Municipal Strategy for Climate Action

UN-HABITAT
FOR A BETTER URBAN FUTURE

SAN NICOLÁS
DE LOS GARZA
GOBIERNO DE LA CIUDAD

San Nicolás de los Garza

Executive Summary

SNG 2030

UN-HABITAT
FOR A BETTER URBAN FUTURE

SNG 2030

Municipal Strategy for Climate Action

San Nicolás de los Garza

Executive Summary

SNG 2030

UN-HABITAT
FOR A BETTER URBAN FUTURE

SAN NICOLÁS
GOBIERNO DE LA CIUDAD

Municipal Strategy for Climate Action
San Nicolás de los Garza

Mexico City, August 2023.

HS Number: HS/058/21S

For citations:
Landa, R. & D. García. (2023). *Municipal Strategy for Climate Action. San Nicolás de los Garza. Executive Summary.* United Nations Human Settlements Programme UN-Habitat, San Nicolás de los Garza Municipality. Mexico City, Mexico. 106 pp.

UN-HABITAT
FOR A BETTER URBAN FUTURE

SNG 2030

Credits

Municipal Government of San Nicolás de los Garza

Daniel Carrillo Martínez	Mayor of San Nicolásde los Garza, N.L.

Project Management and Coordination

Alicia Avendaño Lozano	Director of Strategic Projects and Head of Environmental Protection and Climate Change Unit
Miguel Pérez Meseguer	Technical Secretary

Municipality Team

Jesús Marcos García Rodríguez	Town Hall Office
Rolando Oliverio Rodríguez Hernández	Secretary of Finance and Treasury
Carlos Alberto Villareal Cantú	Office of Strategic Coordination
César Santos García	Secretary for Human Development
Celina del Carmen Hernández Garza	Secretary for Citizen Participation
Rubén López Lara	Secretary of Public Works and Urban Development
Alfredo Gaona Cervantes	Secretary of Public Services
José Martín Doria Mata	Secretary of Public Security
Gabriela González Rodríguez	Municipal Audit Office
Pedro Medina Flores	Secretary of Transportation
Gregorio García Hernández	Directorate-General for Health
Mercedes C. García Mancillas	Directorate-General for Social Welfare
Eduardo Alan Campos Villarreal	Institute for Municipal Planning and Development
Jorge Camacho Rincón	Civil Protection and Fire Brigade

UN-Habitat

Maimunah Mohd Sharif	United Nations Under-Secretary-General, Executive Director of UN-Habitat
Elkin Velásquez Monsalve	Regional Representative for the Latin America and the Caribbean Region

Project Coordination and Management

Eugenia De Grazia	Programme Officer
Samie Raichs Tovany	Programme and Project Development Consultant and Project Manager

Project Technical Team

Authors

Rosalva María Antonieta Landa Ordaz	Environment and Climate Change Specialist
Dulce Yurini García Sánchez	Environment and Climate Change Analyst
Luis Ángel Flores Hernández	Senior Urban Analyst
Juan Manuel Campa González	Public Space and Participation Analyst
Marco Antonio Muñóz González	Geographic Information Systems and Urban Indicators Analyst

Technical Consultants

Elisa Iraís Meza Noguez	Advisor
Mónica Martínez Herrera	Consultant for Climate Analysis and Modelling
Mariajosé Montiel Aguilar	Editorial Design
Anaid Aurora Escandón Zendejas	Translator and Proofreader
Daniela Chong Lugon	Technical Team of Urban Lab
Fernando Rementeria Méndez	Technical Team of Urban Lab
Alina Koschmieder	Technical Team of Urban Lab

Administration and Communication

César Vega	Administration and Finance Specialist
Nataly Vega Arroyos	Administrative and Financial Analyst
Bryan Gregorio Carreño	Administrative and Financial Analyst
Bryan René Alvarado	IT Assistant and Technical Support
Héctor Bayona Acosta	Communication Coordinator
Silvia Espinosa Castillo	Digital Communication Analyst

Acknowledgments

For their valuable contribution to the preparation of the San Nicolás de los Garza Municipal Strategy for Climate Action by participating in the community workshops and/or interviews.

Diego Pérez, Gerardo Mejía, Cristina Martínez, Araceli González, Cristina Hernández, Bernardo Lozoya, Adrián Lozano, Sergio Fernández, Carlos Ramírez, Emma Gómez, Gibrán Quiroga, Eduardo Vázquez, Aldo Ramírez, Alicia Lizárraga, Ricardo Sandoval, Ismael Aguilar Benítez, Alejandra Herrera, Javier Pérez, José Luis Trujillo, María Treviño, Marco Arguiropulos, Edgardo Acosta, Manuel Muzquiz, Gabriel Mata, Andrés Ríos, Luis Pérez, Julieta Leo, Graciela Hernández, Josefina Granados, Rosario Álvarez, Selene Guajardo, Laura Ballesteros, María Elena Espinoza, William Gómez, Daniela Núñez, Erika Vázquez, Cecilia Mota, Sergio Torres, and Fabiola Yepes.

We are also grateful for the valuable contribution of the Ministry of the Environment of the Government of Nuevo León, in particular its Directorate of Climate Change Policy, its Directorate of the State Registry of Greenhouse Gas and Compound Emissions, and its Directorate of Integrated Waste Management; The General Directorate of Parks and Wildlife of Nuevo León, the Integral System of Ecological Management and Waste Treatment of Nuevo León, Servicios de Agua y Drenaje de Monterrey (SADM), Colegio de la Frontera Norte (COLEF), Centro Mario Molina para Estudios Estratégicos sobre Energía y Medio Ambiente A. C., the Water Centre for Latin America and the Caribbean of the Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM), the Sustainability Secretariat of the National Autonomous University of Nuevo León (UANL, for its Spanish acronym), Pronatura A.C.-NE, Sociedad Sostenible A.C, Sextante, A.C., Agua Capital A.C., Citizen Air Quality Observatory of the Monterrey Metropolitan Area (OCCAMM, for its Spanish acronym), and the Chipinque Ecological Park.

Content

Foreword

San Nicolás de los Garza

In an increasingly interconnected and globalised world, climate change has become one of the most pressing challenges for our and future generations. Its effects are felt in every corner of the planet, threatening the stability of ecosystems, human health, economies, and the survival of many species.

Faced with this undeniable reality, it is essential that we, as a society, unite to confront and mitigate the effects of climate change. In this sense, this Climate Action Programme is a concrete and decisive response to this crisis that affects us all.

Our main objective is to raise awareness and mobilise individuals, communities, businesses, and governments to take sustainable action to reduce greenhouse gas emissions and adapt to the inevitability of climate change.

Throughout the programme, we will explore different areas of action: from promoting clean and renewable energy to conserving natural resources, managing waste responsibly and implementing public policies that promote sustainability.

We cannot afford to be bystanders to this global challenge. Each of us has the power and responsibility to help build a more sustainable, equitable and resilient future.

With this in mind, this Climate Action Programme aims to inspire, inform, and empower those interested in taking concrete action to protect and preserve our planet. Through interviews, documentaries, and testimonials from experts in the field, we explore existing solutions and the challenges we face.

Time is running out. Every day that goes by without action is a day lost in the fight against climate change. That is why it is vital that each of us becomes involved and commits to being part of the solution.

This Climate Action Programme is only the beginning. It is up to all of us to keep up the momentum and work together to deliver a sustainable future for generations to come.

We must act to remain the best city option, offering the 'best quality of life'. The power to change the course of our history and ensure a liveable planet for all is in our hands. It is time to act!

Daniel Carrillo Martínez

Mayor of San Nicolás de los Garza

"We cannot afford to be bystanders to this global challenge.

Foreword

UN-Habitat

Throughout history, cities and communities have worked together to tackle a wide range of global challenges. However, coordinated cooperation between cities has not been as important as it is today in tackling one of the greatest challenges humanity has ever faced: climate change.

Globally, climate change has been shown to have a significant impact on the life and development of cities. We are aware of the increase and intensification of weather phenomena such as droughts, floods, and frosts, which, combined with other outcomes such as epidemics, have significantly increased the needs and challenges for infrastructure, housing, livelihoods, and health in cities.

Cities, especially those in the global North, are estimated to be responsible for 70–75% of global carbon dioxide emissions, mainly due to changes in land use, industry, and transport. It is no coincidence that cities should be a focus for the implementation of measures to protect urban life from climate risks, while at the same time being important contributors to reducing greenhouse gas emissions.

Today, we recognise cities as an important arena for promoting the sustainable development of communities. The urban environment is also an area of opportunity for decarbonising the economy, improving atmospheric conditions, and reducing social vulnerability to climate change. All this without losing sight of the fact that achieving carbon neutrality in cities should not hamper their economic and industrial growth.

In this context, various agendas and agreements have set global goals and targets to balance the social, economic, and environmental needs of populations and human settlements. There are major efforts being made to ensure that cities contribute to mitigating and adapting to climate change without compromising the development of nations. The 2030 Agenda for Sustainable Development, the New Urban Agenda, the Paris Agreement, and the Sendai Framework for Disaster Risk Reduction encourage local development to integrate concrete actions to reduce greenhouse gas emissions, strengthen the resilience of human systems and reduce losses from climate risks.

To this end, it is essential that the various sectors of the population are interested in and involved in building adaptive infrastructure, implementing nature-based solutions, strengthening institutional capacity, cross-sectoral coordination and strengthening climate finance.

In San Nicolás de los Garza, Nuevo León, UN-Habitat's work began in 2019 with the creation of its 2030 City Vision, as an effort to accelerate compliance with the Sustainable Development Goals and the New Urban Agenda at local level. This tool proposed urban policy guidelines from a municipal perspective, with the main objective of promoting San Nicolás de los Garza as a sustainable, resilient, prosperous, close-knit, participatory, healthy, and inclusive urban centre.

Thanks to the 2030 City Vision and its implementation efforts, San Nicolás de los Garza currently stands out within the Monterrey metropolitan area as a pioneer in the design and implementation of public policies for the sustainable development of its territory. To date, several transformations have been achieved, including institutional restructuring and the implementation of strategic programmes and initiatives derived from the action lines of this 2030 City Vision and its portfolio of projects.

In addition, because of the water crisis experienced in the State of Nuevo León in 2022, which had a negative impact on this important industrial development pole of the Monterrey metropolitan area, San Nicolás de los Garza has also positioned itself as a benchmark in the incorporation of effective environmental management as a priority area of public policy at the municipal level.

In this regard, UN-Habitat recognises the remarkable work done by the Municipal Government in the implementation of the 2030 City Vision and the inclusion of a climate-environment agenda in the Municipal Operational Programmes. This has led to the creation of the Municipal Strategy for Climate Action.

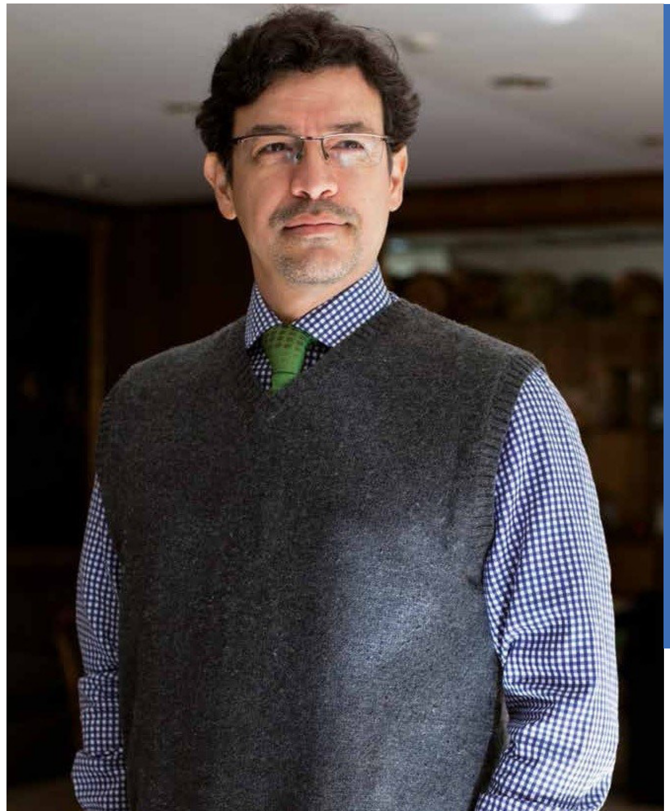
The Municipal Strategy for Climate Action (EMAC, for its Spanish acronym) is a tool that proposes actions adapted to the local context to mitigate and adapt to climate change in a participatory way, promoting environmental protection, urban resilience, and climate governance. Through a Climate Action Pathway, the EMAC classifies actions according to the most relevant areas of interest and concern identified through a comprehensive diagnostic process of the municipality's current and future conditions.

This tool is presented with strong analytical support based on global and national methodological frameworks. Its application has made it possible to identify the main climate challenges faced by the municipality, as well as those it could face if current urban development trends continue. In addition, the EMAC is the first municipal-level tool to propose public policies based on the modelling of expected future climate changes, emissions trajectories, and climate vulnerability.

Beyond this, the EMAC complements and strengthens existing programmes, agendas and portfolios in the municipality, as it is directly linked to the 2030 City Vision of San Nicolás de los Garza and its portfolio of projects, the Municipal Development Programme, national climate strategies and programmes, and Mexico's Nationally Determined Contributions, which were presented to the Conference of the Parties as one of the country's commitments to achieve the goals of the Paris Agreement.

It Is the political and social embrace and commitment of all decision-makers that will determine the strength and impact of the EMAC.

This Strategy therefore represents a solid step for San Nicolás de los Garza towards a sustainable, equitable, resilient, and carbon-neutral urban future.



“

Globally, climate change has been shown to have a significant impact on the life and development of cities.

Elkin Velásquez Monsalve

Regional Representative for Latin America and the Caribbean

Presentation

Climate change and its impacts are the greatest challenge to urban development in this century. The search for human well-being in the context of climate change must focus on the decarbonisation of activities in all sectors, as well as on the design of adaptation mechanisms for urban systems and for settlements in general, whether rural or urban.

Based on the recognition of climate change as one of the greatest challenges facing humanity, this Strategy reflects the commitment of the Municipality of San Nicolás de los Garza to move towards sustainable and climate-resilient development by strengthening local planning in accordance with the Municipal Development Programme 2021–2024 (POE, 2021).

The **Municipal Strategy for Climate Action in San Nicolás de los Garza** (EMAC-SNG, for its Spanish acronym) comprises a set of strategies, policy lines and actions that aim to reduce air pollution, increase urban resilience, and improve governance conditions, based on municipal competences, through the design and implementation of a Climate Action Pathway that supports the strategies and policies of the Municipal Climate Action Programme (PACMUN, for its Spanish acronym).

Part I of the EMAC-SNG introduces general aspects of climate change and the commitments made by the international community and Mexico to address the problem. It also includes a review of national, metropolitan, and local policy planning frameworks, as well as a **technical participatory diagnosis that analyses the environmental context of the municipality**, assesses air pollution behaviour, and estimates future climate vulnerability.

Part II of the Strategy consists of the **Climate Action Pathway**, which presents an analysis of the feasibility of local implementation of existing policies at the municipal, state, and local levels, carried out using tools developed and tested by UN-Habitat, as well as a multi-stakeholder approach methodology, which was part of the participatory component of the Strategy. It also proposes public policy orientations specifically formulated for the conditions of San Nicolás de los Garza (SNG), presented in three main thematic axes: Environmental Protection–Mitigation, Urban Resilience–Adaptation and Climate Governance. Each of these axes includes strategies with their objectives, strategic lines, and actions in the environmental, urban, energy and services sectors. A total of 15 strategies have been identified, grouped into 39 strategic lines, which in turn contain a total of 181 actions. Finally, a set of indicators for monitoring the Strategy is proposed.

The EMAC-SNG is underpinned by, and draws its principles from, the following international instruments:: The United Nations Framework Convention on Climate Change (UNFCCC, 1992), the Paris Agreement (UNFCC, 2016) and the Nationally Determined Contributions (NDCs) derived from its adoption, the 2030 Agenda, and the Sustainable Development Goals (SDGs) related to climate action and building sustainable and resilient cities, as well as the Quito Declaration on Sustainable Cities and Human Settlements for All (2017), the Sendai Framework for Disaster Risk Reduction 2015-2030, the New Urban Agenda (NAU, 2017) and the Sustainable Urban Resilience for the Next Generation (SURGe) initiative adopted at the 27th Conference of the Parties (COP27) of the UNFCCC.

Similarly, it is generally subject to legislation and a wide range of national, state, metropolitan and municipal planning instruments on environmental management, climate change, risk management and urban development, which guide the policies, strategies, and priority actions of this instrument. For the preparation of the EMAC-SNG, 11 laws, 4 local regulations, 26 Official Mexican Norms and more than 10 planning documents from different decision-making levels were thoroughly analysed.

Part I

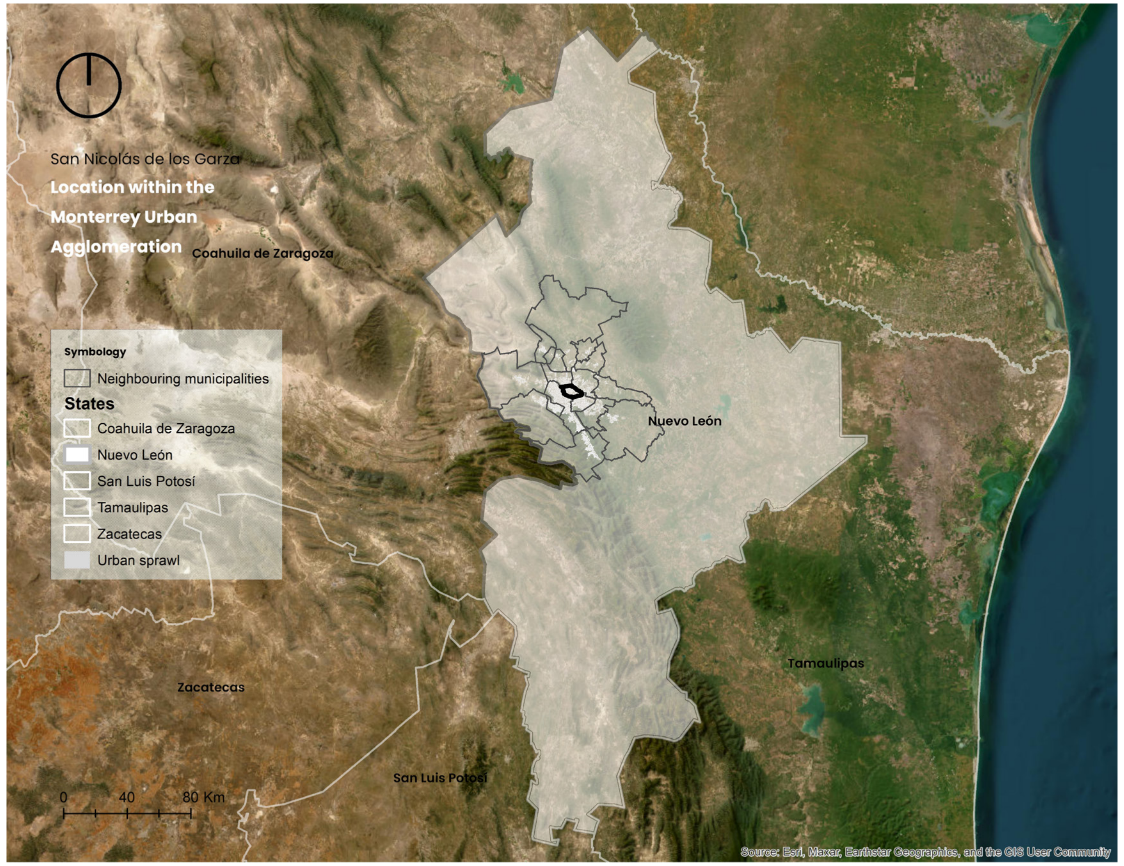
Strategic Diagnosis

Strategic Diagnosis

San Nicolás de los Garza

San Nicolás de los Garza (SNG) is located in the state of Nuevo León, occupies 0.1% of the state's territory and, alongside 16 other municipalities, forms the Monterrey Urban Agglomeration (AUM, for its Spanish acronym) (UN-Habitat, 2018).

