the excess of water can produce floods, that are ultimately translated into monetary and non-monetary damage, wreaking havoc on society.

Through the implementation of NBS in recharge zones, this project aims to face the challenges of water scarcity, reduce the abatement of aquifers and mitigate the impacts of flooding by implementing strategies to create infiltration zones that will promote the capture and infiltration of water runoff, to recharge the main supply sources of the city.

Alignment with city goals

High

According to the Environmental Agenda and the Urban Development Plan, conservation areas are relevant to the city.

Key project outputs

This project focuses on the implementation of NBS in order to achieve:

- Aquifer recharge.
- Conservation of water.
- Creation of infiltration zones.
- Prevention of contamination of aquifers.
- Risk mitigation and reduction of the vulnerability of communities to floods.

Location

Sierra de Zapalinamé and surroundings, particularly in areas with major water recharge potential.

Minimum feasibility/Conditions

It's recommended to have:

- Identification and prioritization of recharging areas.
- Implementation of actions based on nature such as: reforestation, control and reduction of runoff for infiltration through filtering dams, soil management through good practices, infiltration ditches and well-placed stone dams, regulating vessels (wetlands) with vegetation of gallery or native riparian, management of shrub and arboreal vegetation in recharge zones, forest management and restoration, community surveillance programs and firefighting brigades.

It could have:

- The NBS can be complemented with other types of interventions, such as engineering projects with semi-natural elements, information technologies for automation of monitoring, instruments and financial schemes, etc.
- Identification of synergies between different sectors, according to the particularities and context of each situation.
- The design of the intervention should incorporate adequate options to manage disaster risks.
- Continuous monitoring and evaluation plan, and it is applied throughout the entire life cycle of the intervention.

Replicability potential

High

Since there are several natural protected areas, this initiative can be replicated in other areas.

Impact

GHG Emission reduction potential

Zero

This project focuses on climate change adaptation and no CO_2 emission reduction potential is expected from its implementation.

Climate change adaptation potential

High

The potential has been regarded as high, as the direct affectations from climate change to the city will be through increasing floods, and these can be largely mitigated through the proposed project.

Extent of resettlement and rehabilitation issues

Low

No risk because the intervention would be in protected natural areas.

List of stakeholders

- Civil Society: The project should take into account and include the concerns of the locals and they should be efficiently informed about the objectives and relevance of the project in order to obtain their approval
- Statal Commission of Water and Sanitation (CEAS): They are in charge of pluvial drainage infrastructure in coordination with the IMPLAN.
- Municipal Department for Urban Development: Should issue the permits for implementation.
- IMPLAN: Coordination at local level
- Ministry of Environment: Interest in eco-friendly infrastructure measures
- Academia: Further development and improvement of the system.
- AGSAL: The overexploitation of aquifers demands a higher effort of the company, as their production pumps have to descent deeper to reach the water table.
- PROFAUNA: Conservation activities in the Sierra de Zapalinamé

Engagement

High

There are several civil society groups that are involved in the conservation of these areas, as well as in the promotion of their conservation.

Target groups

The city as a whole will be benefitted through the implementation of Nature-Based Solutions (NBS) in recharge areas, since the objective is to face the challenges of water scarcity, reduce the abatement of aquifers and mitigate the impacts of floods, creating filtering zones that to capture the runoff water and infiltrate it into the subsoil, to recharge the main supply sources of the city.

Regulatory constraints, risks, and barriers

Regulatory constraints

Medium

The degree of natural protected areas is maintained.

Risk of project approval

Low

The Sierra de Zapaliname Natural Protected Area is the city's water supplier, which is why actions have been implemented for its conservation.

Other barriers and risks

An important barrier could be the required times for obtaining the pertinent permits for construction in protected areas. The necessary studies (e.g. soil analysis) could also pose a risk for delay.

Project Financials

Approx. costs of the project

The CAPEX and OPEX for this project will comprise the following main elements:

Capital Expenses (CAPEX) components
Cost Heads
Land
Construction cost (different types of dams)
Equipment Cost (As applicable)
Plantation (Green area development + trees)
Measures for acquifers Recharge
Soil management measures
Other costs not identified above
Pre-operative expenses
Total CAPEX

Operating Expenses (OPEX)
Cost Heads
Salaries of core staff
Materials and consumables
Energy Expenses
Other utilities
Maintenance
Total Operating Expenses / year

Total CAPEX will be estimated based on the Project Design Document.

Need for public sector funding support

High

The proposed pilot project has several costs which are needed to build infrastructure in respect of recharging of aquifers (building different types of dams), soil management measures and forestation (e.g. plant trees). The project does not envisage revenue generation. Thus, the project will need relatively high level of public funds.

Likelihood of securing public funding in support of the project

Moderate

The Saltillo Municipal Corporation (SMC) will have to consider this pilot project as an additional responsibility. SMC will need substantial convincing to receive funding support for the project. However, the pilot project envisages positive impact on climate change over a long period. Thus, the likelihood of securing public funding improves to moderate level.

Interest of private sector financial support involvement

Medium

The proposed pilot project idea does not generate any revenue. Secondly the project has infrastructure development cost. Private sector may show interest if appropriate cash incentives are provided (e.g. advertisements allowed around the project area, new real estate development on a piece of land provided elsewhere in the city). **NGOs and other donor institutions** can provide a part of funding (e.g. to undertake small study).

Cost Benefit Analysis

This proposal seeks to implement **strategies for the conservation and rehabilitation of natural recharge sites**, as well as to create priority infiltration zones through the implementation of **Nature-Based Solutions (NBS).** This proposal not only seeks to contribute to the recharge of aquifers, but also to reduce water erosion processes that cause sediment entrainment, the reduction of runoff velocity and the attenuation of peak flows that could cause flooding in low-lying areas of the watershed and the city of Saltillo.

As the key information for a financial cost-benefit assessment are yet to be worked out at this stage of the project preparation, the following **costs and benefits** could be anticipated:

Financial costs:

- Construction costs (filtering dams)
- Reforestation (of limited area) Planting of tree
- Soil Management measures and or riparian vegetation
- Other associated costs

Social Costs:

- Frequent flooding of city
- Water shortage

Social Benefits:

- Aquifer recharge.
- Water conservation.
- Creation of infiltration zones.
- Prevention of aquifer contamination.
- Risk mitigation and reduction of community vulnerability to flooding.
- Overall better health and quality of life for the community

Quantification possible at this stage? ***No***

Investment Plan

The proposed project can be financed by Saltillo Municipal Corporation (SMC), IMPLAN, Departments of Environment and Urban Development. The indicative Investment Plan is as follows:

Indicative Means of Financing	% Share
Saltillo Municipality	55%
Deptt. Of Environment	20%
Deptt. Of Urban Development	20%
IMPLAN (in-Kind)	5%
Total	**100%**

Quantification possible at this stage? ***No***

Major Assumptions

- The proposed project does not envisage any **revenue generation**.
- Total cost of the project is yet to be ascertained hence **investment plan mentioned is an indicative**.
- The pilot project involves construction of different types of dams and implementing measures for soil management.

Financing of the project is mainly through **grant** funding.