With an area of 60.1 km^2, its location is strategic for the dynamics of the metropolis, as it is in the central area of Monterrey (Government of San Nicolás de los Garza and UN-Habitat, 2022).

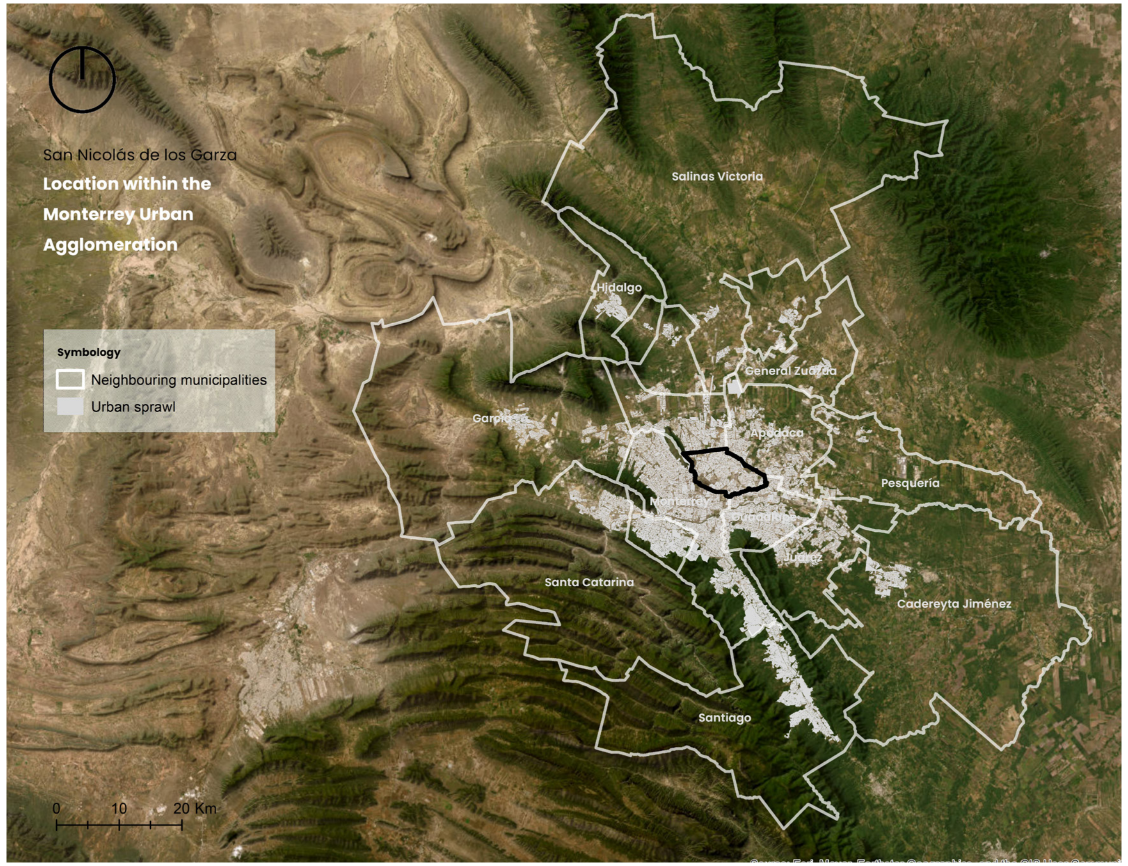


Map 1. Regional location of the Monterrey Urban Agglomeration (AUM) and the municipality of San Nicolás de los Garza (SNG), State of Nuevo León, Mexico.

Source: Author's elaboration with data from the National Institute of Statistics and Geography (INEGI, 2022)**.

San Nicolás de los Garza has a variety of physiographic features that confer on it unique environmental conditions. The municipality's terrain is mostly flat, although the surrounding mountains and hills stand out, forming the watersheds of the hydrological sub-basin in which the municipality is located and also of its main stream, the Topo Chico.

The municipality has only one natural ecosystem, the Natural Protected Area (ANP, for its Spanish acronym) Cerro del Topo Chico State Natural Reserve, and many green spaces that serve as environmental assets. The blue-green infrastructure elements in the territory provide different types of ecosystem services to its inhabitants (Figure 1).



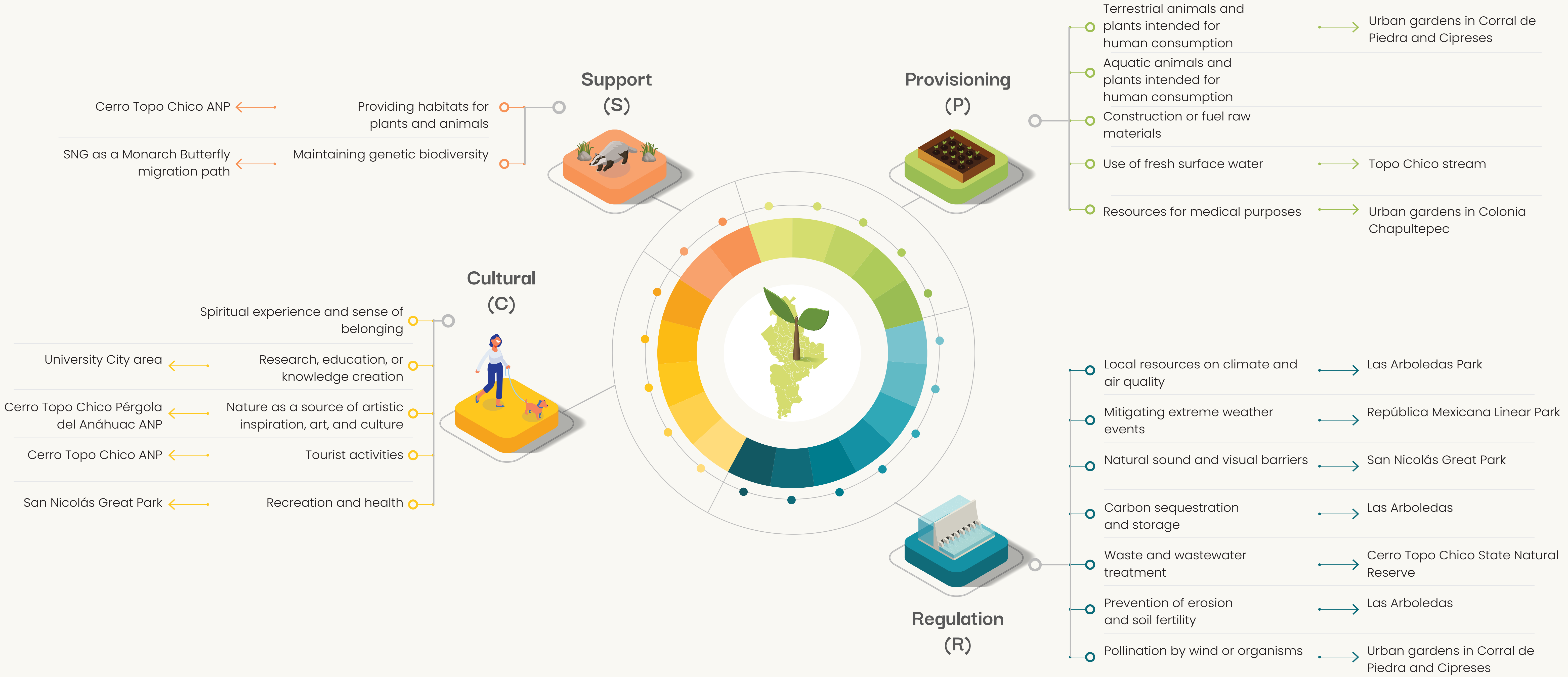


Figure 1. Blue-green infrastructure providing ecosystem services by category within the SNG area.

Source: Author's elaboration with data from TEEB methodology, 2011 and CICES, 2018..

San Nicolás de los Garza in figures

Population and housing

69
inhab /ha

28.6
household /ha

Relief and soils

460 – 910
masl

Feozem
45 %
of SNG

Hydrology

Hydrological-Administrative Region
RHA-VI

5 800 m²
of water bodies

19.35 km
of watercourses

Green infraestructure

Green infrastructure occupies
12.82 % of SNG

14 types
of green infrastructure

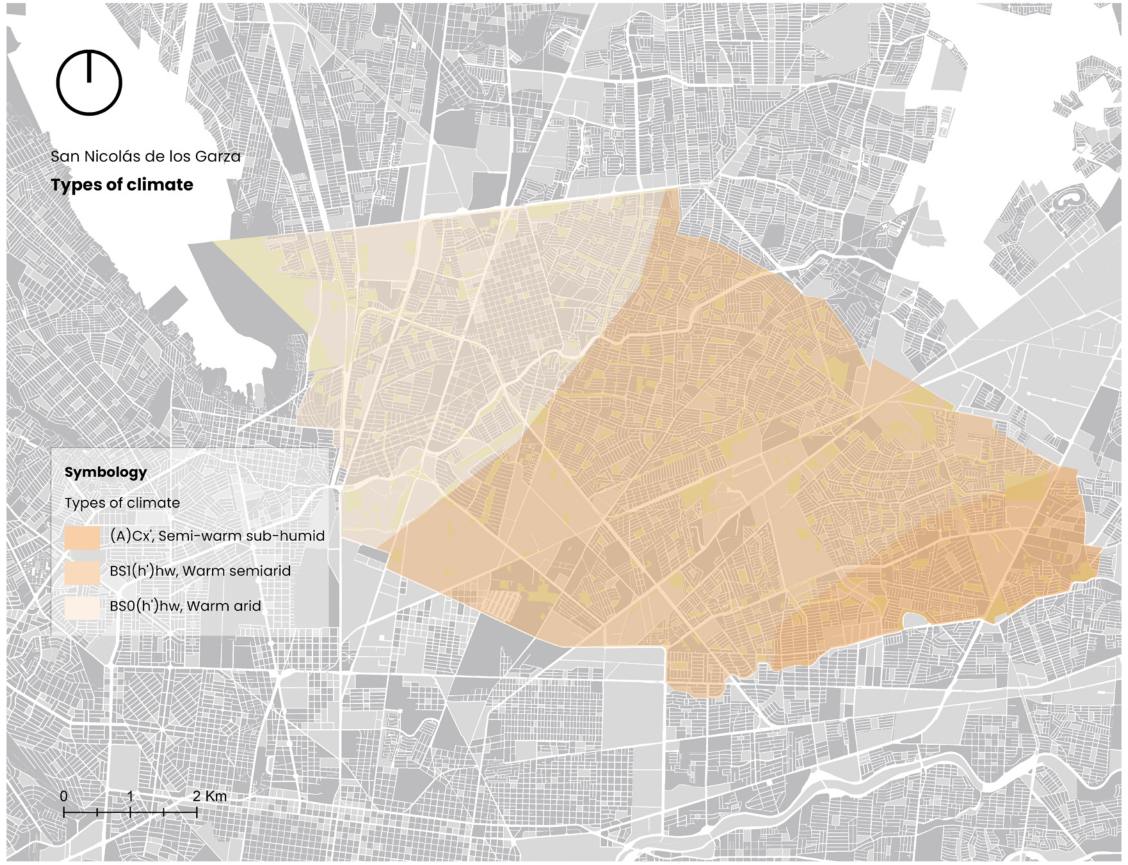
Environmental Services from
7 regional ANPs

Green areas determined by 2018 CPI
5.62 m²/inhab

Climate

The municipality is located in a mainly semi-warm semi-arid region, so the predominant climate is the warm semiarid BS1(h’) hw type, with average annual temperatures above 18 °C, with temperatures below 18 °C in the coldest month, and summer rainfalls of between 5 % and 10.2 % per year. To a lesser extent, there is also the semi-warm sub-humid climate’(A) Cx’, recorded in the southeast of the municipality, and the warm arid climate BS0(h’) hw, in the northwest (Map 2).

According to data from the National Meteorological Service (SNM, for its Spanish acronym) for the period 1951–2010, historical maximum temperatures reached 50 °C and historical minimum temperatures reached -9 °C. The average maximum temperature was above 30 °C and the average minimum temperature was below 6 °C. The average precipitation in the municipality is estimated at 400 to 800 mm of cumulative annual precipitation.



Map 2. Distribution of climate types in the Monterrey Urban Agglomeration (AUM).

Source: Author's elaboration with data from García (1964) and INEGI (2008).

Hydrometeorological risks

Similarly, to other municipalities in the AUM, in San Nicolás de los Garza the riskiest events in terms of intensity and frequency are extreme rainfall events, which can lead to floods, droughts and frosts (Figure 2).

In recent decades, there have been occasional torrential rainfall events that have led to floods with severe consequences. During the period 2000–2020, a total of 28 disasters, emergencies and climatic contingencies were declared, most of them related to atypical rainfall (36%), followed by frost and drought (11% each).

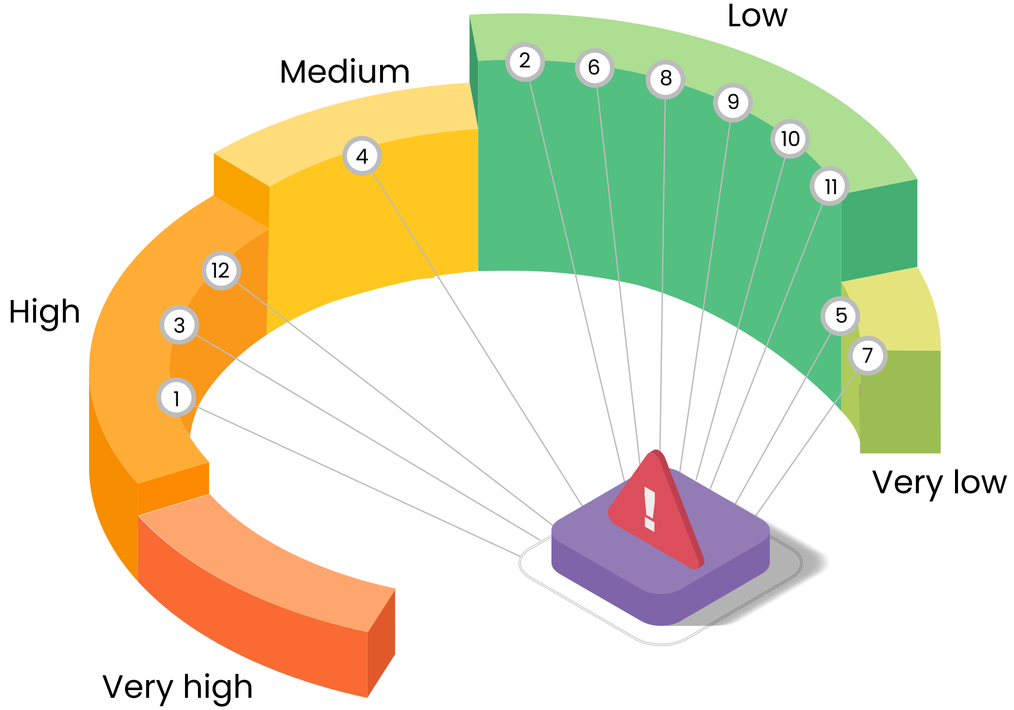
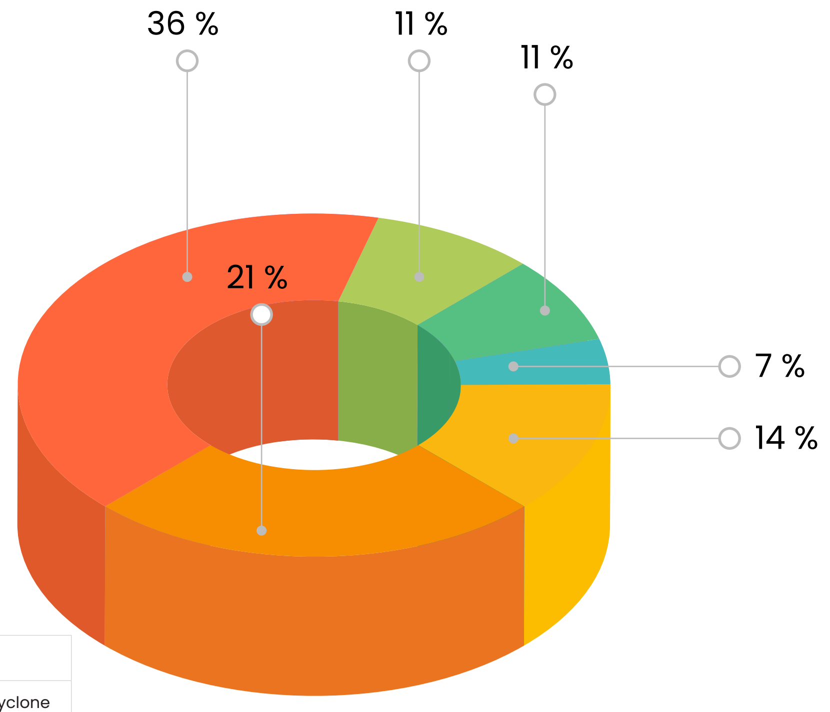


Figure 2. Hydrometeorological risk level of San Nicolás de los Garza.

Source: Government of the Municipality of San Nicolás de los Garza, 2021.

1	Cold waves	4	Droughts	7	Cyclones	10	Storms
2	Frost	5	Hailstorms	8	Tornadoes	11	Extreme reinfall
3	Warm waves	6	Snowfall	9	Dust storms	12	Floods

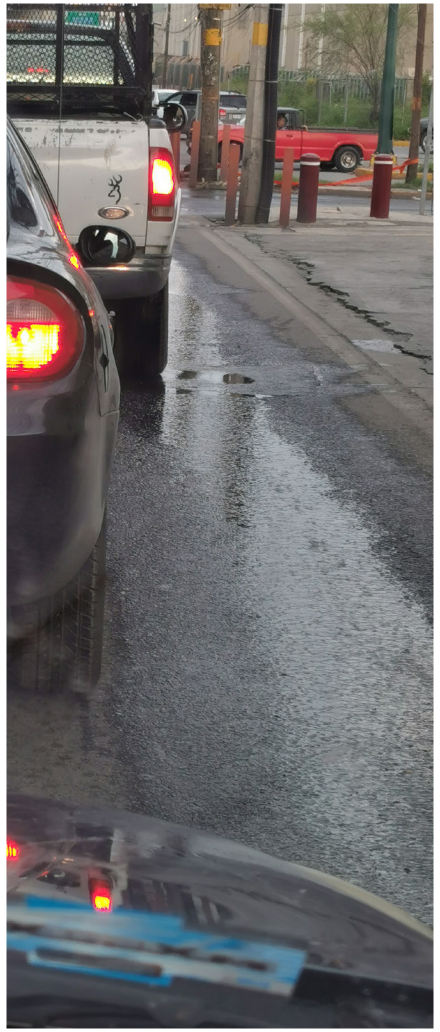


	Atypical rainfall
	Extreme rainfall due to tropical cyclone
	Extreme rainfall + flooding
	Droughts
	Frosts
	Extreme rainfall

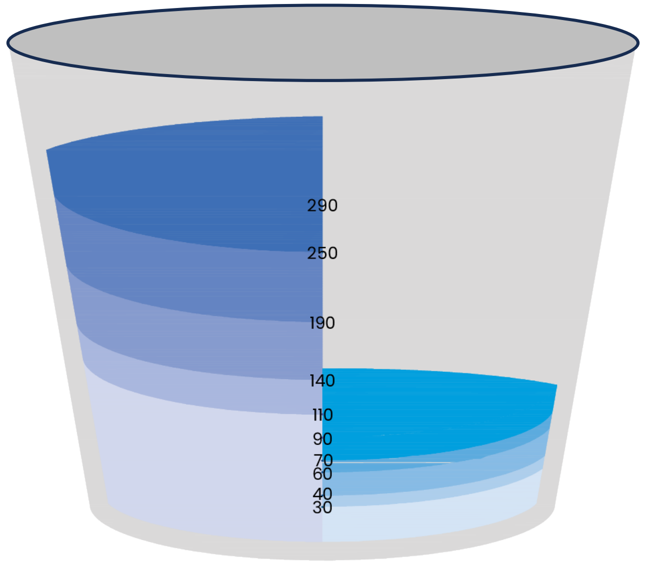
Figure 3. Share of emergency declarations by type of event for the period 2000-2020 in San Nicolás de los Garza.

Source: Author's elaboration with data from National Centre for Prevention of Disasters (CENAPRED, 2022).

Extreme rainfall and flooding



Considering the historical behaviour of intense storms in the area, it is estimated that for the 50-year return period, rainfall intensities of up to 250 mm accumulated in one day and extreme rainfall with an accumulation of up to 70 mm in one hour could be expected. The highest accumulation expected in 5 years is 104.7 ml and for 100 years is 285.6 ml, an increase of more than twice the previous intensity.



Accumulated precipitation

1 day storm	1 hour storm
5 years	5 years
10 years	10 years
20 years	20 years
50 years	50 years
100 years	100 years

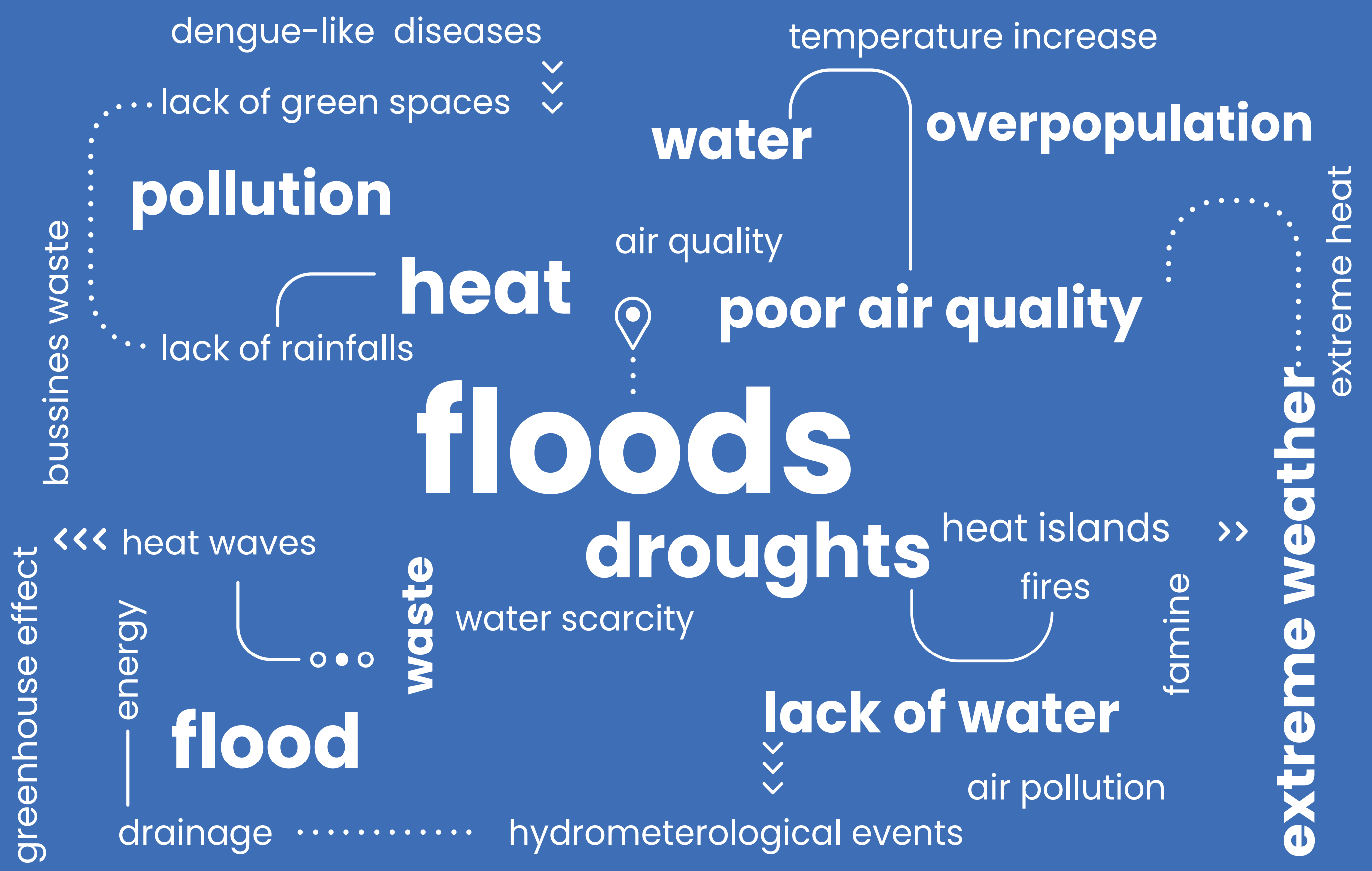
Figure 4. Summary of predicted extreme precipitation by day and time in San Nicolás de los Garza.

Source: Author's elaboration with data from the Institute of Engineering, National Autonomous University of Mexico (UNAM, 2016).

Citizen perception

The most frequently mentioned risk during the participatory process for developing the Strategy was flooding. This was followed by drought and heat waves.

It reveals that the perception of the population includes pollution and lack of green spaces as risks that may determine the community's ability to adapt to climate change.



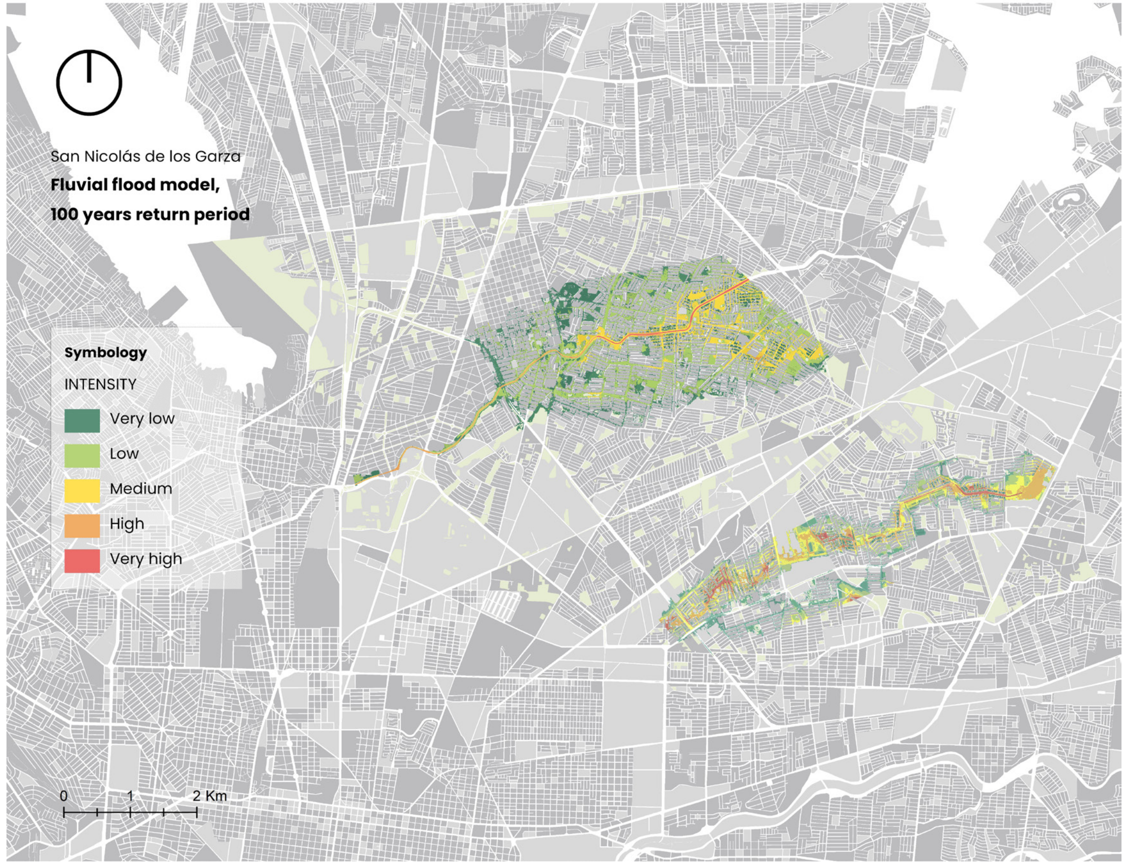
Perception of the main risks in San Nicolás de los Garza, as mentioned during the community consultation exercises.

Source: Author's elaboration using the Mentimeter platform, 2022.

The most frequent areas of flooding or waterlogging caused by rain are in the neighbourhoods of Arboledas de San Jorge, Ampliación del Vidrio Sectors 1 and 2, Bosques de Santo Domingo, Bosques del Nogalar, Estancia Minera Sector 1, José López Portillo, Las Misiones, Margarita Salazar, commercial and industrial areas, Avenida Manuel L. Barragán, Sendero Divisorio, Alonso Reyes, Lerdo de Tejada, Carretera Monterrey-Nuevo Laredo, Anillo Vial Metropolitano, San Nicolás, Lic. Adolfo López Mateos, De Las Flores, De la Juventud. The areas with the highest incidence of surface flows derived from the Topo Chico and Los Pinos streams are located mainly in the neighbourhoods of Las Puentes, Ciudad Universitaria, Cuauhtémoc Sector 1, Nova, Parques de Anáhuac, Valle de Las Puentes, Rincón de Los Álamos, Pradera de Santo Domingo, Margarita Salazar, Privada Nogalar, Los Mezquites, Ampliación Villas Oriente, etc. Based on dynamic flow modelling, it has been estimated that for a 5-year return perio d (Map 3), the flood flow of the Topo Chico stream could reach a maximum depth of 12.5 m, as opposed to 5.5 m for Los Pinos stream, which would increase to 12.9 m and 6.07 m, respectively, in 100 years (Map 4). The area affected by streamflow would increase, particularly to the northeast of the Topo Chico stream and to the south of Los Pinos.

Map 3. Fluvial flood model (surface flight) by maximum depth for a 24-hour accumulation period over the Topo Chico and Los Pinos streams, 5-year return period.

Source: Adapted from Atlas de Riesgo para el Municipio de San Nicolás de los Garza, Nuevo León (Municipal Government of San Nicolás de los Garza, 2021).



Map 4. Fluvial flood model (surface flight) by maximum depth for a 24-hour accumulation period over the Topo Chico and Los Pinos streams, 100-year return period.

Source: Adapted from Atlas de Riesgo para el Municipio de San Nicolás de los Garza, Nuevo León (Municipal Government of San Nicolás de los Garza, 2021).

Droughts

San Nicolás de los Garza is highly vulnerable to drought and critical situations related to water stress, in particular the overexploitation of the metropolitan aquifer. There have been abnormally dry conditions since 2005, and in 2011 there were 8 extreme drought events. The highest number of droughts was recorded in 2021, with 11 abnormally dry periods and 6 severe droughts (Figure 5).

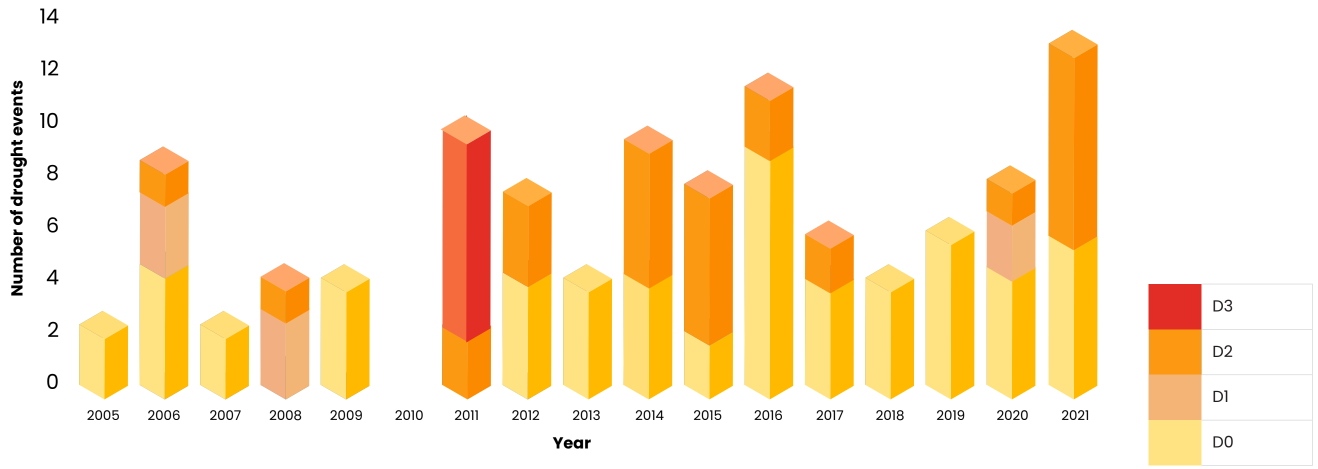
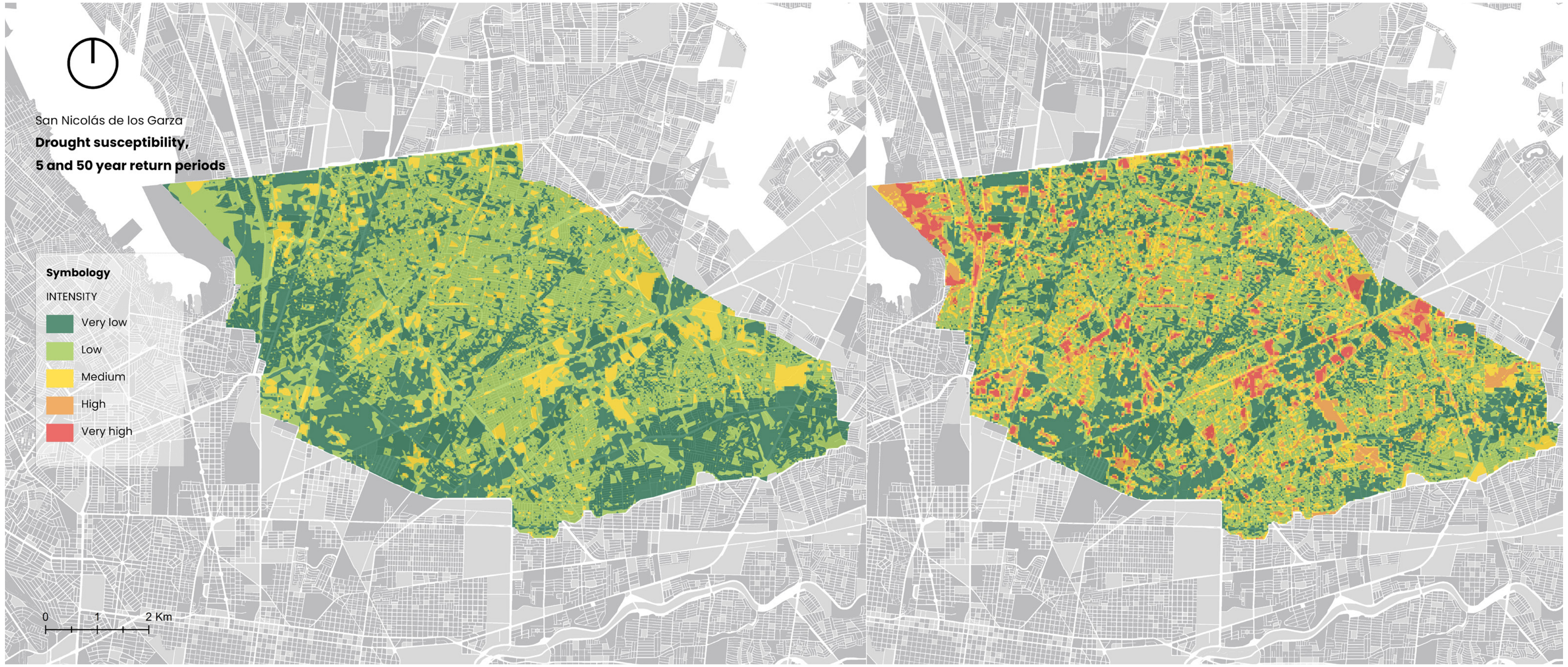


Figure 5. Declared droughts for the period 2005-2021 in SNG.

Source: Author's elaboration with data from Mexico's Drought Monitor of the National Water Commission (CONAGUA, 2022).



Map 5. Drought susceptibility of TR05 and TR50.

Source: Atlas de Riesgo para el Municipio de San Nicolás de los Garza, Nuevo León, 2021.

The drought vulnerability for the 5- and 100-year return periods shows that in the east and centre of the area there is a medium level of vulnerability for the 5-year return period. On the other hand, for the 100-year return period, areas of high and very high vulnerability can be distinguished in the north-west, centre and east of the municipality (Map 5).

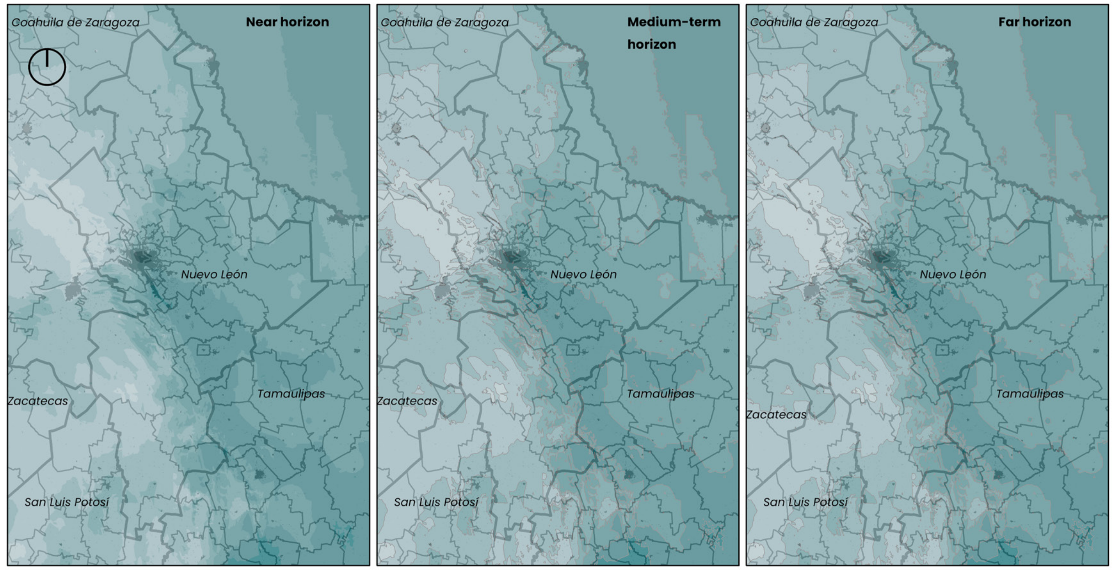
Expected climate change scenarios

In accordance with the methodology proposed by the IPCC (2017 and 2022), changes in temperature and precipitation were analysed using two emission concentration scenarios, RCP 4.5, and RCP 8. 5 and three time horizons: The near or short term (2021-2040), the medium or intermediate term (2040-2060) and the far or long term (2081-2100); according to information from the Informatics Unit for Atmospheric and Environmental Sciences (UNIATMOS) of the Institute of Atmospheric and Climate Sciences of the National Autonomous University of Mexico (UNAM), daily climatological data from the National Meteorological Service (SMN) of Mexico on temperature and precipitation with high spatial resolution (926 m x 926 m) for the period 1981–2010.

Projections of average annual cumulative rainfall in the municipality show variations in rainfall ranging from a maximum of 21.5 mm to a deficit of -162.15 mm in the most unfavourable long-term scenario, equivalent to up to 27% less rainfall than the current cumulative average and ranging from 435.5 mm to 619.2 mm.