Envisaged Activities and Technologies

Activities	Timeframe
• Involvement of main actors and establishment of a technical implementing council. • Review of the regulatory framework of the territory (natural areas, reserves, among others) to carry out interventions. • Identification of the intervention area with hydrological criteria, biophysical and hydraulic characteristics of the area (permeable areas). • Definition of vision, objectives, and scale of the intervention, as well as its area of influence. • Definition of strategies and actions, portfolio of projects to be implemented. • Planning and design of the intervention. • Establishment of budget, funding, and financing. • Planning of implementation activities. • Evaluation and monitoring. • Maintenance.	2 – 3 weeks 1 – 2 weeks 4 – 6 weeks 1 – 2 weeks 3 – 7 weeks 6 – 10 weeks Support from IMPLAN and FSF required Constant monitoring

Preconditions

Project Conceptualization

- Review of the regulatory framework of the territory where there are previous studies of being a potential recharge zone (plans, programs, etc.)
- Definition of vision, scale and area of influence of the Project.
- Alignment of the project to plans and programs (regulatory framework).

Diagnosis

- Review of the biophysical characteristics of the potential intervention area.
- Identification of recharge zone with hydrological criteria, biophysical and hydraulic characteristics (permeable zones).

Technologies/Products

Implementation of nature-based solutions such as: reforestation, control and reduction of runoff for infiltration through filter dams, soil management through good practices, infiltration ditches and well-placed stone dams, regulating wetlands with native vegetation (riparia), management of shrub and arboreal vegetation in recharge zones, forest management and restoration, community surveillance programs and firefighting brigades

For the identification of priority areas, as well as for the evaluation of results, various remote sensing technologies, drone flights and geographic information systems can be applied.

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
AP (Action People): Number of people directly supported by the project regarding adaptation to the consequences of climate change or regarding ecosystem conservation	• Water security • Sustainability • Annual number of local floods	• 119m3/cap/a • 7% • Unknown	• CONAGUA – average availability of aquifers • Consejo de Cuenca del Río Bravo • Dirección de Medio ambiente y espacios urbanos
AE (Action Ecosystems): Ecosystem area enhanced or protected by project activities	• Local air quality index • Green space coverage • CO_2 emissions • Green areas in public spaces	• Good • 4.7 m2/(100k ha) • 16.4 tCO_2e/ha • 99%	• SINAICA • IMPLAN • Secretaría de Medio Ambiente

Tramway Line Connecting the City with the Industrial Parks

The tramp is a public transport option for passengers that transits for tramways within urban areas. The advantages of a tram are: i.) the reduction of the noise pollution, ii.) the decrease of pollutant emissions, and iii.) lower energy consumption by passenger compared to other transportation modes. This initiative fosters the use of public transport in the city, reducing the use of private vehicles and dependence on fossil fuels. In addition, a tramp is a way to active the tourism for its visual attractiveness. For the successful of the project, this initiative should be implemented under conditions of high passenger and transportation demand.

Objectives

Develop an efficient mass transportation system that connects the different areas of the city, which is environmentally friendly and affordable for the entire population.

Description

The tram reduces congestion, thus reducing the travel time from the city center to the industrial parks on the outskirts of the city.

It is justified only by a strong demand for transportation.

The project replaces the use of private automobiles and public transportation vehicles that use internal combustion engines, thereby reducing energy consumption and greenhouse gas emissions.

Alignment with city goals

Partial

Although the aim is to reduce congestion, it is not considered a necessity for the city.

Key project outputs

The project focuses on the following points:

- Reduction of vehicular traffic and emissions
- Project inclusive of all social classes.
- Integration with the public transportation system.
- Contributes to the generation of sustainable communities
- Tourist attraction of the city

Location

Saltillo

Minimum feasibility/Conditions

The project requires a significant initial investment for road infrastructure (exclusive lane and rails), units and stations. In addition, it is suggested to include an integrated payment system.

Replicability potential

Low

Because the initiative requires a significant initial investment and infrastructure, it makes difficult that can be a replicable project.

Impact

GHG Emission reduction potential

High

Next to the industrial sector, the mobility sector is the largest energy-consuming sector in Saltillo. This is, most importantly, due to the high share of individual mobility, strongly driven by the need by employees to commute to work in industrial parks in and outside the city. This project has a very high potential to reduce energy use and CO_2 emissions from fuel combustion in the transport sector by offering a massive transportation, public mobility alternative to individual transportation. At the same time, the electrification of the mobility sector is one of the most promising alternatives to decarbonize the mobility sector, by sector-coupling the mobility and electricity sector.

Climate change adaptation potential

Low

The adaptation is not the focus of this solution.

Extent of resettlement and rehabilitation issues

Low

The main goal of the project does not impact the resettlement and rehabilitation issues.

List of stakeholders

- IMPLAN
- Municipal transit institute
- Federal and municipal government
- Private transportation companies
- Universities and research centers
- Automotive industry

Engagement

Low

The implementation of the project requires a joint effort between public and private institutions that are not yet aligned on the same objective.

Target groups

- General public
- Industry
- Private and public companies

Persons reached

- Public and private employees
- Students
- General public

Regulatory constraints, risks, and barriers

Regulatory constraints

Medium

For its implementation it should be considered as a priority due to the high volume of investment. It should coordinate the will of the municipalities that make up the metropolitan area, so the state has to be involved.

Risk of project approval

High

It should coordinate the will of the municipalities that make up the metropolitan area

Other barriers and risks

- Political will
- Significant initial investment
- Infrastructure development

Project Financials

Approx. costs of the project

The Capital Expenses (CAPEX) and operating expenses (OPEX) for this project will comprise the following indicative elements:

Capital Expenses (CAPEX) components
Development of Tram Line infrastructure
Tram Cars
Yard / Tram cars Shed
Computer system (Hardware and software)
Route Planning execrise
Training expenses
Total CAPEX
Operating Expenses (OPEX)
Salaries of core staff
Materials and consumables
Repairs and maintenance
Energy Expenses (Electriity for charging)
Administrative expenses
Total OPEX

As such, total CAPEX will depend on the technologies chosen, scope, number of tram cars to purchased and deployed, among others. Total CAPEX is estimated to be around EUR 250 million.

Quantification possible at this stage? ***No***

Need for public sector funding support

High

The project requires substantial infrastructure expenses towards tram route lines, tram cars and associated electrical equipment. Such an infrastructure expenses can generally be funded through public finding. These projects tend to have long payback periods (more than 20 years). Therefore, need for public sector funding support is on the higher side.

Likelihood of securing public funding in support of the project

Moderate

While infrastructure expenses for this project idea is high, there is revenue generation from the tickets and seasonal passes. Besides, this project is expected to result in GHG emission reductions. In view of these positive aspects there is an adequate likelihood of securing public funding in support of the project.

Interest of private sector financial support involvement

Medium

There is a possibility of private sector interest mainly due to revenue generation aspect of the project. Public Private Partnership (PPP) approach may be possible for handling tram operations. Therefore, private sector investors will have medium level interest in supporting the project financially.

Cost Benefit Analysis

The proposed pilot project idea envisages setting up a tram line between the Saltillo City and industrial parks area. The tram reduces congestion, thus reducing the travel time that exists from the urban center of the city to the industrial parks located on the outskirts. The Project replaces the use of private cars as well as public transport vehicles that use internal combustion engines, thus reducing energy consumption and greenhouse gas emissions.

As the key information for a proper financial cost-benefit assessment are yet to be determined at this stage of the project preparation, the following **qualitative costs and benefits** could be anticipated:

Costs (Financial / Economic Costs):

- Tram line infrastructure cost
- Cost of Tram cars (Electric)
- Yard / Tram cars shed (Maintenance infrastructure)
- Route planning and system related costs
- Training expenses

Operating costs will include salaries of core operational staff, repairs and maintenance, materials and consumables and other overheads.

Social Costs:

- Higher transportation costs to individuals (using private vehicles)
- Higher environmental costs (higher CO_2 emissions due to traffic of fossil fuel vehicles.
- Traffic congestion

Financial benefits / Revenues:

- Ticketing revenue
- Advertising revenue
- Lower travelling costs for individuals (more savings).

Social benefits:

- Reduction of vehicular traffic and emissions hence lower exhaust emissions (lower GHG / CO_2 emissions)
- Inclusive project with all social classes.
- Integration with the public transport system.

Quantification possible at this stage? ***No***

Investment Plan
The project is expected to be financed by Central Government, State Government, Saltillo Municipality, IMPLAN (in-kind), private sector investors.

Indicative share of financing / Investment Plan:

Indicative Means of Financing	Percentage Share
Central and state governments	50%
Saltillo Municipality	25%
IMPLAN (In-kind)	5%
Private Sector Organisations	20%
Total	**100%**

Quantification possible at this stage? ***No***

Major Assumptions
- Total cost of the project is yet to be ascertained hence investment plan mentioned is an indicative.
- No quantitative data is available at this stage and **hence qualitative cost-benefit analysis** has been presented.

There will be substantial amount of expenses towards tram line infrastructure, tram cars and other systems. Thus, total cost of the project is expected to be in the order of EUR 250 million.

Envisaged Activities and Technologies

Envisaged Activities	Timeframe

• Comprehensive assessment of the current public transportation system.
• Project feasibility analysis
  ○ Market study
  ○ Market segmentation
• Technical study	

○ Location study ○ Project design ○ Civil works • Financial study • Complementary studies ○ Legal, social, political, ecological evaluation	
• Soil survey	6 months
• Final design	6 months
• Civil Works	2 years
• Value and services	5 years
• Urban development around the intervention	10 years

Preconditions

- Political will
- Cost Benefit Analysis for Project Development and Implementation
- Assessment of current mobility situation
- Electrical infrastructure
- System administrator

Technologies/Products

- Automatic fare collection stations
- Public transportation integrated payment system
- Integrated mobility system (MaaS)
- Optimization of system operation
- Energy from renewable sources

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
Mobility	Modal split: Share of traffic by public transport	32.06%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 36
Mobility	GHG emissions per capita	6.22 M	Greenhouse emisión inventory for Coahuila state. Inventario de gases y compuestos de efecto invernadero del estado de Coahuila (2016) pp.21
Mobility	Travel time by public transport	39.52 min	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 41
Mobility	Portion of household expenditures devoted to transport, particularly by lower-income households.	22.3 %	Encuesta Nacional de Ingresos y Gastos de los Hogares (INEGI, 2018)

Mobility as a Service (MaaS)

Mobility as a Service (MaaS) combines the different current mobility trends with the public transport offer without considering a dependence on the private vehicle. This establishes a challenge and opportunity for evolution for traditional mobility services and actors in cities, representing an opportunity for new ideas and participants. In Latin America there are several providers of this service in the main cities of the continent, which have demonstrated success in the results obtained using these platforms.

The implementation of Mobility as a Service is a global trend that transforms the way of moving through technological innovation. This new way of thinking about transport and new methods of collaboration are fundamental to guarantee a continuous urban flow through more efficient alternative modes of transport. MaaS is based on the connectivity, access, and affordability of the different transport options present in the region of interest.

Objectives

Integrate different modes of transport in a single platform of public access

Description

- Have a single platform that provides information in real time of all the mobility systems available in the city to move from one desired point to another.
- Have a single payment method from a consolidated integrated public transport system

Alignment with city goals

Partial

It seeks to promote alternative modes of transportation to the car, however, public transportation is mentioned.

Key project outputs

The project focuses on the following points:

- Create a private company - universities - government consortium to implement the MaaS platform.
- Deploy with MaaS providers
- Integration program of the different transport options (BRT, conventional buses, shared bicycle), etc.
- Use of MaaS information to design and implement mobility improvement strategies.

Location

Metropolitan Area of Saltillo

Minimum feasibility/Conditions

Must have:

- Online payment method
- Minimum coverage area (entire city)
- Integrate modes of transport (buses, bicycles, taxis ...)
- System operator independent of governmental authority
- Promotion of walking as a mode of transport

It is recommended to have:

- Other modes of transport (scooters, electric motorcycles)
- Use the information generated to reorganize routes and schedules of the Bus Service.

It may have:

- Buses with the ability to transport bicycles and other micromobility vehicles.

Replicability potential

Medium

Due to the need for investment, it would be difficult.

Impact

GHG Emission reduction potential

High

Improving public mobility is key to reduce individual transportation and hence reduce energy related CO_2 emissions in the transportation sector. Bundling different public transportation modes into one platform and improving access to public mobility can have a substantial impact on individual mobility and thereby reduce CO_2 emission in the mobility sector.

Climate change adaptation potential

Low

Extent of resettlement and rehabilitation issues

Medium

The connectivity infrastructure would need to be adapted.

List of stakeholders

- Municipality
- Public transport service providers
- Citizens organizations
- Universities and research centers

Engagement

Low

Citizen participation would be minimal.

Target groups

- Transportation service companies
- Citizen groups
- Municipality
- Universities and research centers

Persons reached

- City mayor
- Public transport concessionaires
- Municipal Institute of Transportation
- IMPLAN

Regulatory constraints, risks, and barriers

Regulatory constraints

High

The public transportation scheme with concessionaires

Risk of project approval

Moderate

Stakeholder resistance

Other barriers and risks

- Lack of support from municipal authorities

- Risk in low acceptance
- Resistance of current actors to integration
- Risk generated by invasion of the platform

Project Financials

Approx. costs of the project

The CAPEX and OPEX for this project will comprise the following main elements:

Capital Expenses (CAPEX) components
Cost Heads
Models development
App development cost
Software cost
Specialised studies
Training expenses
Awareness and education (one time expenses)
Total CAPEX

Operating Expenses (OPEX)
Cost Heads
Salaries of core staff
Materials and consumables
Energy Expenses
Software maintenance and app upgrades
Administrative expenses
Total Operating Expenses / year

CAPEX will be estimated on the basis of the project design document (PDD) or expanded report on the project ideas selected.

Need for public sector funding support

Low

The proposed pilot project mainly involves systems development and associated apps and software development. Besides there will be training and awareness creation expenses. Thus, the cost of the project will be several hundred Euros. There will not be any high expenditure on equipment or construction of infrastructure elements. All these factors will lead to lower need for public sector funding.

Likelihood of securing public funding in support of the project

Moderate

The project needs funding for soft costs. The public funding support for the project will be forthcoming however will need some time for justification. Secondly, positive support from private sector will help in creating overall positive impression. We feel that there is moderate likelihood of securing public funding.

Interest of private sector financial support involvement

High

Considering the importance of the subject (transportation) and that the project needs systems development (soft costs), the private sector may be adequately interested in supporting the project. Many corporates may provide contributions as their **social responsibility**.

Cost Benefit Analysis

The proposed pilot project envisages developing and implementing a platform for mobility as a service (MaaS) through a business-university-government consortium. The project will be implemented with MaaS providers. The project will develop a system (or Program) for the integration of different transportation options (BRT, shared buses, bike sharing), etc. The pilot project proposes to use MaaS information to design and implement mobility improvement strategies.