Precipitation ranges in millimetres per annum
200
300
400
500
600
750
1000
1500

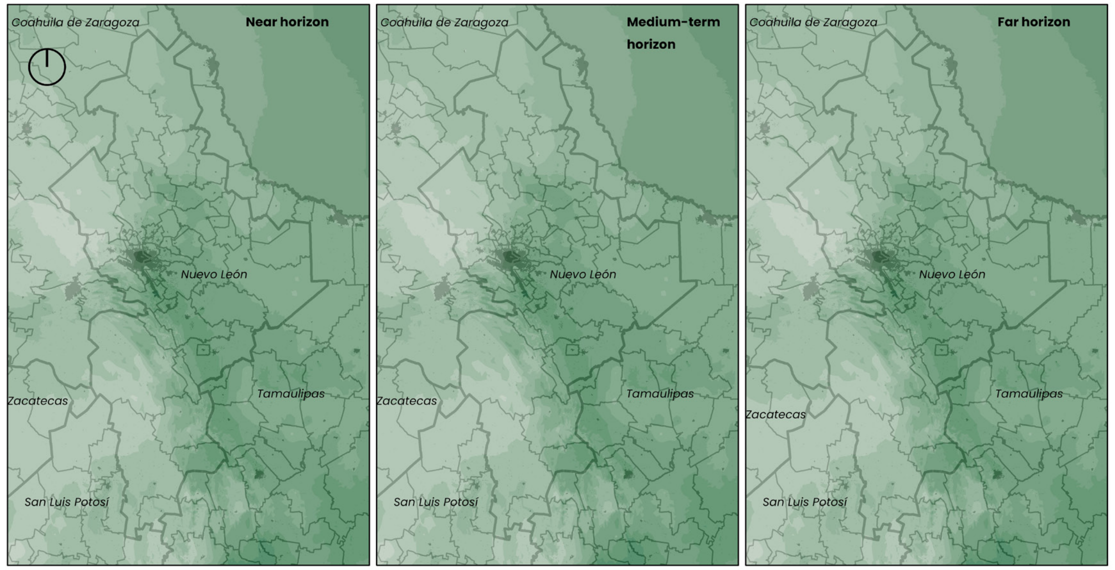
RCP 4.5 precipitation scenarios for the three horizons



Map 6. RCP 4.5 precipitation scenarios for the three horizons.

Source: Author's elaboration with data from AR5-IPCC (2014), IPCC (2017) and Oliver et al. (2017).

RCP 8.5 precipitation scenarios for the three horizons



Precipitation ranges in millimetres per annum
100
200
300
400
500
600
750
1000
1500

Map 7. RCP 8.5 precipitation scenarios for the three horizons.

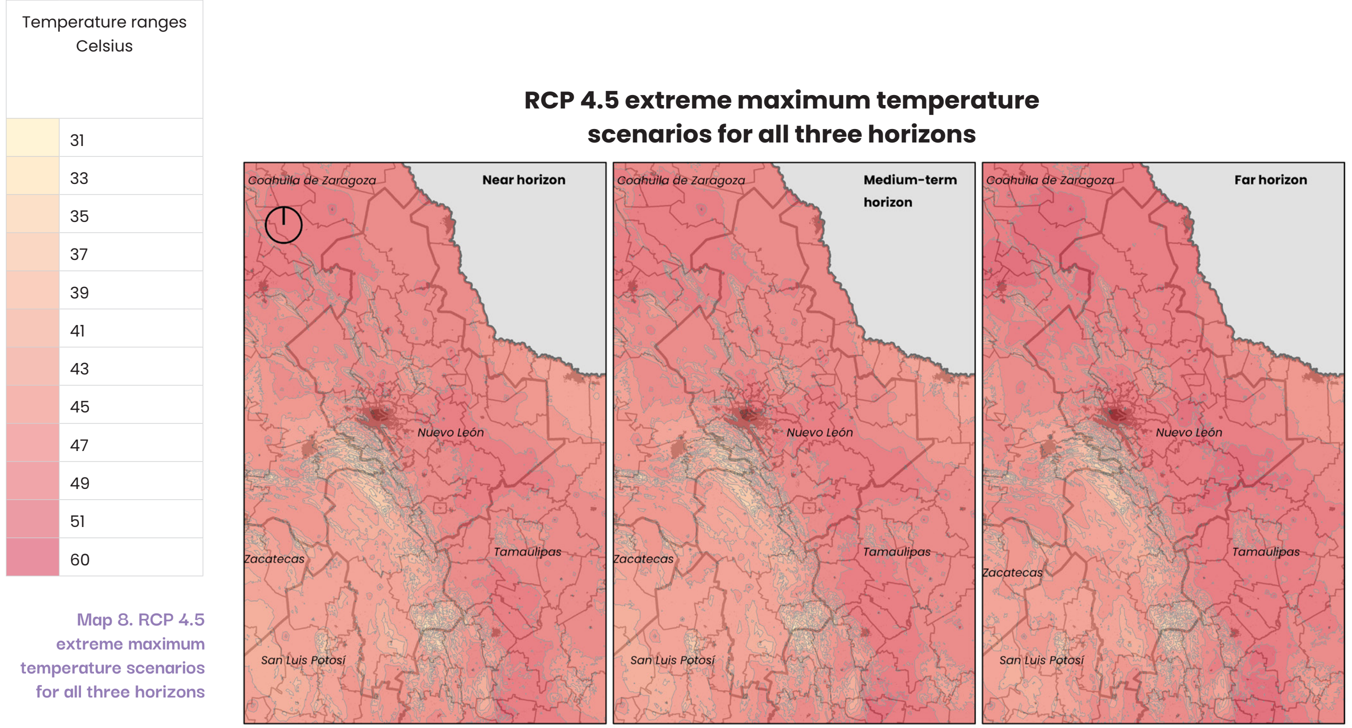
Source: Author's elaboration with data from UNIATMOS (UNAM, 2022).

For the annual mean temperature, the projections show a short-term increase of 2.16 °C, about 10.24 % compared to today, up to an increase of 26.88 %, which corresponds to 5.67 °C. The annual minimum temperature shows a gradual increase in all climate change scenarios, which could reach ranges between 16.71 °C and 20.11 °C. For the annual maximum temperature, projections show a gradual increase over different future time horizons: from 1.5 °C in the short term, about 5.3 % higher than today, to 5.11 °C in the long term, about 18.1 % higher than today's annual maximum temperature.

Maximum and minimum temperature extremes increase in all climate change scenarios, implying warming in the future as lower temperatures are projected to be less cold. During the period 1951–2010, the maximum temperature extreme was 46 °C in SNG; depending on the scenarios, it could increase by up to 4.35 °C, reaching up to 50.35 °C in the long-term SSP5-RCP 8.5 scenario. Over the same period, the extreme minimum temperature was -6.3 °C, projected to increase by 2.14 °C in the SSP2-RCP 4.5 scenario to reach -4.16 °C in the long-term future. For the SSP5-RCP 8.5 scenario an increase of 4.68 °C is projected, reaching -1.62 °C.

A synthesis of the results of the expected behaviour of temperature and precipitation under climate change conditions for different time horizons and under different GHG emission scenarios for the municipality of San Nicolás de los Garza is shown in Figure 6.

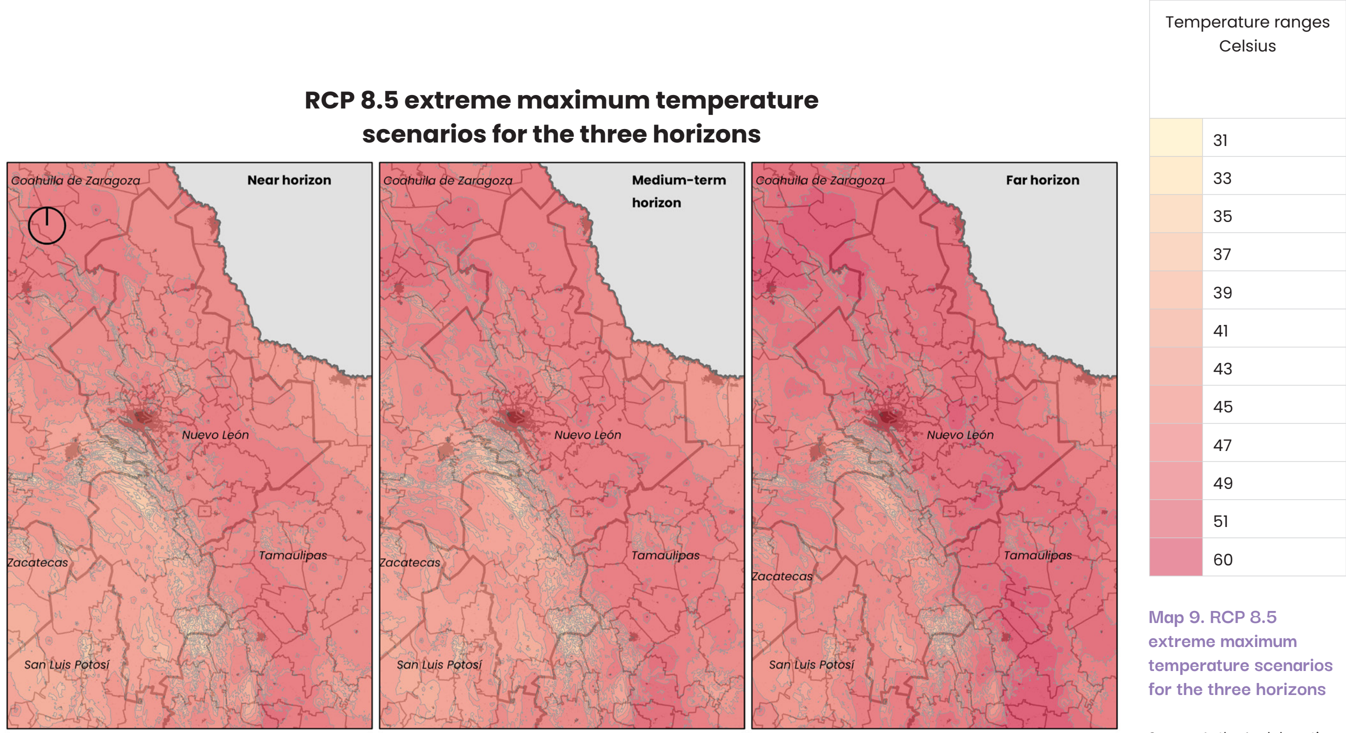
RCP 4.5 extreme maximum temperature scenarios for all three horizons



Map 8. RCP 4.5 extreme maximum temperature scenarios for all three horizons

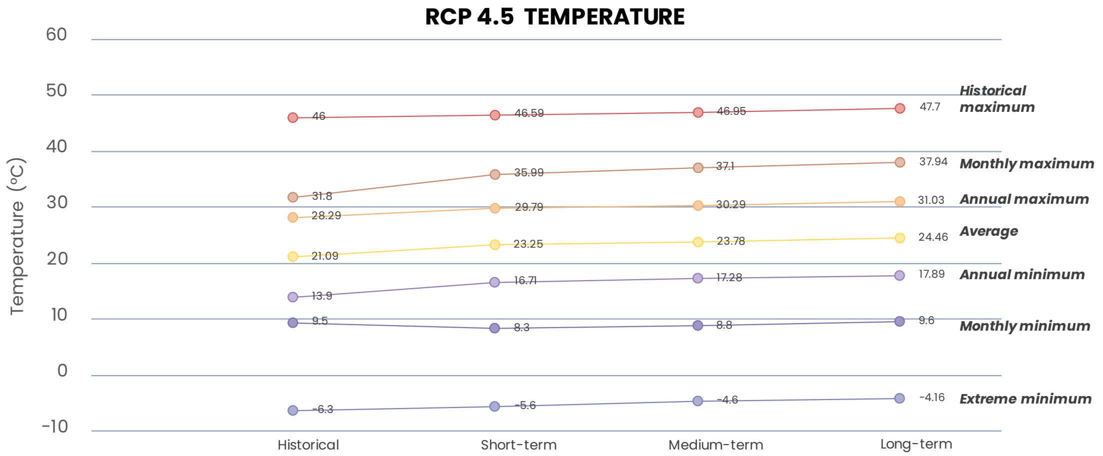
Source: Author's elaboration with data from UNIATMOS (UNAM, 2022).

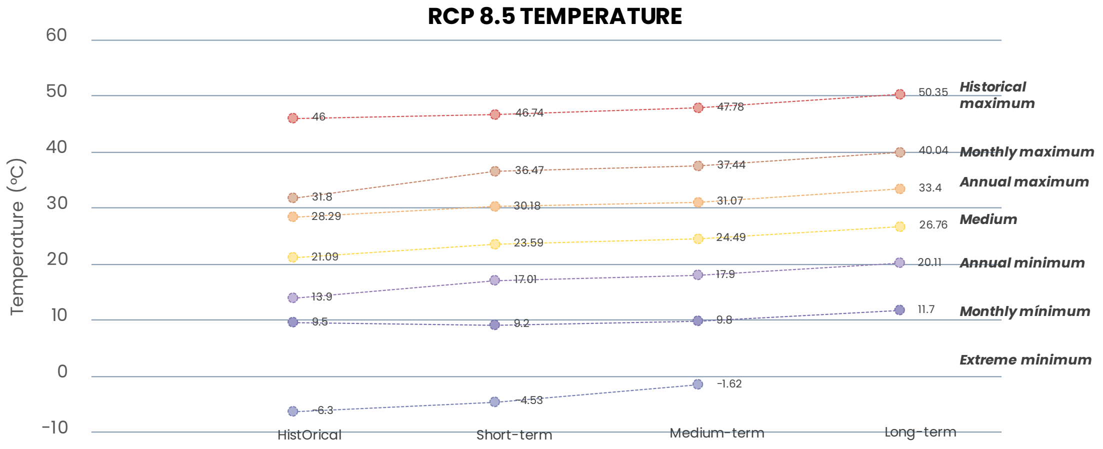
RCP 8.5 extreme maximum temperature scenarios for the three horizons



Map 9. RCP 8.5 extreme maximum temperature scenarios for the three horizons

Source: Author's elaboration with data from UNIATMOS (UNAM, 2022).





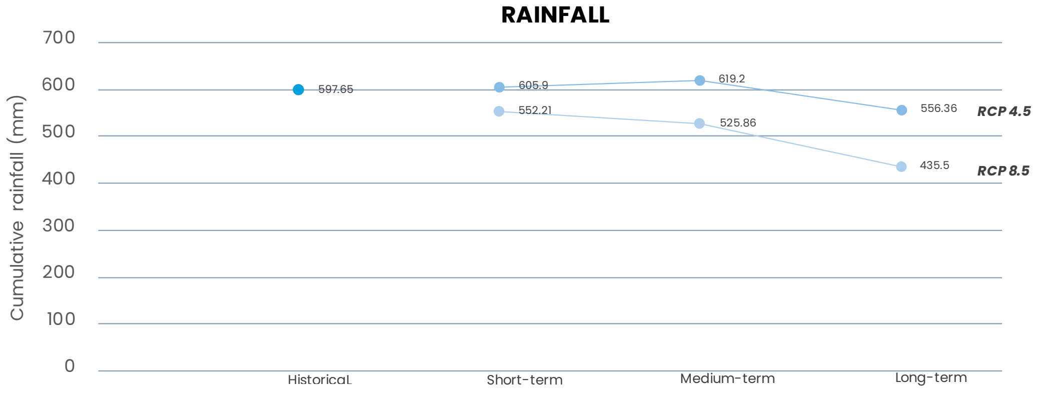
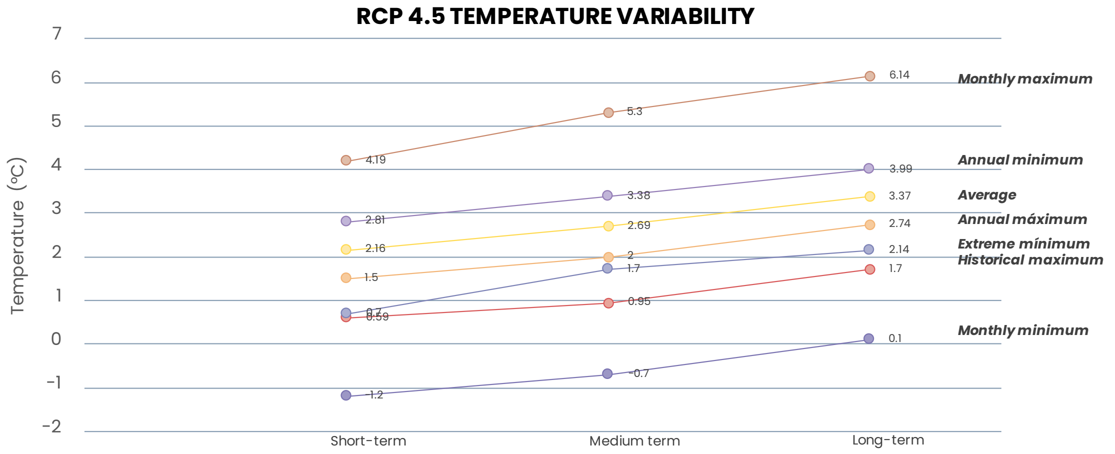
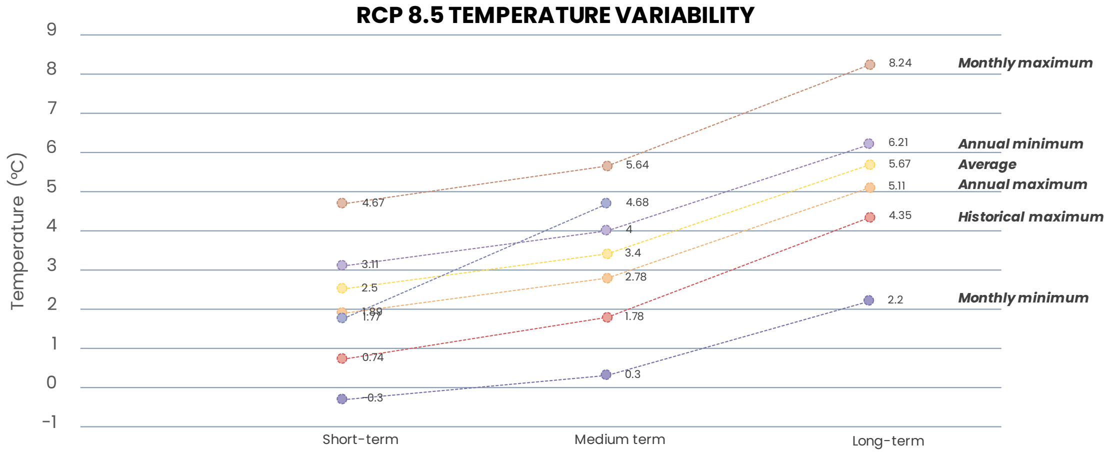


Figura 6. Resumen de temperaturas y precipitaciones promedio por escenarios climáticos para SNG

Fuente: Elaboración propia con datos de AR6-IPCC (2021), del Instituto de Ciencias de la Atmósfera y Cambio Climático de la UNAM y de la UNIATMOS (UNAM, 2022).