As the key information for a financial cost-benefit assessment are yet to be worked out at this stage of the project preparation, the following **costs and benefits** could be anticipated:

Financial costs:

- Models development
- App development cost
- Software cost
- Specialised studies
- Training expenses

Social costs:

- Higher traffic density
- Higher level of CO_2 emission
- Health issues due to high level of pollution

Social Benefits:

- Reduction of vehicular traffic and emissions
- Low cost compared to other alternatives.
- Integration with the public transportation system.
- Contributes to the generation of sustainable communities.

Quantification possible at this stage? ***No***

Investment Plan

The proposed pilot project idea can be financed by Municipal Corporation of Saltillo, IMPLAN, private sector organisations, University and citizen groups.

Indicative investment plan is as follows:

Indicative Means of Financing	% Share
Saltillo Municipality	15%
IMPLAN (In-kind)	5%
Private Sector Organisations	70%
University / Research groups	5%
Citizen Groups	5%
Total	**100%**

Quantification possible at this stage? ***No***

Major Assumptions

- The proposed project does not envisage any direct revenue generation.
- Total cost of the project is yet to be ascertained hence **investment plan mentioned is an indicative**.
- The pilot project involves systems development and software integration.
- Financing of the project is mainly through **grant** funding.

Support from NGOs can be explored for financing studies under the project.

Envisaged Activities and Technologies

Envisaged Activities	Timeframe
• Design of implementation plan • Consortium generation • Pilot project • Assessment and improvement	3 months 12 months 12 months 12 months

• Expansion	3 years

Preconditions

- Political will (Leadership of government authorities)
- Include the project in the city's PACMUN
- Training for decision makers

Technologies/Products

Interactive platform that integrates the different modes of transport and indicates to the user the most efficient mode in relation to travel time and cost.

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
Mobility	Hours spending in congestion	NA	
Modal split	Modal share by public transport	32.06%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 36
	Active users if MaaS	0	There is no MaaS platform available in Saltillo
	Integrated services	0	There is no MaaS platform available in Saltillo

Sustainable Industrial Park

The industry sector is one of the most relevant sectors in terms of its overall sustainability impact, from local pollution to greenhouse gas emissions. The over 40 industrial parks in Saltillo region represents a unique opportunity to transform Saltillo's industries to a more sustainable model. By clustering a number of industry actors in proximity to each other, sustainable industrial park offer the exceptional opportunity to address a number of industrial actors in an organized and simultaneous manner and therefore transform the industrial sector as a whole.

Objectives

The main objective of sustainable industrial parks is to tap into the high potential of the industry sector to improve energy efficiency, utilize renewable energies, reduce waste, water consumption, reduce air, water and soil pollution and to reduce greenhouse gas emissions.

Description

There is large space to tackle energy efficiency and renewable energy self-supply within Saltillo´s industrial parks. Addressing the sustainability of industrial parks bears a number of potential benefits:

- Possibility to address a number of industrial actors clustered in the industrial park
- Improvement of energy efficiency and higher use of renewable energies and thus reduction of greenhouse gas emissions.
- Reduction of local pollution, e.g. less air, water and soil contamination
- Awareness raising for the set of industries located in the industrial park

Improvement of industrial competitiveness by reducing costs of energy, creation of employment, creation of local value added.

Alignment with city goals

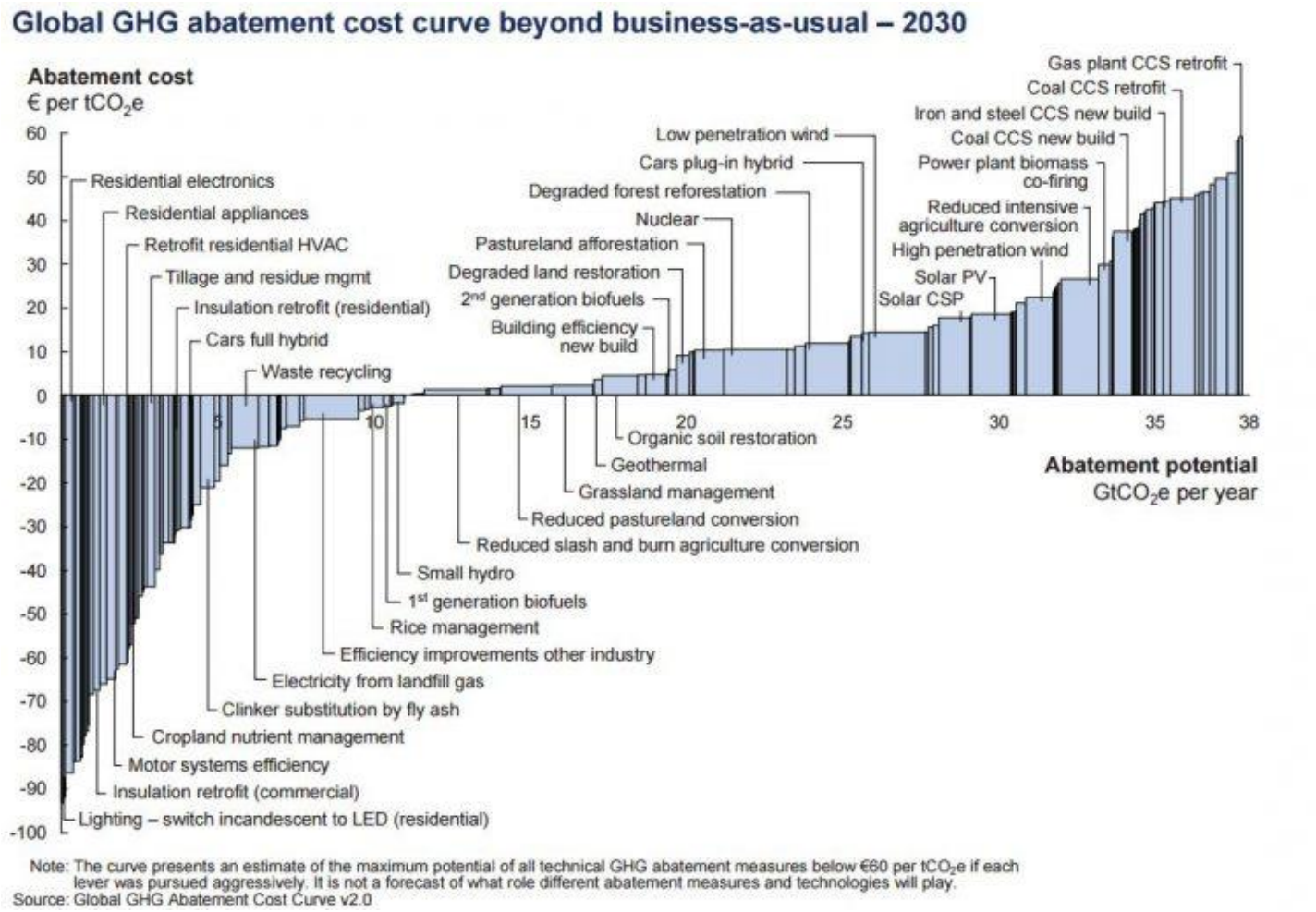
Partial

It is not made explicit, but good environmental practices are promoted in the industrial sector.

Key project outputs

The project focuses on the following points:

- The project should focus on the high potential to reduce waste, water consumption, energy consumption, to improve air, water and soil pollution, as well as to reduce greenhouse gas emissions. However, the industrial park management cannot impose regulations for industries to use renewable energy or improve energy or water efficiency. For that reason, a sustainable industrial park can only be achieved with an active participation of industrial park management, of the industries located in park, as well as a clear regulatory framework.
- The implementation of energy efficiency measures and renewable energies might be a financially viable alternative to status quo technologies. Energy efficiency measures typically have negative costs, that is, the initial investment pays off by the monetary value of the energy savings by the implemented measure. Similarly, massive cost reductions in equipment for key renewable technologies, most importantly solar PV, might lead to cheaper costs of self-supply than grid electricity. Despite its generic nature, for reference, marginal abatement cost curves can be used to provide a very rough estimate of costs ranges of different project measures. Typical measures in the industrial sector, such as motor systems, efficient lightning and appliances, waste recycling, clinker substitution by fly ash, show negative GHG abatement costs. Thus, the implementation of measures in a sustainable industrial park can focus first in those measures that have negative costs, that is, those measures representing viable investment options and thereby improve profits and competitiveness of participating industries.



source: https://www.cbd.int/financial/doc/Pathwaystoalowcarboneconomy.pdf

Location

Any of Saltillo´s over 40 industrial parks

Minimum feasibility/Conditions

Realizing the project would require the participation of industrial park management, the participation of industries located in park, as well as a clear regulatory framework (representing a chicken and egg problem, as the regulatory framework must first be developed in the Peruvian context). Further, realizing the project would require a clear institutional structure, that is, a strategic planning document addressing the topic, defining clear targets, defining a governing body and monitoring progress. Also, a partnership with the electricity distribution company and regulators could be useful, as for to define clear regulations with regard to the use of i.e. self-supply of electricity.

Replicability potential

High

Sustainable industrial parks can be a model to follow and there are numerous examples of sustainable industrial parks worldwide. A general overview on the United Nations Framework for Eco Industrial Parks can be found here: https://www.unido.org/our-focus-safeguarding-environment-resource-efficient-and-low-carbon-industrial-production/eco-industrial-parks

Impact

GHG Emission reduction potential

High

Industrial parks cluster a number of industrial facilities in regional proximity to each other. The GHG emissions abatement potential is very high, considering that the industrial sector is one of the largest sectors in terms of GHG emissions in Saltillo.

Climate change adaptation potential

N.A.

Generally, this project aims at climate change and local pollution mitigation, the climate change adaptation possibility is rather low.

Extent of resettlement and rehabilitation issues

Low

There is no resettlement or rehabilitation issues involved in the greening of the already existing industrial park area.

List of stakeholders

A possible consortium should comprise:

- the industrial park management
- the industries located in its perimeter
- the electricity distribution company
- the regulators
- the providers of energy efficiency equipment and services
- the provider of renewable energy equipment and services

Engagement

Medium

The industrial sector participates in the environmental programs that have been implemented.

Target groups

Most relevant actors would be:

- Industrial park management
- Industries located in the industrial park
- Regulatory entity
- Providers of energy efficiency services

Providers of renewable energy equipment and services

Persons reached

-

Regulatory constraints, risks, and barriers

Regulatory constraints

Medium

While the industrial park management, as well as industries, have room to act by themselves, the lack of clear regulations for certain sustainable measures, such as the use of solar PV, creates a problem for their implementation. Thus, partnering with the electricity distribution company and with the regulator bears an opportunity to create non-existent regulatory schemes.

Risk of project approval

Low

This project can be initiated and carried out as a private sector initiative, or a public private partnership.

Other barriers and risks

-

Project Financials

Approx. costs of the project

Although at this stage of the project it is somewhat complex to calculate exact capital and operating costs, but an estimate can be made of the items needed throughout the project. These items are presented below:

Capital investment (CAPEX) components

- Waste-Water Treatment Plant
- Solar/Wind power generation plant
- Efficient Lighting
- Sensors and automation equipment
- Waste collection system
- Efficient motors and energy-efficient assets

Operating expenses (OPEX) components

- Administrative expenses
- Salaries
- Energy expenses
- Other services
- Maintenance
- Financial expenses
- Interest paid
- Loss/gain in TRM

It is estimated that the project as a whole will have a capital expenditure of $50,000 USD and it will be very complex to determine an approximate value because it will depend on the complexity and size of the industrial park. It is also common for these projects to grow in phases.

Is quantification possible in this phase? ***No***

Need for public sector funding support

High

Usually, the need for public resources for this type of construction is quite high. Not necessarily in capital contribution, but it can also be with tax benefits from the government and preparing an attractive investment ecosystem for companies to participate in it. In any case, since it is such a relevant project for the region, it is foreseen that the region will participate.

Likelihood of securing public funding in support of the project

Low

As mentioned above, being a project also with private interests it will be very complex to get direct funding from the government. However, a suitable investment ecosystem is most urgently needed.

Interest of private sector financial support involvement

High

Industrial parks have recently been enjoying immense popularity. The boom in e-commerce and other extractive or production industries means that more and more suitable and efficient/sustainable spaces are required. For this reason, there are several private investors specialized in industrial parks and it will not be complex to raise capital.

Cost Benefit Analysis

Below is a summary table of the economic, environmental and social impacts of the project. This is a first approximation of those benefits and costs without a possible quantification, but later, if selected, each aspect should be quantified:

Financial benefits:

- Savings in energy consumption
- Circular economy
- Sustainable energy production and less exposure to grid power price volatility

Financial costs:

- Wastewater treatment plant
- Solar/wind power generation plant
- Efficient lighting
- Sensors and automation equipment
- Waste collection systems
- Efficient motors and energy efficiency assets

Environmental benefits:

- Energy saving
- Circular economy
- Climate change mitigation
- Reduced GHG emissions
- Reduced waste and wastewater

Environmental costs:

- Visual contamination (if present)
- Extensive land use

Social benefits:

- Employment generation
- Climate change awareness
- Community involvement

Investment Plan

The investment structure of the project presented below is an estimate and assumption of how the project stakeholders would participate. In no case should it be taken as mandatory. In addition, where possible, similar investment structures were used in international projects, considering the local context.

Indicative means of financing	Percentage share
Saltillo City	15%
State of Coahuila (key ministries)	25%
Private investors	50%
International cooperation	10%

Universities	0%

Major Assumptions

- The total cost of the project has not yet been determined, so the above investment plan is indicative.
- The project and its impact will depend entirely on the size and ambition of the investors/community.

Envisaged Activities and Technologies

Envisaged Activities	Timeframe
Most important activities are the following: • Coordinate initiative over industrial park management • Create an analysis of status quo of sustainability performance of industries located in the park • Identify energy efficiency, renewable energies, waste management, water efficiency potentials • Identify best practices to address the existent potentials (e.g. replacement of industrial motors with best-of-class, replacement of inefficient lightning with LEDs, identify if water reuse is possible, installation of solar panels, etc.) • Disseminate best practices and raise awareness so other industries (in- and outside of industrial parks).	In terms of timeframe, the analysis of status quo and identification of measures and best practicies is envisioned to take between 1 to 1.5 years, while the implementation of measures around 2 years.