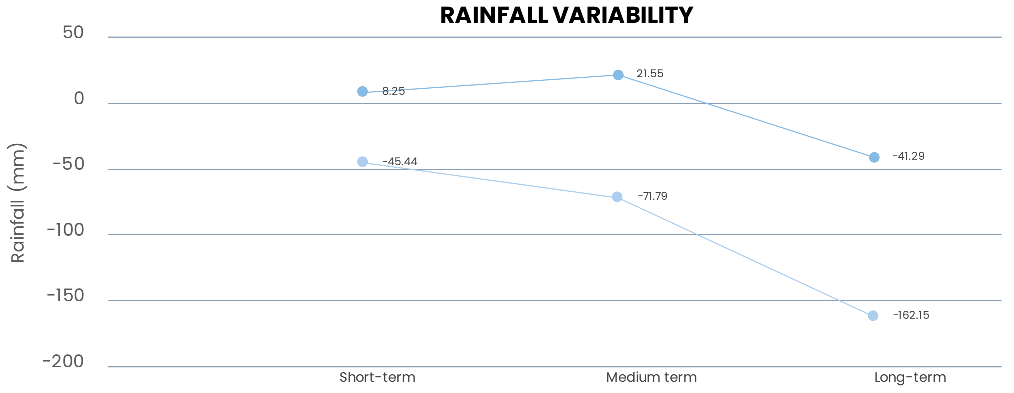


Figure 7. Summary of mean temperature and precipitation variation by climate scenario for SNG.

Source: Author's elaboration with data from AR6-IPCC (2021) and UNAM's Institute of Atmospheric Sciences and Climate Change.

Climate in San Nicolás de los Garza

Main climatic features

Semi-arid warm

400 - 800 mm
Annual rainfall

21.5°
Average historical temperature

Main hydrometeorological hazards

·Droughts

·Extreme rainfall flooding

Icy and warm waves
Frosts

Expected climate change scenarios

Desertification

Rise up to
50.35 °C

Decrease in rainfall
27 %

Air emissions analysis

The design and implementation of the Municipal Strategy for Climate Action in San Nicolás de los Garza (EMAC-SNG) involved the analysis of two main components: air quality and the characterisation of atmospheric emissions, which allowed the identification of risk areas and mitigation options.

Regarding air quality, information from the AUM air quality monitoring system is listed and the types of particles and pollutants that were in the air during the period 2017–2021 are enumerated.

With regard to the characterisation of atmospheric emissions, a detailed identification of the sources responsible for these emissions was carried out, as well as the types of pollutants released and their contribution to the problem. Sources and areas of municipal responsibility for which information was lacking were also identified, with a view to subsequently modelling these emissions.

The Climate Action for Urban Sustainability (CURB) tool developed by the World Bank was used for this modelling exercise. This tool allowed not only to model existing emissions, but also to project them over three-time horizons. This is particularly useful for understanding the emissions that the municipality would face in the absence of mitigation actions.
.

Air quality

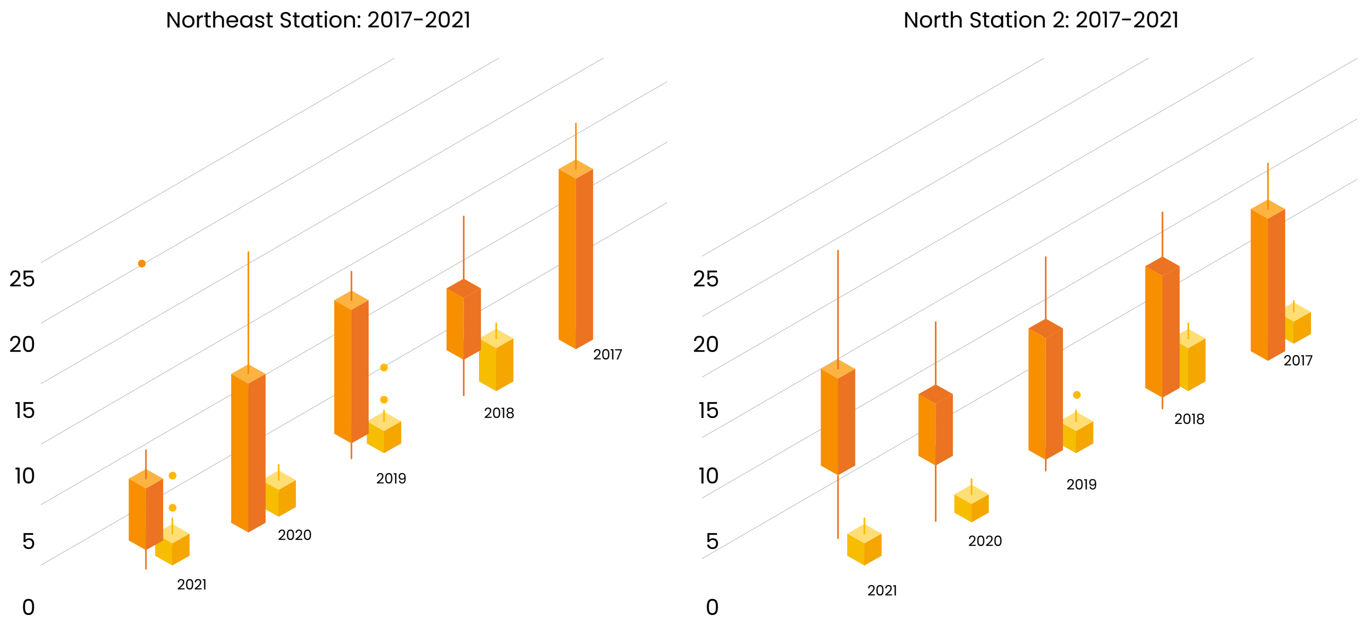
Nuevo León has an Integrated Environmental Monitoring System (SIMA for its spanish acronym) that records and reports daily concentrations of regulated criteria pollutants and classifies them according to their toxicity to human health. The information provided by the system has made it possible to analyse air quality reports at the metropolitan and municipal levels in order to identify criteria pollutants for which reduction and control measures should be implemented.

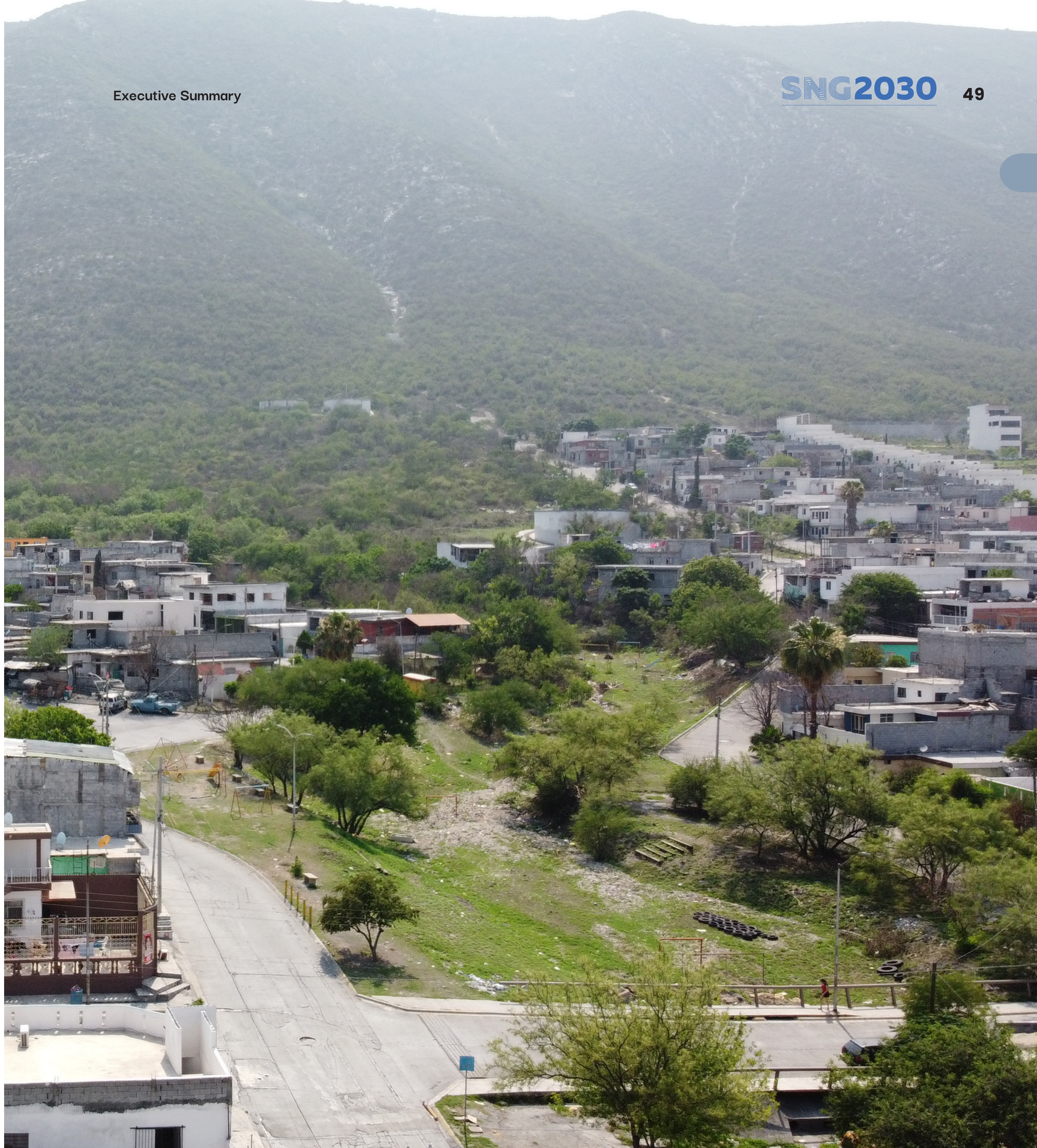
In 2018, the pollutant that most frequently determined a poor air quality condition in the AUM was suspended particulate matter PM_{10}, which exceeded the standard limits on almost 194 days of the year, followed by ozone (O_3) and suspended particulate matter $PM_{2.5}$, which combined, exceeded the standard limits on almost 37 days of the year. Other pollutants such as CO, NO_2 and SO_2 did not exceed the standard limits.

At the municipal level, the dispersion of pollutants in the atmosphere follows a specific pattern, according to studies of simulated releases from industries in the municipality of San Nicolás de los Garza (CMM, 2019). In this pattern, the simulated

Figure 8. Trend in the number of days when the limit value for particulate matter was exceeded.

Source: Author's elaboration with data from the Integrated Environmental Monitoring System of Nuevo León.





cloud at 12:00 h moves in an easterly direction within the AUM, with concentrations around 0.1 mg/m³, and then dissipates in the same direction until it reaches 0.01 mg/m³. These results show that the wind direction plays a crucial role in the persistence of high pollutant concentrations in the municipality during the first half of the day. This is because all emissions originating to the north of the AUM, even if they are not emitted in San Nicolas itself, tend to disperse and spread across the municipal boundaries due to the central location of the municipality.

This, coupled with the location of the monitoring stations within the municipality, has helped to identify patterns of days with higher or lower concentrations of criteria pollutants.

In this regard, it is important to note that the municipality has two monitoring stations dedicated to measuring the concentration of pollutants: the Northeast Station (NE) and the North 2 Station (NTE_2). These records have shown that the concentration of PM_{10} particles in the municipality is acceptable for only 85 out of 365 days of the year (UN-Habitat, 2021). Specifically, in 2021, the North 2 station (NTE2) recorded average daily concentrations of 59.5 mg/m³, with a total of 132 days exceeding the limits set by the standard (NOM-025-SSA1-2021). This represents an increase of 2.31 times compared to similar days recorded in 2017 (Nuevo León Government, 2017; 2021).

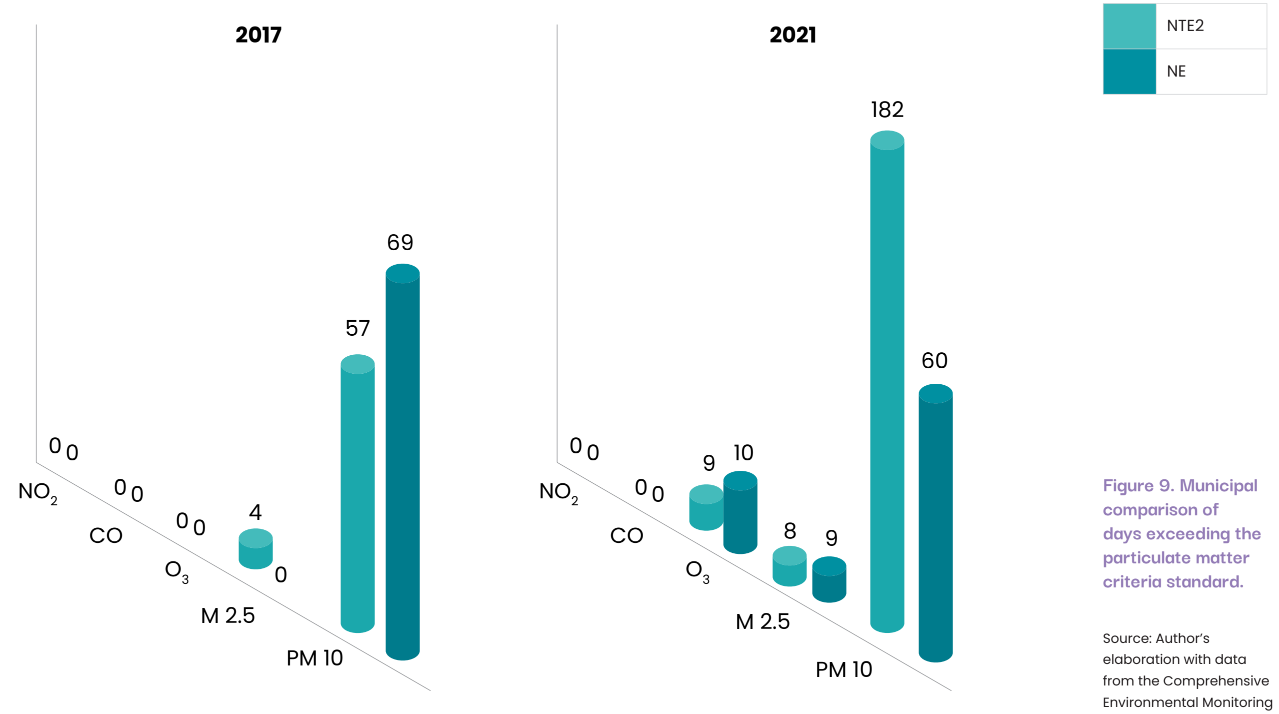


Figure 9. Municipal comparison of days exceeding the particulate matter criteria standard.

Source: Author's elaboration with data from the Comprehensive Environmental Monitoring System of Nuevo León, 2017–2021.

In comparison, the North East (NE) station reported a daily average of 55.88 mg/m³, a nine-day reduction from the norm compared to 2017 data.

In the year 2021, there were eight days outside the limit values for $PM_{2.5}$ particulate matter at the station North 2 and nine days at the Northeast Station. Similarly, for ozone (O_3) there were nine days with concentrations above the standard at the North 2 station and ten at the Northeast station.

As far as nitrogen dioxide (NO_2) and carbon monoxide (CO) measurements are concerned, no records have been found to indicate high concentrations of these pollutants in the municipality of San Nicolás de los Garza.

Emissions characterisation

To characterise the emissions within the municipality, the types of emitting sources, their activity or category, the type of pollutant emitted, and the quantity emitted per source were analysed. For this purpose, four document bases were reviewed: The Inventory of GHG Emissions for the State of Nuevo León (CCEF, 2010), the Management Programme to Improve Air Quality (ProAire, 2018), the Inventory of Atmospheric Emissions of the Metropolitan Area of Monterrey (Nuevo León Government, FAMM, 2021) and the Pollutant Emissions and Transfers Register (Nuevo León Government, 2022b).

Contributions by type of source

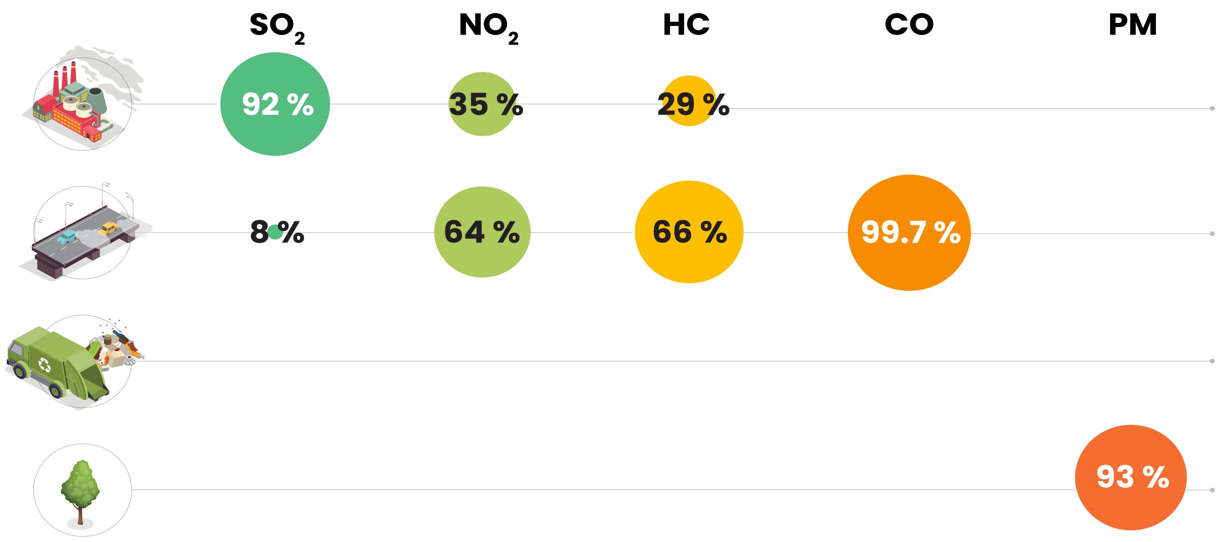
The Inventory of Greenhouse Gas Emissions in the State of Nuevo León (IEGEI-NL, by its Spanish acronym), with information based on 2005, identifies stationary sources under federal jurisdiction, mobile sources, and natural sources, reporting total emissions of 1 932 622 tonnes/year of CO_2e, of which 7 % corresponded to stationary sources, 53 % to mobile sources and 40 % to natural sources, whose contribution was mainly due to changes in land use.

Stationary sources were the main contributors to sulphur dioxide, while mobile sources were the main contributors to concentrations of carbon monoxide, nitrogen oxides and unburned hydrocarbons.

For its part, the Air Quality Improvement Management Programme 2016–2025 (ProAire), based on information from 2013, identifies the main sources of air pollutant emissions in the AUM as stationary, area, mobile and natural sources.

Figure 10. Percentage share of emissions by source at metropolitan level. Base year 2005.

Source: Author's elaboration with data from the Inventory of GHG Emissions for the State of Nuevo León (ProAire, 2016).



Comparatively, in the Inventory of Atmospheric Emissions of the Monterrey Metropolitan Area (IEAAMM, for its Spanish acronym), with information based on 2018, the types of sources classified corresponded to stationary sources (state and federal jurisdiction), mobile sources (highway and non-highway), area sources and natural sources (Clear Air Institute, 2020). Regarding the number and location of sources, according to the Pollutant Release and Transfer Register of the Air NL platform (PRTR, for its Spanish acronym), it was found that 54 stationary sources of state jurisdiction are in SNG (SIMA, 2019), among which, firstly, those corresponding to industries and, secondly, those of services stand out. These are mainly located in industrial zones, and there is a tendency for them to be concentrated in the south-western part of the district.

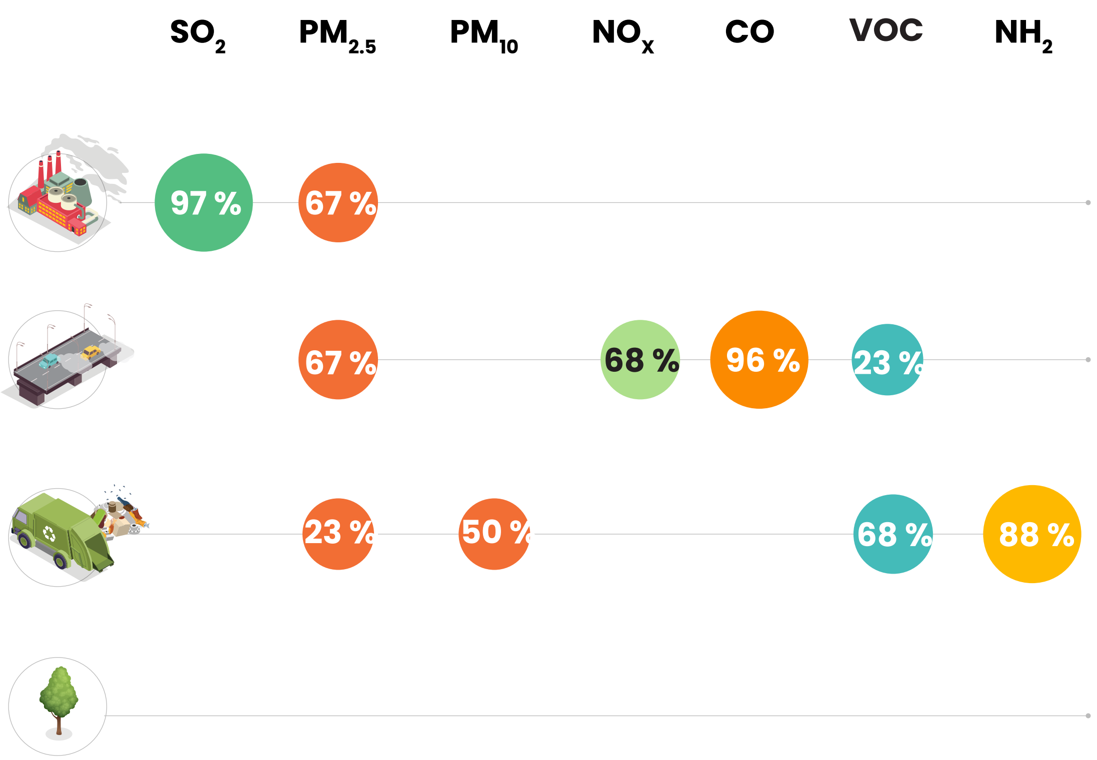
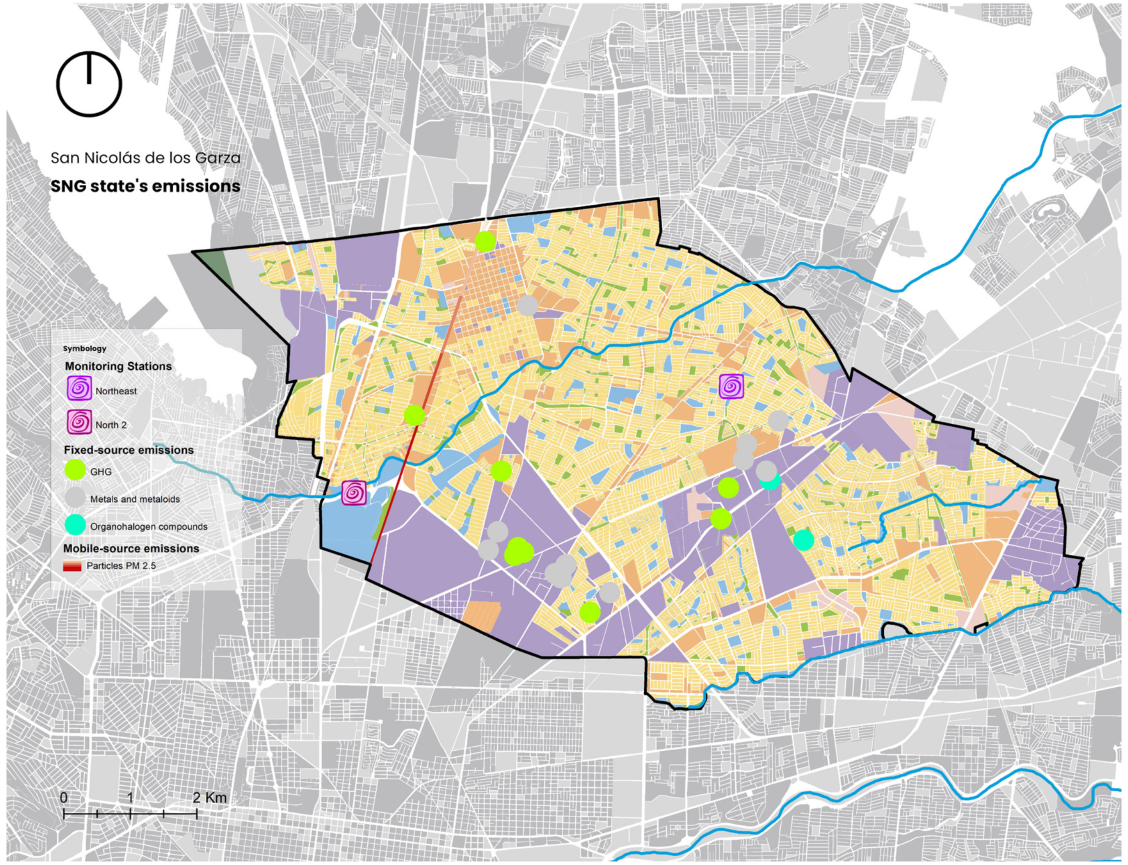


Figure 11. Percentage share of emissions by source at metropolitan level. Base year 2013.

Source: Author's elaboration with data from the Air Quality Improvement Management Programme (ProAire, 2016).



Map 10. Summary map of air emissions at municipal level in SNG base 2013.

Source: Authors' own elaboration based on data from the Pollutant Release and Transfer Register of SIMA (Government of Nuevo León 2022b).

Contributions by industry

At State level, the contributions of the petroleum and petrochemical industries stand out as the main contributors to the emission of a large part of the criteria pollutants, indicating the strong vocation of the State of Nuevo León in this sector until 2013. The percentage contribution of the AUM to total emissions reflects the economic, industrial, and environmental importance of the metropolitan area in the state context.

In the AUM it was found that $PM_{2.5}$ emissions are mainly produced by stationary industrial sources, in particular the oil and petrochemical, chemical and glass industries, which accounted for 30 % of $PM_{2.5}$ emissions. Material extraction (6 %), construction (8 %) and metallurgy (6 %) are also important contributors to emissions of this pollutant.

In turn, oil processing and petrochemicals are the main source of industrial emissions, accounting for 49 % of SO_2, 12 % of $PM_{2.5}$, 5 % of PM_{10}, 5 % of NO_x and 3 % of VOCs.

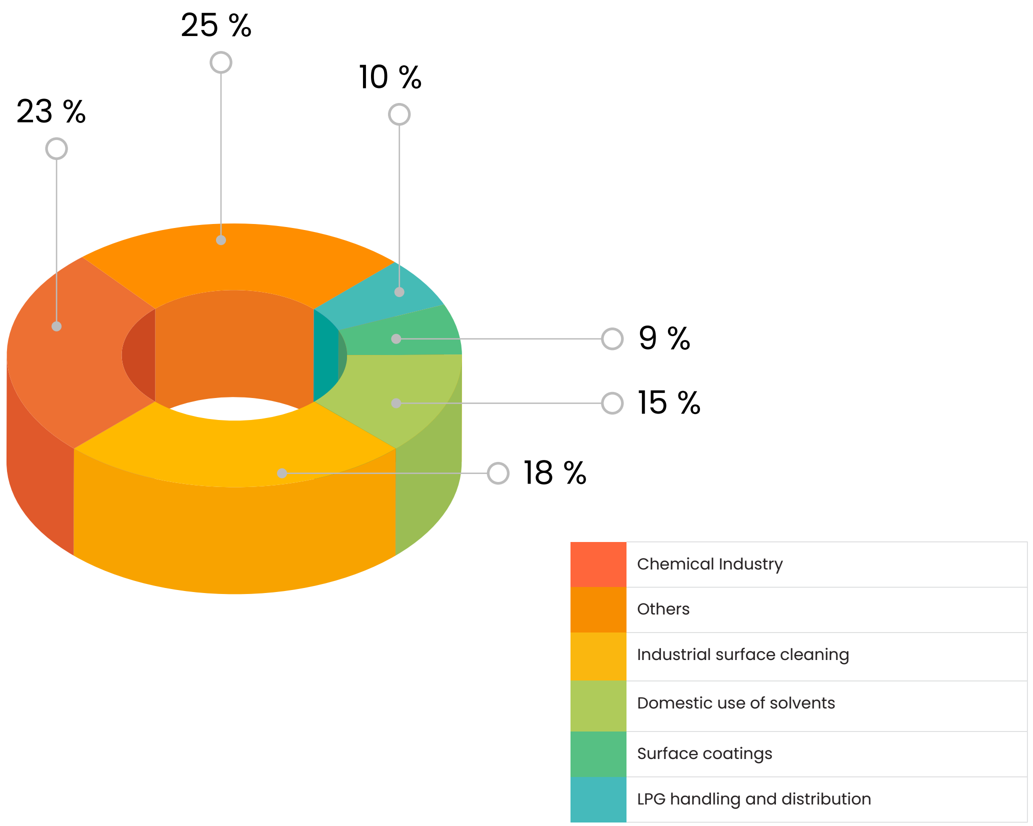


Figure 12. Percentage of VOC emissions Nicolás de los Garza 2015.

Source: Own elaboration with data from the Air Quality Improvement Management Programme (ProAire, 2016).

In the 2005 national emissions inventory, San Nicolás de los Garza stands out as one of the nine municipalities that produce 80 % of the emissions of volatile organic compounds (VOCs), accounting for 9.5% of the emissions.

The industrial sector located to the southwest of the municipality's industrial corridor was also identified as a major emitter of compounds such as NO_2 (CMM, 2019). In terms of criteria pollutants and greenhouse gases, three categories of pollutant compound emissions were recorded from the industrial sector in the municipality between 2015 and 2019 (Nuevo León Government, 2022b).

The largest emitter of pollutants classified as combustion and greenhouse gases and organohalogenates is the automotive industry, while the main contributor of metals, metalloids and non-metals is the industry in the category "Manufacture of electrical and electronic apparatus, equipment or accessories" from the Integrated Environmental Monitoring System (SIMA, for its Spanish acronym) with data from 2019 (Nuevo León Government, 2022b).

The observed data highlight the need to regulate stationary and mobile sources, especially in the industrial sector, which is the main source of air pollution in the region. It is essential to regulate industrial stationary sources under federal jurisdiction and those under state jurisdiction.

In this context, it also highlights the urgent need to regulate the sub-sectors of the automotive

Table 1. Total annual emissions by category of air pollutants for the period 2015-2019 in the municipality of San Nicolás de los Garza.

Source: Author's elaboration with data from the Pollutant Release and Transfer Register (Government of Nuevo León 2022b)

Pollutant category	tCO_2e/ year				
	2019	2018	2017	2016	2015
Combustion and greenhouse gases	14 194.32	13 715.09	52 583.0	39 684	18 837
Metals, metalloids and non-metals	0	0.08182	0.09202	0.0573	7721
Organohalogen compounds	0	1	1	0	0.4776

industry, the manufacture of electrical and electronic equipment, the petroleum and petrochemical industry and the metallurgical industry. However, since the municipality has only limited powers to regulate these sources, its action should focus on establishing coordination mechanisms with the competent authorities to promote an effective energy and technological transition in industrial sources that will reduce their annual emissions.

The regulation of other sectors under municipal jurisdiction—not including federal and state industrial stationary sources—is particularly important for pollutants such as carbon dioxide, nitrates, sulphides and PM. This requires the regulation of area sources, in particular the construction and solvent use subsectors.

In addition, the municipality shall focus on actions related to the control of fugitive emissions from commercial activities, services, public and private works and governmental activities resulting from the use of energy, the use of emitting substances in everyday activities and the use of fossil fuels. The measures to be implemented by the municipality may focus on the regulation, registration and monitoring of commercial and residential sources whose distribution results from these types of activities.

Approximate modelling of emissions under the responsibility of municipal authorities

To determine the necessary scope of regulation of sources and sectors under municipal jurisdiction, direct and indirect emissions were estimated using the CURB tool, using information on consumption patterns in San Nicolás de los Garza as a baseline. Emissions from sectors such as the residential-commercial sector, the government sector, which includes miscellaneous activities and lighting services, the transport sector, which includes only private transport, and the waste and biogas sector, where the categories of solid waste and waste from water and sanitation services (sludge) were disaggregated.

The modelling results show that the total municipal emissions in SNG in 2020 are 1 791 876 tCO_2e/year. Of this amount, it is estimated that 340 558 tCO_2e/year are emitted by the residential and commercial sector, 28 123 tCO_2e/year by the public sector, 148 377 tCO_2e/year by the transport sector, 1 253 909 tCO_2e/year by the solid waste sector and 20 909 tCO_2e/year by the water sector. The largest emission contributor was the solid waste sector, followed by the residential and commercial sector.

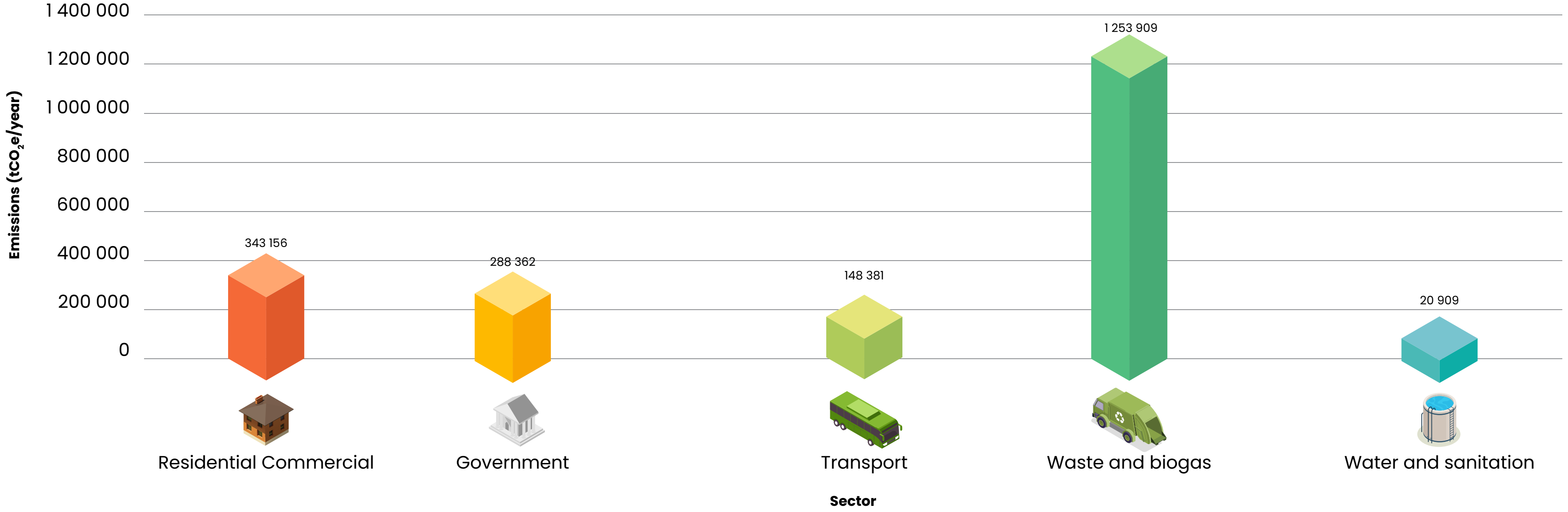


Figure 13. Approximate modelling of municipal emissions by sector in San Nicolás de los Garza. Base year 2020.

Source: Author's elaboration based on modelling with the CURB tool and statistical data from INEGI, 2014–2020.

Trajectory of cumulative GHG emissions and trend towards carbon neutrality

Figure 14. Estimated cumulative municipal emissions trajectory by sector up to 2070. Business as usual model.

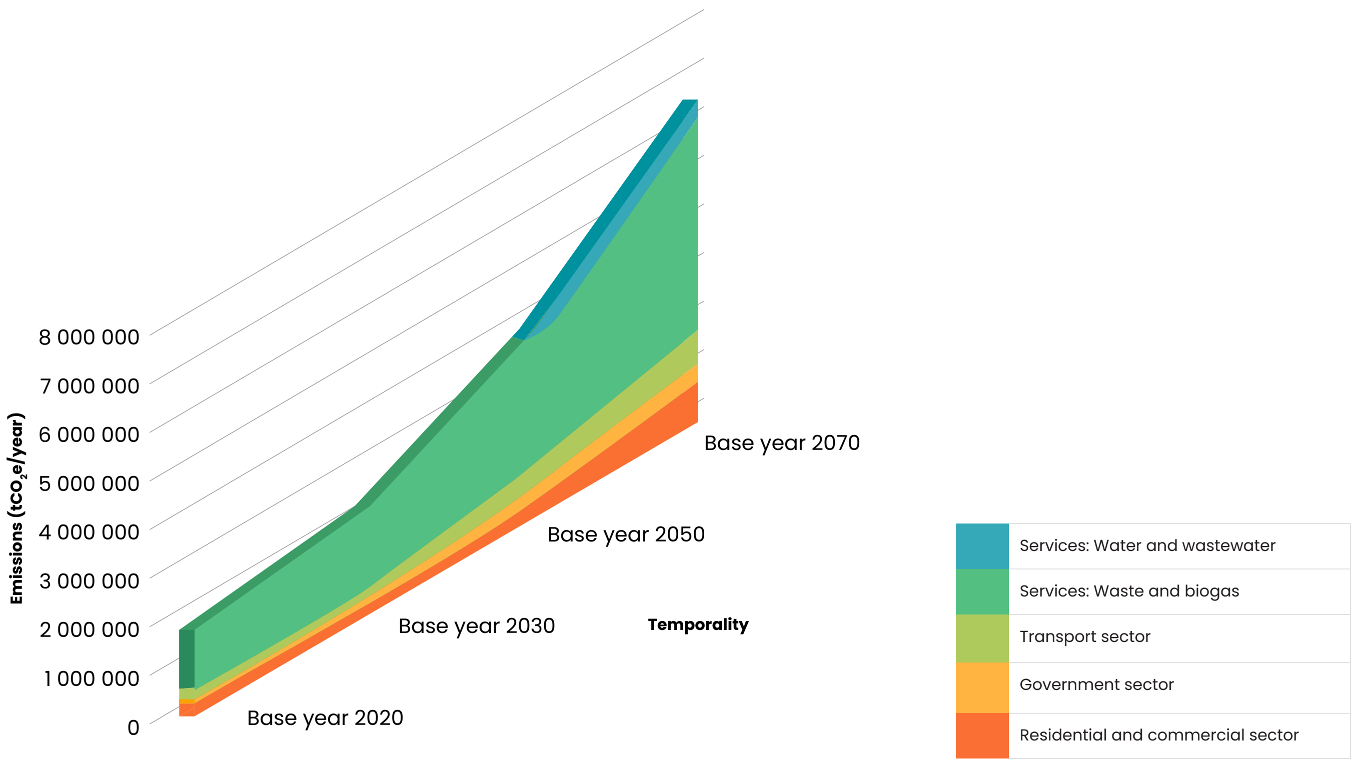
Source: Author's elaboration by modelling with CURB tool and with statistical data from INEGI, 2014–2020.

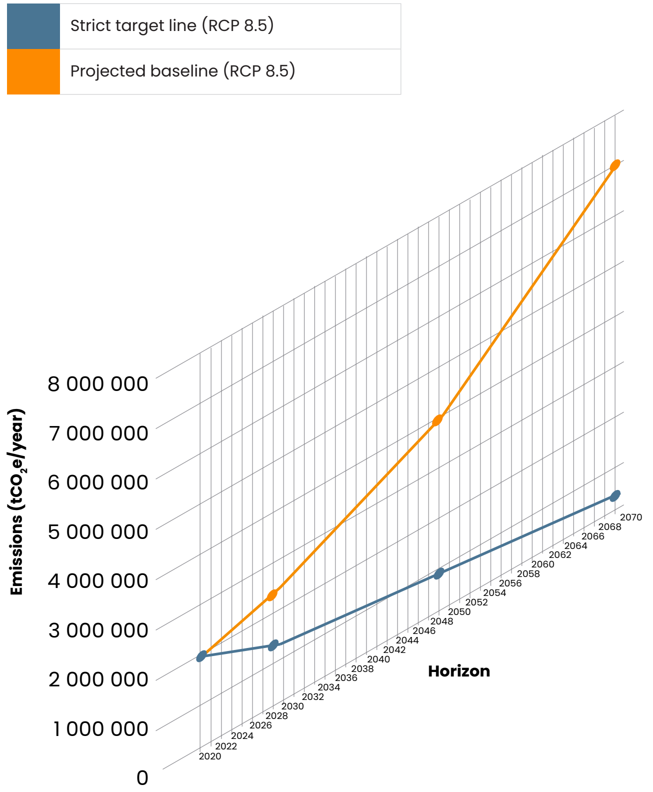
Based on the sectoral modelling, in order to identify the emissions that will be realised over time and to know how far or close to the carbon-neutral trend the NDCs are aiming for, the CURB tool (World Bank, 2016) was used to calculate emissions trajectories for three horizons.