Preconditions

Most important precondition is the active participation of following actors:

- Participation of industrial park management
- Participation of industries located in park
- Clear regulatory framework (representing a chicken and egg problem, as the regulatory framework must first be developed in the Peruvian context)

Technologies/Products

Generally, the applied technologies depend very much on the industries located in the industrial park. Generic technologies that might apply to many parks are:

- Solar photovoltaics
- Highly efficient industrial motors
- Highly efficient cooling devices
- Highly efficient heat exchangers
- Highly efficient appliances, devices and lightning
- Highly efficient water use technologies

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
AM (Action Mitigation): Reduced greenhouse gas emissions and expansion of carbon storage in the project / program field	**1** CO_2 emissions reduction .		1. Data on energy and fuels consumption before and after interventions.
AM (Action Mitigation): Water use	**2** Water reuse		Water reuse volumes.

Solar Photovoltaic Energy in Universities as a Real Laboratory

Considering the unique solar resources of the Coahuila state, this project has the objective to implement solar photovoltaic energy in universities as real laboratory. This initiative will strengthen new building capacities in Saltillo, and it contributes to the reduction of energy consumption from fossil fuels. Thus, indirectly contribute to the mitigation of greenhouses gases. The solution are real demonstrative energy projects, located at university campuses, which can be scalable and replicable in the commercial, residential, and industrial sector, based on the knowledge and experiences of the universities. This project foster research and innovation on renewable energy in universities, however it requires a significant initial investment to be implemented.

Objectives

- Implement solar photovoltaic energy in universities as real laboratories.
- Foster research and innovation on renewable energy and energy efficiency in Saltillo.
- Strengthen building capacities on energy topics within universities.

Description

This project proposes using universities as laboratories that implement solar photovoltaic energy, based on the exceptional solar resources of the region, trying to combine energy efficiency and renewable energy for a net zero balance of energy. This will be a real demonstrative project that could be scalable and replicable on the commercial, residential, and industrial sector, based on the building capacities developed in the universities. It means, that universities could become solution providers that foster the transition to a low-carbon energy in the city.

The new energy infrastructure within the universities will foster the research and innovation in the energy sector for the city, being a referent in the north region of Mexico. New building capacities will be promoting in their students, preparing next generation with a comprehensive background in sustainable energy and universities will have the opportunity to offer specialized courses on energy topics for government and industrial sector.

Alignment with city goals

Partial

The Saltillo municipality has already implemented initiatives to reduce the energy consumption in buildings, and this project converge with these initiatives.

Key project outputs

The outputs and benefits of the project could be the following:

- Reduction of the electricity consumption from fossil fuels in buildings
- Development of new building capacities in the city
- Demonstrative projects of renewable energy in Saltillo

Minimum feasibility/Conditions

The project requires the willingness of the universities to facilitate their infrastructure in order to install the solar panels and the instrumentation requires for its operation and control.

Replicability potential

High

This solution could be replicable and scalable in the commercial, industrial, and residential sector, based on the experiences and knowledge of universities.

Impact

GHG Emission reduction potential

Low

While universities can play a key role as solution providers for the technical implementation of solar PV systems, the project aims to foster the local expertise of universities with regard to solar PV and thus the direct impact on GHG is limited.

Climate change adaptation potential

N.A.

The adaptation is not the focus of this solution.

Extent of resettlement and rehabilitation issues

Low

The main goal of the project does not impact the resettlement and rehabilitation issues.

List of stakeholders

- Universities
- Private consultants
- Providers of solar technologies
- The Federal Electricity Commission
- IMPLAN

Engagement

High

Universities have the willingness to cooperate in projects that promotes the sustainability in the city, and four of them have the building capacity through their environmental programs to implement this solution.

Target groups

- Students
- Interested citizens
- Professors
- Researchers

Industry energy leaders

Persons reached

All people interested in the installation and operation of renewable energy system from solar energy.

Regulatory constraints

Medium

There are federal electricity regulations that could restrict the capacity of energy generation from solar energy.

Risk of project approval

Medium

The project does not interfere with the city goals and is attractive as a real demonstrative solution, however depending to the final energy to be generated it could be relatively cost-intensive.

Other barriers and risks

-

Project Financials

Approx. costs of the project

The CAPEX and OPEX for this project will comprise the following main elements:

Capital Expenses (CAPEX) components
Solar PV electricity systems
Associated equipment for experiments
Hardware and software associated
Training and Education
Total CAPEX
Operating Expenses (OPEX)
Salaries of core staff
Materials and consumables
Energy Expenses (Net of generation)
Other utilities
Maintenance
Total OPEX

Total CAPEX will be estimated on the basis of the expanded version on detailed project feasibility report.

Quantification possible at this stage? ***No***

Need for public sector funding support

Moderate

The proposed pilot project has principal expenses towards solar PV systems installation. Considering universities as public sector entities, moderate level of funding support is expected. Solar PV systems are expected to be of moderate (kW) size with main purpose as demonstration of technology. The project is expected to generate electricity bill savings (electricity self-consumption from solar PV).

Likelihood of securing public funding in support of the project

Moderate

Local university(ies) (as public entities) can fund a part of the cost of the project out of budget. Therefore, moderate likelihood of securing funding in support of the project is expected. Private sector investors such as solar PV systems manufacturers can also partly finance the project.

Interest of private sector financial support involvement

High

The proposed project is expected to result in to multiple of projects in residential and industrial sectors after successful demonstration. These factors will result into high level of interest of private sector to support project.

Cost Benefit Analysis

The proposed pilot project proposes to demonstrate solar PV technology and its efficacy. The objective of the project is to demonstrate the reductions in energy consumption through the real-scale implementation of energy technologies. The project can be replicated in residential, commercial and industrial sectors.

This is a small project, and the financial cost-benefit may not be important. Cost of the project is yet to be worked out at this stage of the project preparation, the following **costs and benefits** could be anticipated:

Financial costs:

- Solar PV systems
- Experimentation and testing equipment
- Training and education expenses

Financial benefit:

- Electricity bill savings from solar PV electricity generation.

Social Benefits:

- Lower GHG emissions from reduced electricity consumption from the grid
- Make visible the benefits of the implementation of energy technologies

- Promotes the leadership of universities towards the energy transition as a benchmark in the city
- Strengthens the formation of human capital in energy matters
- Strengthens research and development

Quantification possible at this stage? ***No***

Investment Plan
The proposed project is expected to be financed as follows:

Indicative Means of Financing	% Share
Universities	60%
Private Sector Investors	40%
Total	**100%**

It is expected that private sector investors to fund up to 40% of the cost of the project.

Quantification possible at this stage? ***No***

Major Assumptions
- The proposed project envisages monetary savings from **electricity bill savings**. (Solar PV electricity generation)
- Total cost of the project is yet to be ascertained hence **investment plan mentioned is an indicative**.
- The pilot project involves demonstration of solar PV technology and hence cost benefit is of less significance. Education and training are primary objectives.

Envisaged Activities and Technologies

Envisaged Activities	Timeframe
Definition of the universities that would implement the solar panel system.	6 months
Site selection and design of the solar panel system within the universities.	2 months
Acquisition of the solar technologies according to the site requirements	1 year
Acquisition and set up of the instrumentation system for the operation of the solar panels.	1 year

Preconditions
- Financing for the acquisition of energy technologies
- Local universities are willing to lend their facilities for the development of the laboratory.

Technologies/Products
- Solar photovoltaic technology
- Instrumentation system based on Internet of things

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
Energy	Share of the renewable energy in the power mix	< 20% Grid electricity	

Technological Update of Public Transport in Saltillo

The policy of modernizing public transport is based on technical instrumentation to improve performance indicators and user perception. These renewed systems must include the use of information technology and permanent monitoring of all units, which must meet current emission standards.

The main results include reduction of pollutants, greenhouse gases, noise, and traffic. As well as more efficient compared to traditional services. For the development of these initiatives, government support is essential and focused on the user: improving quality, various mobility options, integrated fare and exclusive lanes, and modern and adequate infrastructure.

Objectives

Ensure that public transport operates with a modern bus fleet (replace the vehicles that provide public transport with newer vehicles that meet the emission standards of the current regulations)

Description

- Promote public transport operating with a modern fleet of buses (electric, natural gas).
- Reorganization of public transport in the city.
- Reduced operating cost compared to combustion technologies.
- More efficient and comfortable service for citizens.
- The improvement in air quality in the city will be reflected, allowing the reduction of greenhouse gas emissions.
- Reduction of noise pollution in the city.

Alignment with city goals

Partial

It is proposed to improve public transportation; however, the use of technology is not considered due to the investment required

Key project outputs

The project focuses on the following points:

- Operation with lower fuel costs.
- It contributes to the improvement of the health of the inhabitants of the city.
- Incentives from the government.
- Reduction in greenhouse effect gasses emissions
- Focused on citizens in general, in high traffic sectors.
- https://www.uitp.org/publications/bus-fleet-renewal-checklist/
- http://pdf.wri.org/modernizing_public_transportation_es.pdf

Location

Metropolitan Area of Saltillo

Minimum feasibility/Conditions

- Discourage the use of the personal car.
- Motivate the use of the public transport service.
- Greenhouse gas reduction

It must have:

- Study of the current state of the operation of the public transport system.
- Strategies for the renewal of the vehicle fleet.
- Strategies for the reorganization of public transport.
- Profitability and financing plans for service providers

It is recommended to have.

- Solutions that allow decision makers to benefit from an efficient and sustainable service, without impact on investments and an optimized management of urban transport.

- Integrated to mobility as a service system (MaaS).

Replicability potential

Medium

Due to the need for investment, it would be difficult.

Impact

GHG Emission reduction potential

High

Improving public mobility is key to reduce individual transportation and hence reduce energy related CO_2 emissions in the transportation sector. Improving both the technologies used and access to public mobility can have a substantial impact on individual mobility and thereby reduce CO_2 emission in the mobility sector.

Climate change adaptation potential

Medium

Extent of resettlement and rehabilitation issues

Medium

It would be necessary to adapt the public transportation fleet.

List of stakeholders

- Automotive companies
- Public transport service companies
- Government authorities
- Community

Engagement

Low

The participation would be from the private sector

Target groups

- Electric bus manufacturers and investors.
- IMPLAN.
- Service operator.
- Government.
- Citizens

Persons reached

- Public transport concessionaires
- Municipal Institute of Transportation
- IMPLAN

Regulatory constraints, risks, and barriers

Regulatory constraints

High

The public transportation scheme based on concessionaires

Risk of project approval

Moderate

The public transport scheme based on concessionaires and investment could make implementation difficult.

Other barriers and risks

- High political power of the transport service providers
- High cost of initial investment
- Government support and service providers

Project Financials

Approx. costs of the project

The CAPEX and OPEX for this project will comprise the following main elements:

Capital Expenses (CAPEX) components
Cost Heads
Cost of new Buses (Electric) + Charging stations
Optimization studies
Software costs as applicable
Information and awareness development
Training expenses
Total CAPEX

Operating Expenses (OPEX)
Cost Heads
Salaries of core staff
Materials and consumables
Repairs and maintenance
Energy Expenses (Electriity for charging)
Administrative expenses
Total Operating Expenses / year

CAPEX will be estimated on the basis of the project design document (PDD) or expanded report on the project ideas selected.

Need for public sector funding support

High

The proposed pilot project mainly involves procuring modern fleet of buses for the public transportation strategy development and systems development. There is substantial amount of capital expenditure involved. Also the project proposes to undertake training and awareness creation about sustainability. All these factors will lead to high need for public sector funding.

Likelihood of securing public funding in support of the project

Low

The project needs funding for large capital costs. While the project can help reducing pollution problem, however the scale of cost of the project itself indicates lower likelihood of securing public funding support.

Interest of private sector financial support involvement

High

Considering the importance of the subject (transportation) and that the project can have high level of visibility. The private sector especially electric buses manufacturers may be adequately interested in supporting this project. Many corporates may provide contributions as their **corporate social responsibility**

Cost Benefit Analysis
The pilot project proposes to ensure that public transportation operates with a modern fleet of buses (replace public transportation vehicles with newer vehicles that meet current emission standards). Main steps of the project include diagnosis of the current operation of the public passenger transportation system and design of strategies for the renewal of the vehicle fleet, including the optimization and reorganization of public passenger transportation, to ensure profitability for companies and maximize service to users.

As the key information for a financial cost-benefit assessment are yet to be worked out at this stage of the project preparation, the following **costs and benefits** could be anticipated:

Financial costs:

- Cost of new Buses (Electric) + Charging stations
- Optimization studies
- Software costs as applicable
- Information and awareness development
- Training expenses

Social costs:

- Increased operating costs for public transport
- Inefficient transport systems
- Higher level of CO_2 emission
- Health issues due to high level of pollution

Social Benefits:

- Better acceptance and use of public transport
- Lower emission and cleaner air
- Reduction of noise pollution in the city
- Improved health

Quantification possible at this stage? ***No***

Investment Plan
The proposed project can be financed by Saltillo Municipal Corporation (SMC), IMPLAN, private sector companies and local electricity distribution company. The indicative Investment Plan is as follows:

Indicative Means of Financing	% Share
Saltillo Municipality	25%
IMPLAN (In-kind)	5%
Private Sector Organisations	60%
Electricity distribution company	10%
Total	**100%**

Quantification possible at this stage? ***No***

Major Assumptions
- The proposed project may generate **marginal revenues.**
- Total cost of the project is yet to be ascertained hence **investment plan mentioned is an indicative**.
- The pilot project involves procurement of capital goods. Hence cost will be on the higher side.

Financing of the project is mainly through **grants and soft debt**

Envisaged Activities and Technologies

Activities	Timeframe
• Diagnosis of the current operation of public passenger transport	6 months
• Design of strategies for the renewal of the vehicle fleet that includes the optimization and reorganization of public passenger transport, to ensure profitability for companies and maximize service to users	6 months 12 months
• Reconcile implementation plan	6 months
• Pilot project	

Preconditions

- Leadership of government authorities
- Diagnosis of the actual current state
- Include the project in the city's PACMUN
- Include transport service providers

Technologies/Products

Modern buses for public transport fleet (low emissions and modern service)

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
	Modal share by public transportation	32.06%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 36
	share of traffic by personal vehicles (cars, motorcycles etc.)	38.07%	IMPLAN_Sistema Indicadores Mobilidad urbana (2015) Pg. 36
	Hours spending in congestion	NA	

Electric Buses

Electric vehicles are being used for urban transportation in the main Asian and European cities, despite the high initial cost of the implementation of this technology, worldwide there are several car manufacturers interested in promoting its application. The operating environment must be analysed based on the energy consumption during the actual operation of traditional buses, this to ensure that the proposed fleet meets the actual demand due to the autonomy of electric vehicles. In addition, a pre-feasibility analysis is mandatory to propose various scenarios of a pilot project on specific routes, then economic efficiency analyses must be carried out to obtain the benefit of this project. The results in other cities and countries show economic benefits after 5 years of implementation.