In this trajectory modelling, it was observed that in a business-as-usual scenario for San Nicolás de los Garza, the total municipal emissions could increase to 2 358 801 tCO_2e by 2030 and almost triple to a total of 6 934 257 tCO_2e by 2070. The main contributor to these emissions would continue to be the waste and biogas sub-sector, followed by the residential and commercial sector. These results can be used as a guide to which sectors should be prioritised for mitigation strategies and the desirable range of emission reductions.

To understand the magnitude of these reductions, the carbon neutrality trajectory of the municipality was projected considering three time horizons: short-term (2030), medium-term (2050) and long-term (2070). The amount of allowable emissions was also estimated by subtracting the percentage reduction from the 2020 baseline, which in turn was calculated based on the NDCs and their trajectory towards carbon neutrality by 2100 (RCP 2.6).

As the reduction rates based on the NDCs were estimated to be 35 % by 2030, 54 % by 2050, and 81 % by 2070, the allowable emission levels were obtained by calculating the reduction target for the base





Emission reduction targets	
Projected emissions in 2030 (tCO_2e / year)	
2 348 801	Services sector: water and wastewater
35 %	Services: waste and biogas
1 164 719	Transport sector
1 184 082	Government sector
Projected emissions 2050 (tCO_2e / year)	
4 035 739	Projected baseline
54 %	Target (% below base year)
824 263	Allowable emissions
3 211 476	Emissions to be avoided
Projected emissions 2070 (tCO_2e / year)	
6 934 257	Projected baseline
81 %	Target (% below base year)
340 456	Allowable emissions
6 593 801	Emissions to be avoided

Figure 15. Cumulative GHG emissions trajectory and carbon neutrality trend for San Nicolas de los Garza.

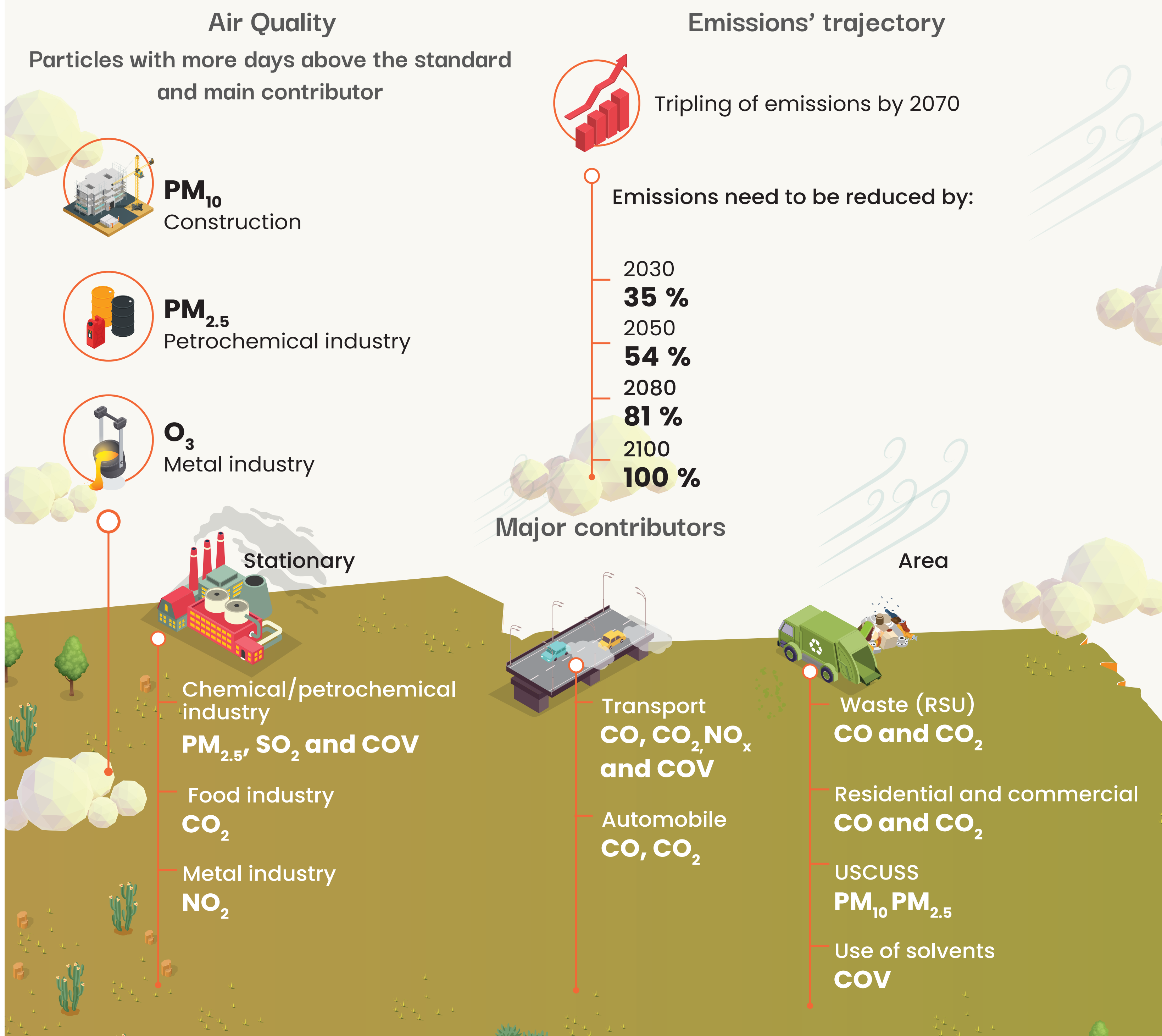
Source: Authors' own elaboration through modelling with the CURB tool and statistical data from INEGI, 2014-2020.

year 2020 (1 791 876 tCO_2e). This means that if the municipality achieves a 35 % reduction compared to the base year 2020, up to 1 164 719 tCO_2e could be allowed in 2030, while if it achieves a 54 % reduction compared to the base year 2020, a total of 824 263 tCO_2e could be allowed in 2050.

By the same logic, if the municipality guarantees an 81 % reduction by 2070 compared to the base year 2020, then 340 456 tCO_2e could be allowed to be emitted in 2070. In this trend line, by the year 2100, since the goal is carbon neutrality, the aim would be to "avoid" 100% of the emissions by matching the number of emissions sequestered with those emitted.

It is important to note that the emission reductions that the municipality should pursue in each of the horizons could be achieved through direct emission avoidance or through sequestration and delivery. Thus, for each horizon, the municipal climate action targets could aim at preventing or sequestering the emission of 1 184 082 tCO_2e by 2030 of 3 211 476 tCO_2e by 2050 and of 6 593 801 tCO_2e by 2070. To this end, the municipality could implement measures in the waste and biogas, residential and commercial, and transport sectors.

Air pollution in San Nicolás de los Garza



Assessing future climate vulnerability

To understand the municipality's vulnerability to climate change and associated risk events, methodological bases and various inputs developed by UN-Habitat (2019, 2020 and 2021) were used, including the Climate Change Vulnerability Assessment Manual (UN-Habitat and UNEP, 2018). The nationally recognised methodologies of the National Atlas of Vulnerability to Climate Change of the National Institute of Ecology and Climate Change (INECC) of 2019 and that of the National Centre for Disaster Prevention (CENAPRED) were adapted.

To this end, the Climate Vulnerability Index was formulated by calculating 30 indicators: 7 for exposure, 8 for sensitivity and 15 for adaptive capacity, grouped into 7 categories that constitute the three factors used to assess vulnerability to climate change (Figure 16). From the analysis of these factors, an average indicator was obtained to geographically represent the areas of high exposure, high sensitivity, and high adaptive capacity, in order to generate a Final Climate Vulnerability Index, from which an average indicator per district was also obtained.

The indicators used to formulate the local climate vulnerability index in SNG (Table 2) incorporate information from the climate change scenarios analysed in the preceding sections and the results of geospatial analyses of social and environmental elements.

Figure 16. Structure of SNG climate change vulnerability analysis.

Source: Author's elaboration.

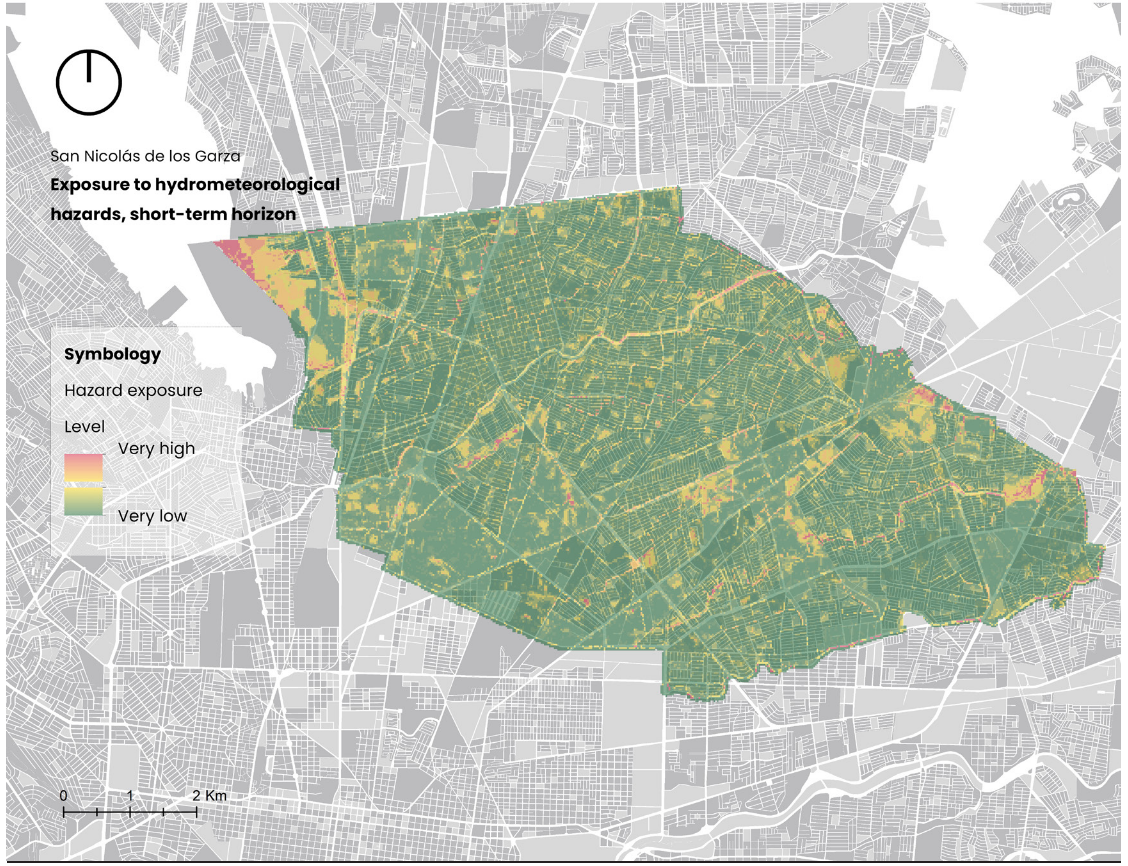
Table 2. List of indicators used to analyse the climate vulnerability of SNG municipality by factors and categories.

Source: UN-Habitat, 2022

Factor	Category	Code	Indicator
Exposure	Hydrometeorological hazard	E1	Degree of flood hazard
		E2	Degree of drought hazard
		E3	Degree of frost hazard
	Climate change scenarios	E4	RCP 4.5 scenario of historical maximum temperatures
		E5	RCP 4.5 scenario of historical minimum temperatures
		E6	RCP 8.5 scenario of historical maximum temperatures
		E7	RCP 8.5 historical minimum temperature scenario
Sensitivity	Vulnerability of the population	S1	Overcrowding
		S2	Percentage of vulnerable population, children, and elderly
		S3	Percentage of population speaking an indigenous language
		S4	Urban marginalisation degree
	Urban infrastructure	S5	Exhibited public facilities
		S6	Housing typology
		S7	Bare Soil Index, BSI
		S8	Density of economic activity
Adaptive capacity	Ecosystems	C1	Distance to public spaces
		C2	NDVI vegetation cover
		C3	Illiteracy rate
	Capacity by socio-economic conditions of the population (education, health, housing, employment, and income)	C4	Percentage of the population between 6 and 14 years of age not attending school
		C5	Average level of education
		C6	Coverage of health services, percentage of ineligible population
		C7	Percentage of population with some form of disability and activity limitation
		C8	Percentage of households without piped water supply
		C9	Percentage of households without a sewerage system
		C10	Percentage of households without an electricity supply
		C11	Percentage of dwellings with dirt floor
		C12	Rate of dependency
		C13	Open unemployment rate
	Appropriate and effective response	C14	Distance to medical facilities
		C15	Coverage of emergency services

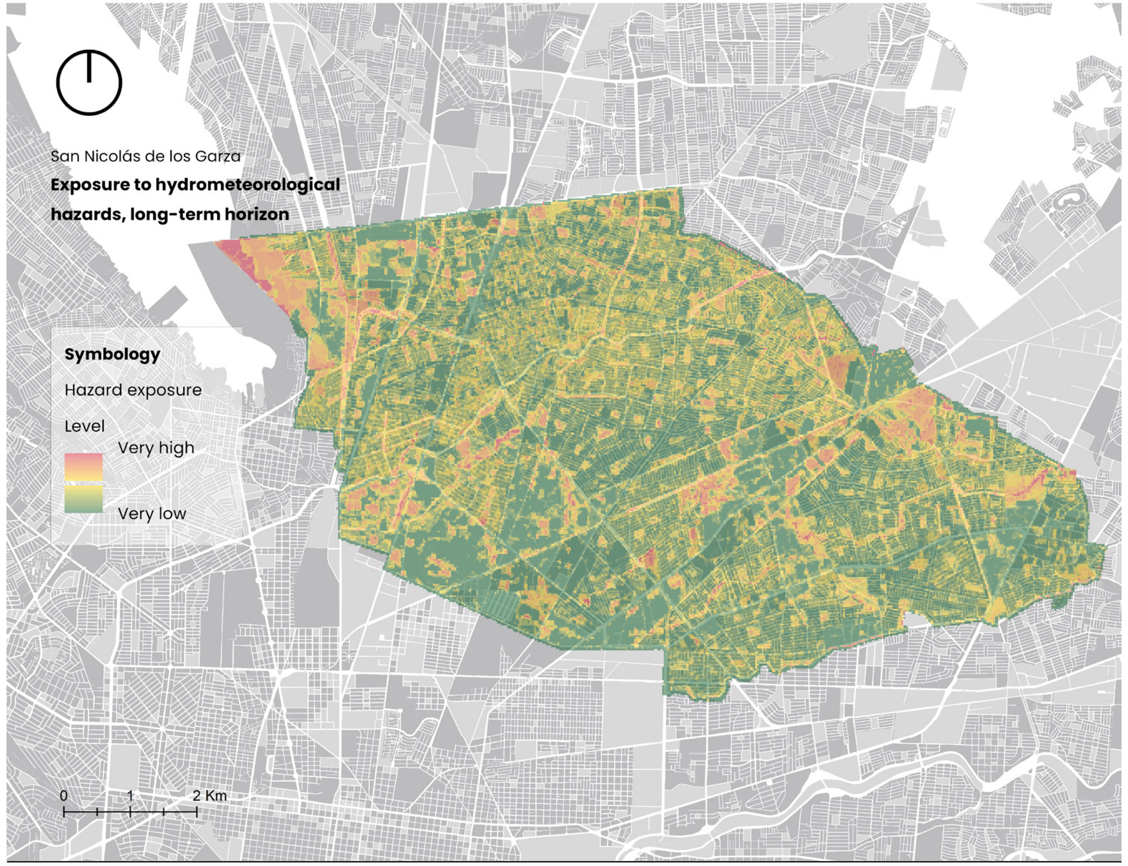
Exposure

Exposure has been analysed in terms of hydrometeorological hazards and scenarios expected under climate change conditions. For the near or short-term horizon, the highest levels of vulnerability are concentrated in the north-west and east of the municipality, and in the areas around the Topo Chico and Los Pinos streams. For the distant or long-term horizon, there is an increase in the area with high levels of vulnerability, grouped in the northwest, east and centre of SNG, in the districts of Balcones, Residencial Anáhuac, Casa Bella, Industrial, Cuauhtémoc, Lagrange, Andalucía, Casa Blanca, San Cristóbal, Vicente Guerrero, Santo Domingo and La Fe.



Map 11. Exposure to hydro-meteorological hazards (floods, droughts, and frosts) for the short-term horizons.

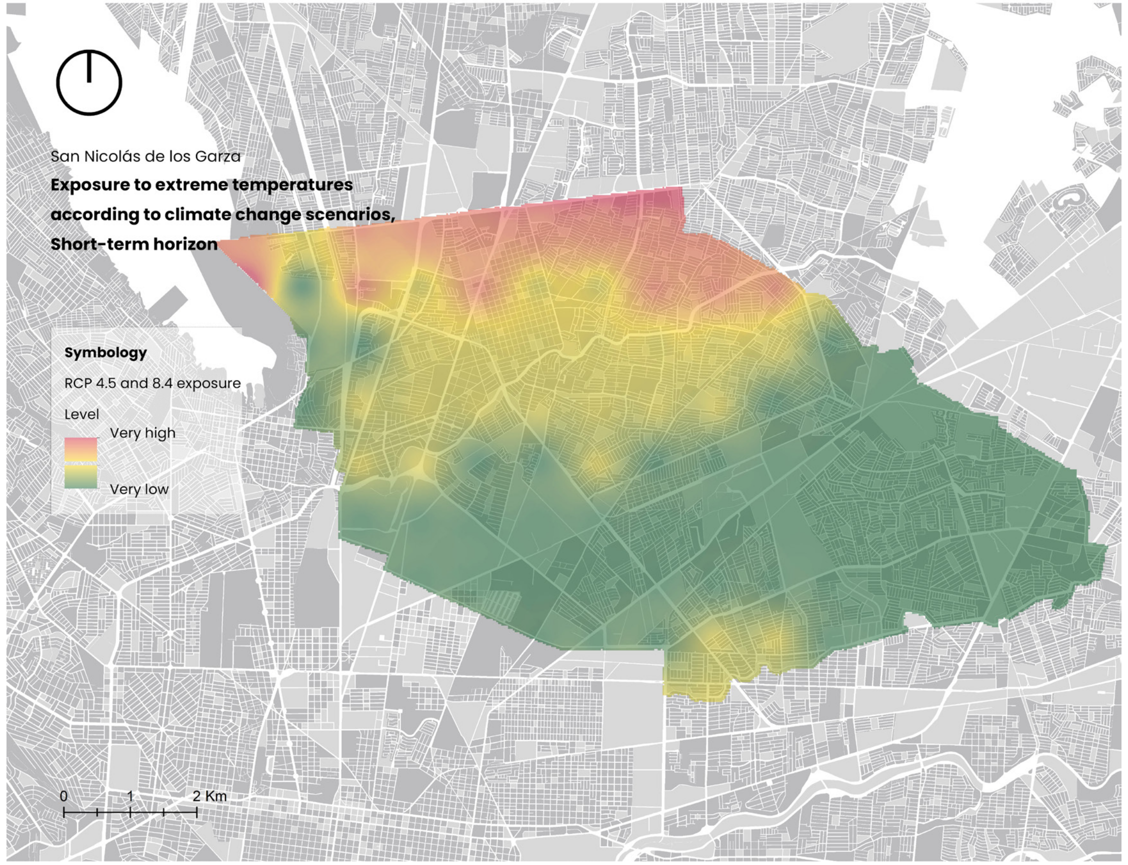
Source: Author's elaboration with data from the Atlas de Riesgos para el Municipio de San Nicolás de los Garza, Nuevo León, 2021.