Objectives

Gradually replace the current bus fleet (based on combustion engines) with electric buses.

Description

- Operating with electric buses substantially reduces the emissions of pollutants generated by the transportation sector.
- The acquisition of electric buses can reach the point where their operations become profitable.
- CO_2 emissions from the public transport sector will be significantly reduced, in turn reducing the use of fossil fuel and improving the air quality of the city.
- This project reduces energy consumption and greenhouse gas emissions.

Alignment with city goals

Partial

It is proposed to improve public transportation; however, the use of technology is not considered due to the investment required

Key project outputs

The project focuses on the following points:

- Improved air quality in the city
- Greenhouse gas reduction.
- Coping with climate change.
- Reduction of consumption of fossil fuels.
- Improvement of public transport in the city.

Must have:

- Baseline study (loads demanded of current buses)
- Electric buses, designed with the requirements of the city.
- Buses free of noise, vibrations and polluting emissions.
- Appropriate charging infrastructure.
- Consortium company - universities - government to implement electric transport in the city.

It is recommended to have:

- Model of ownership and operation of electric buses (business model).
- Tax incentives by the government.
- Allied with the electric power sector.

Location

Saltillo Metropolitan Area

Minimum feasibility/Conditions

- Encourage the use of public transport.
- Greenhouse gas reduction.
- Reduction of consumption of fossil fuels.
- Improve air quality in the city.

Replicability potential

Medium

Due to the need for investment it would be difficult.

Impact

GHG Emission reduction potential

Medium

Improving public mobility is key to reduce individual transportation and hence reduce energy related CO_2 emissions in the transportation sector. Improving both the technologies used and access to public mobility can have a substantial impact on individual mobility and thereby reduce CO_2 emission in the mobility sector.

Climate change adaptation potential

Medium

Extent of resettlement and rehabilitation issues

Medium

It would be necessary to adapt the public transportation fleet.

List of stakeholders

- Electric bus manufacturers and investors.
- IMPLAN.
- Service operator.
- Government.
- Electric power distribution companies.

Engagement

Low

The participation would be from the private sector

Target groups

- Citizens
- Government / municipality
- Automotive companies
- Electric power distributors

Persons reached

- IMPLAN
- Municipal Institute of Transportation
- Public transport concessionaires.

Regulatory constraints, risks, and barriers

Regulatory constraints

High

The public transportation scheme based on concessionaires

Risk of project approval

Moderate

The public transport scheme based on concessionaires and investment could make implementation difficult.

Other barriers and risks

- High cost of initial investment
- Lack of support from the government and service providers

Project Financials

Approx. costs of the project

The CAPEX and OPEX for this project will comprise the following main elements:

Capital Expenses (CAPEX) components
Cost Heads
Cost of new Buses (Electric) + Charging stations
Associated studies (sizing of buses to suit city needs)
Harmonization of local automotive industry
Technology and Product development expenses
Training expenses
Total CAPEX

Operating Expenses (OPEX)
Cost Heads
Salaries of core staff
Materials and consumables
Electricity expenses (Energy)
Repairs and maintenance
Administrative expenses
Total Operating Expenses / year

CAPEX will be estimated on the basis of the project design document (PDD) or expanded report on the project ideas selected.

Need for public sector funding support

High

The proposed pilot project mainly involves first conducting studies, developing new designs of buses and then harmonizing the local manufacturing to suit new designs and procuring fleet of buses for the public transportation. There is substantial amount of capital expenditure involved. All these factors will lead to high need for public sector funding.

Likelihood of securing public funding in support of the project

Low

The project needs funding for large capital costs. While the project can help reducing pollution problem, however the scale of cost of the project itself indicates lower likelihood of securing public funding support.

Interest of private sector financial support involvement

High

Considering the importance of the subject (transportation) and that the project can have high level of visibility. The private sector especially local manufacturers may be adequately interested in supporting this project. Many corporates may provide contributions as their **corporate social responsibility**.

Cost Benefit Analysis

The proposed project envisages gradual replacement of the current fleet of buses (with combustion engines) with electric buses. The project proposes creating a business-university-government consortium implement electric transportation in the city. The other steps include establishing a baseline (loads demanded from current buses), sizing of the most appropriate electric bus for local conditions, harmonizing the local automotive industry for the manufacture of electric buses at competitive prices, training of transportation service providers in the use of electric buses. Then implement the pilot project with private passenger transportation.

As the key information for a financial cost-benefit assessment are yet to be worked out at this stage of the project preparation, the following **costs and benefits** could be anticipated:

Financial costs:

- Cost of new Buses (Electric) + Charging stations
- Associated studies (sizing of buses to suit city needs)
- Harmonization of local automotive industry
- Technology and Product development expenses
- Training expenses

Social costs:

- Increased operating costs due to petroleum fuel use
- Higher level of CO_2 emission
- Health issues due to high level of pollution

Social Benefits:

- Improvement of the city's air quality
- Reduction of greenhouse gases.
- Tackling climate change.
- Reduction of fossil fuel consumption.
- Improvement of public transportation in the city

Quantification possible at this stage? ***No***

Investment Plan
The proposed project can be financed by Saltillo Municipal Corporation (SMC), IMPLAN, private sector companies and local electricity distribution company. The indicative Investment Plan is as follows:

Indicative Means of Financing	% Share
Saltillo Municipality	25%
IMPLAN (In-kind)	5%
Private Sector Organisations	60%
Electricity distribution company	10%
Total	**100%**

Quantification possible at this stage? ***No***

Major Assumptions
- The proposed project may generate **marginal revenues.**
- Total cost of the project is yet to be ascertained hence **investment plan mentioned is an indicative**.
- The pilot project involves procurement of capital goods. Hence cost will be on the higher side.

Financing of the project is mainly through **grants and soft debt**

Envisaged Activities and Technologies

Activities	Timeframe
• Analyze the current policy, related to incentives and favorable regulations for the transition to electric buses. • Evaluate baseline related to load demands on current buses and analyze their transition to electric buses. • Sizing the most appropriate bus considering local conditions and your requirements. • Harmonize the local automotive industry for the manufacture of electric buses at competitive prices.	3 months 3 months 3 months 3 months 12 months 6 months 6months 6 months

• Create a company - universities - government consortium to implement electric transport in the city. • Training of transport service providers in the use of electric buses • Create pilot project with private passenger transport. • Prepare a transition plan and gradual implementation.	

Preconditions

- Leadership of government authorities
- Diagnosis of the actual current state
- Include the project in the city's PACMUN
- Include citizen groups.

Technologies/Products

- Electric buses
- Charging stations
- Exclusive use lanes
- Unique method of payment
- Integrated public transport system

Impact Monitoring

Area	Indicator	Baseline Value	Source/data collection tool
	Modal share by public transportation	32.06%	IMPLAN_Sistema Indicadores Movilidad urbana (2015) Pg. 36
	Travel time by public transport	39.52 min	IMPLAN_Sistema Indicadores Movilidad urbana (2015) Pg. 41
	Hours spending in congestion		
	Emissions by public transport		
	Accessibility to public transport stations	16.4%	IMPLAN_Sistema Indicadores Movilidad urbana (2015) Pg. 62