Map 12. Exposure to hydrometeorological hazards (floods, droughts, and frosts) for the long-term horizon.

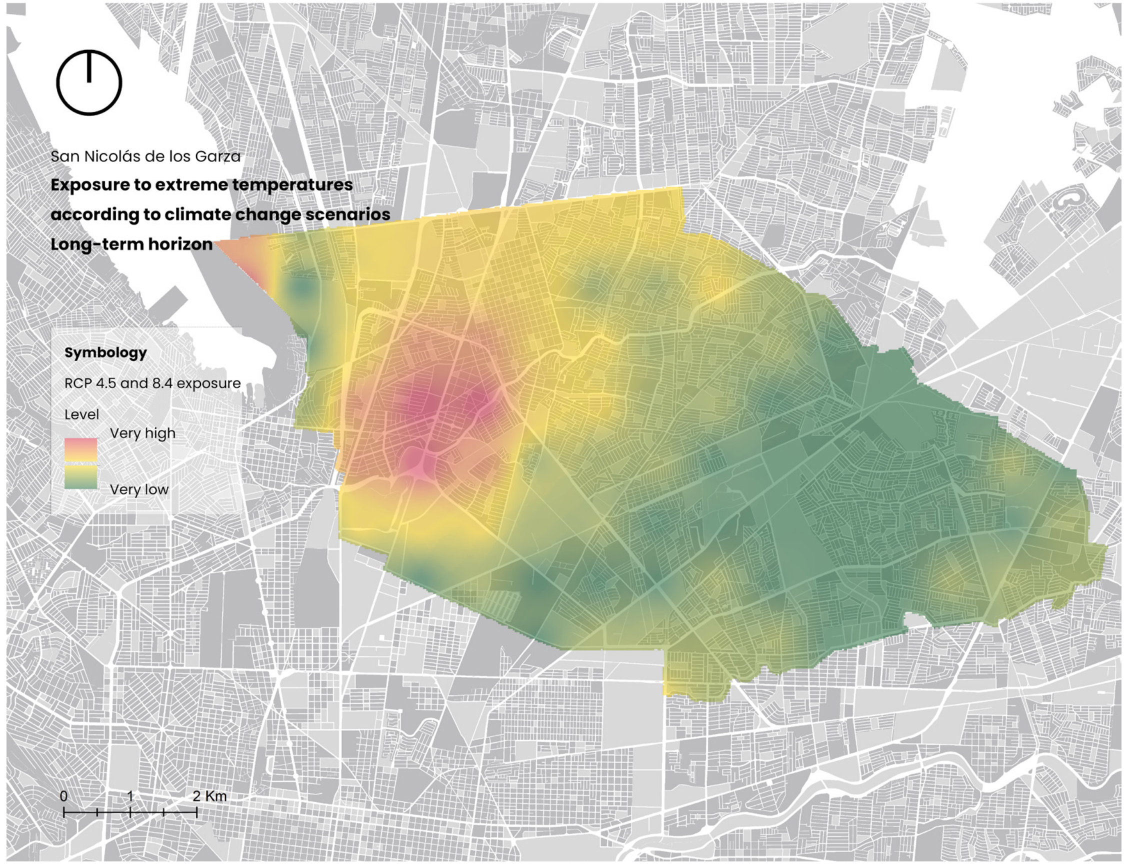
Source: Author's elaboration with data from the Atlas de Riesgos para el Municipio de San Nicolás de los Garza, Nuevo León, 2021.

The following maps show the most exposed areas according to the RCP 4.5 and RCP 8.5 climate change scenarios of historical maximum and minimum temperatures for the near future (2021–2040) and the far future (2081–2100). In the near or short-term scenario (2021–2040), the highest levels of exposure are found in the north of the municipality, in the neighbourhoods of Balcones, Casa Bella, Centro, CEDECO, El Refugio and Vicente Guerrero. In the long-term scenario (2081–2100), the highest levels of exposure are in the northwest of the SNG, in the districts of Anáhuac, Residencial Anáhuac, Cuauhtémoc, Casa Bella, Centro, Industrial and Balcones.



Map 13. Exposure to RCP 4.5 and RCP 8.5 climate change scenarios of historical maximum and minimum temperatures for the short-term horizon (2021-2040) in SNG.

Source: Author's elaboration with data from AR6-IPCC (2021), UNAM's Institute of Atmospheric Sciences and Climate Change and UNIATMOS (2022).



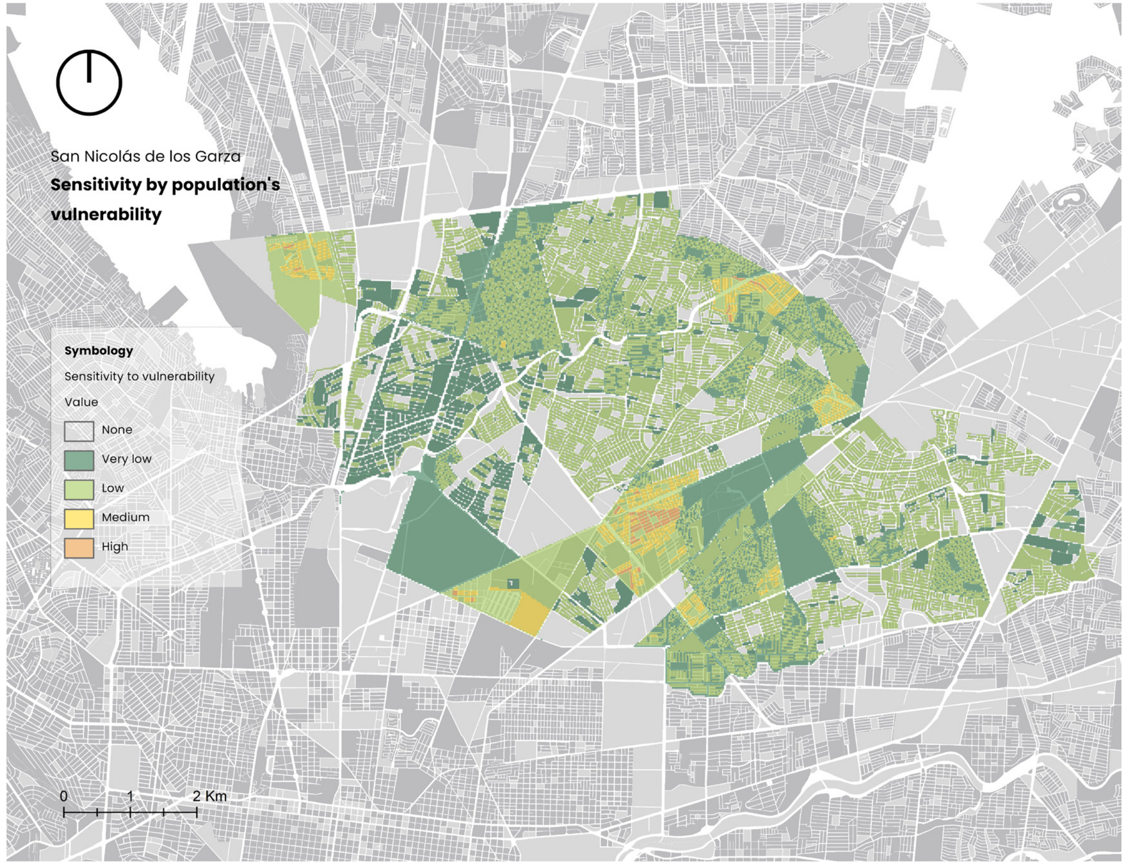
Map 14. Exposure to RCP 4.5 and RCP 8.5 climate change scenarios of historical maximum and minimum temperatures for the long-term horizon (2081-2100) in SNG.

Source: Author's elaboration with data from AR6-IPCC (2021), UNAM's Institute of Atmospheric Sciences and Climate Change and UNIATMOS (2022).

Sensitivity

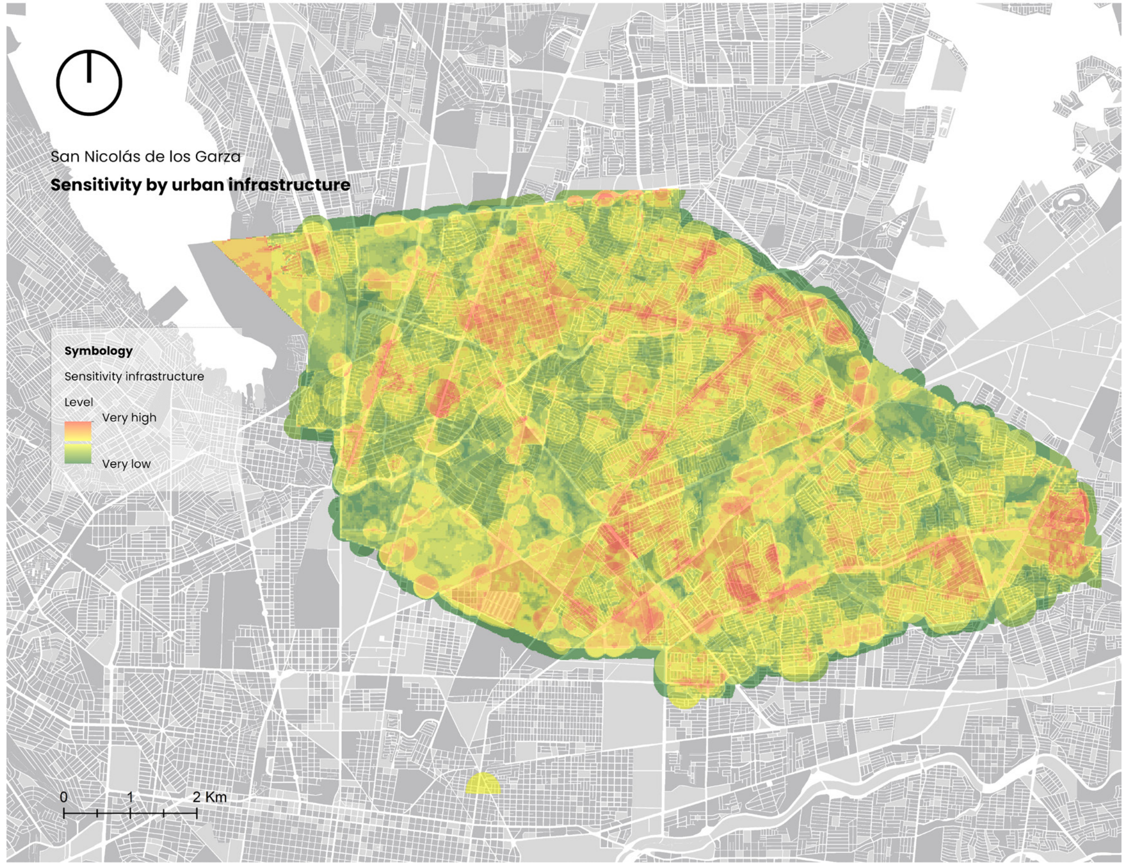
The sensitivity analysis included the socio-demographic conditions of the population and the urban infrastructure. Map 15 shows the areas of highest and lowest vulnerability of the population, with the highest levels in the centre, south, north-east, and north-west of the municipality, in the districts of Lagrange, Pedregal, Nogalar, Industrial, Vicente Guerrero, Balcones and Constituyentes.

Map 16 shows areas with a high concentration of infrastructure and, in blue, those with a low density, indicating that the districts of Lagrange, Constituyentes, Nogalar, Centro, Industrial, Pedregal, La Fe, Santo Domingo, Vicente Guerrero, Del Paseo, El Refugio and Talaverna are the most sensitive to urban infrastructure in SNG.



Map 15. Sensitivity by vulnerability of the population of SNG.

Source: Author's elaboration with data from INEGI Population and Housing Census, 2020 and the National Population Council (CONAPO, 2020).



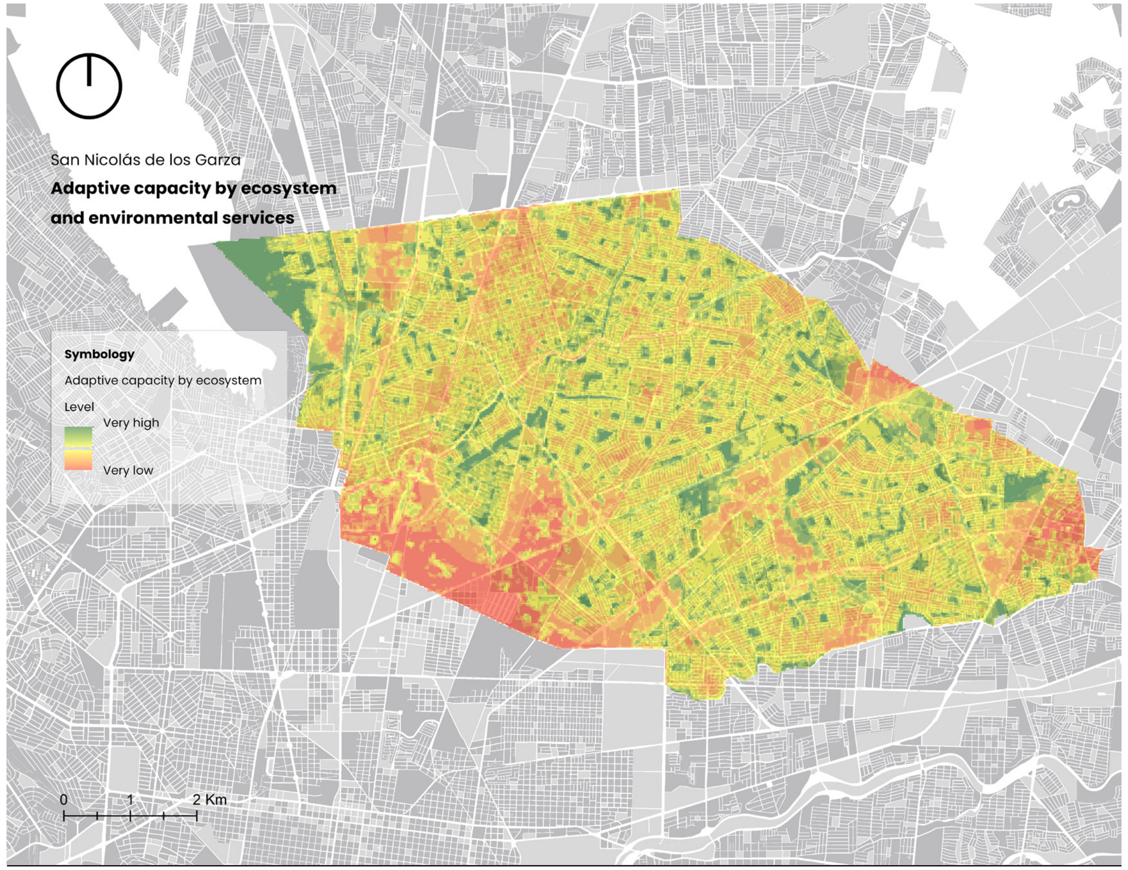
Map 16. Sensitivity by urban infrastructure in SNG.

Source: Prepared by the authors with data from the Atlas de Riesgos para el Municipio de San Nicolás de los Garza, Nuevo León (2021), Sentinel-2 (2021) and the National Statistical Register of Economic Units (DENUE, 2023).

Adaptive capacity

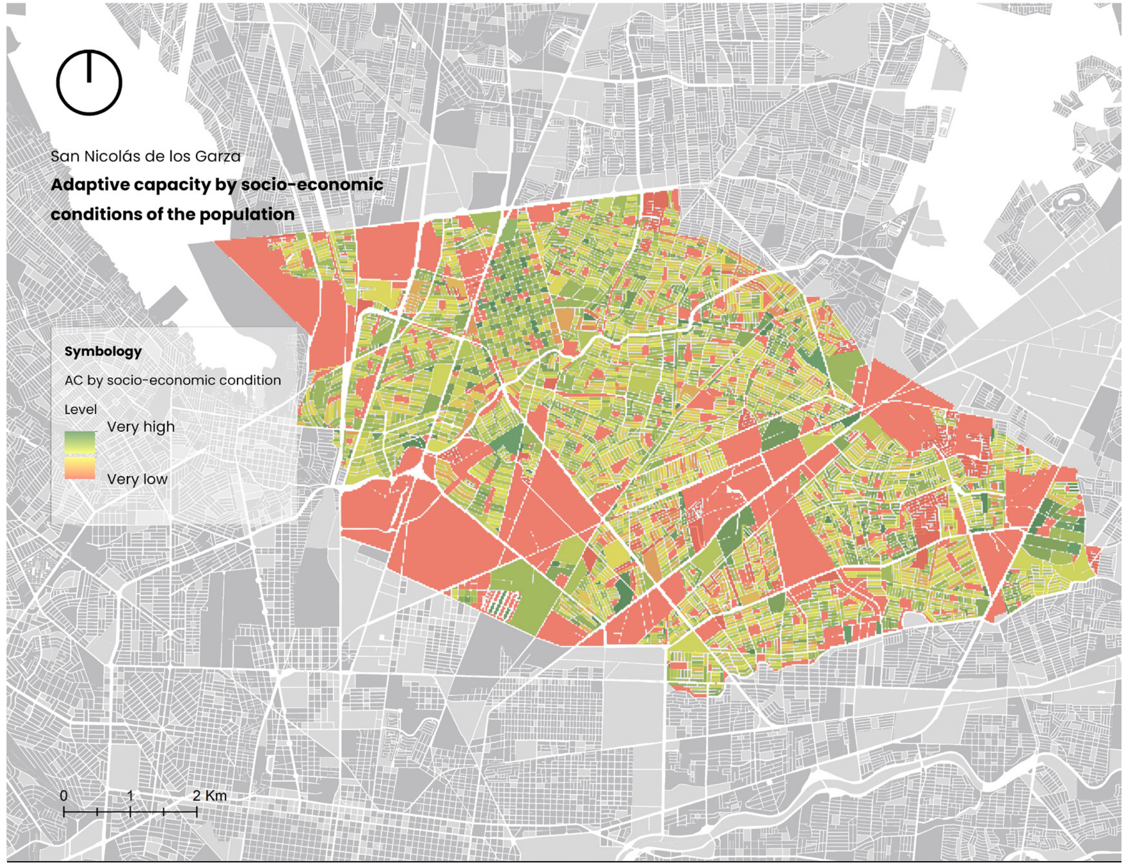
Adaptive capacity was analysed considering the presence of ecosystems, the socio-economic conditions of the population and the ability to respond effectively to climate change. The districts with the highest adaptive capacity by ecosystem are Balcones, Residencial Anáhuac, Cuauhtémoc, Jardines de Anáhuac, Del Paseo, Las Puentes, Lagrange, Casa Blanca, San Cristóbal, Casa Bella and Santo Domingo.

Most of the area has high and very high levels of adaptive capacity (Map 18) due to the socio-economic conditions of the population. However, as can be seen in the following map at the level of urban blocks, there are areas with medium, low, and very low levels within the municipality. The districts of Lagrange, Nogalar, Constituyentes, Del Vidrio, Talaverna, Vicente Guerrero, Casa Blanca, Pedregal, El Refugio and CEDECO have several urban blocks with poor socio-economic conditions and therefore have a lower adaptive capacity to face the possible impacts related to climate change in their territories.
.



Map 17. Adaptive capacity through ecosystems and environmental services in SNG.

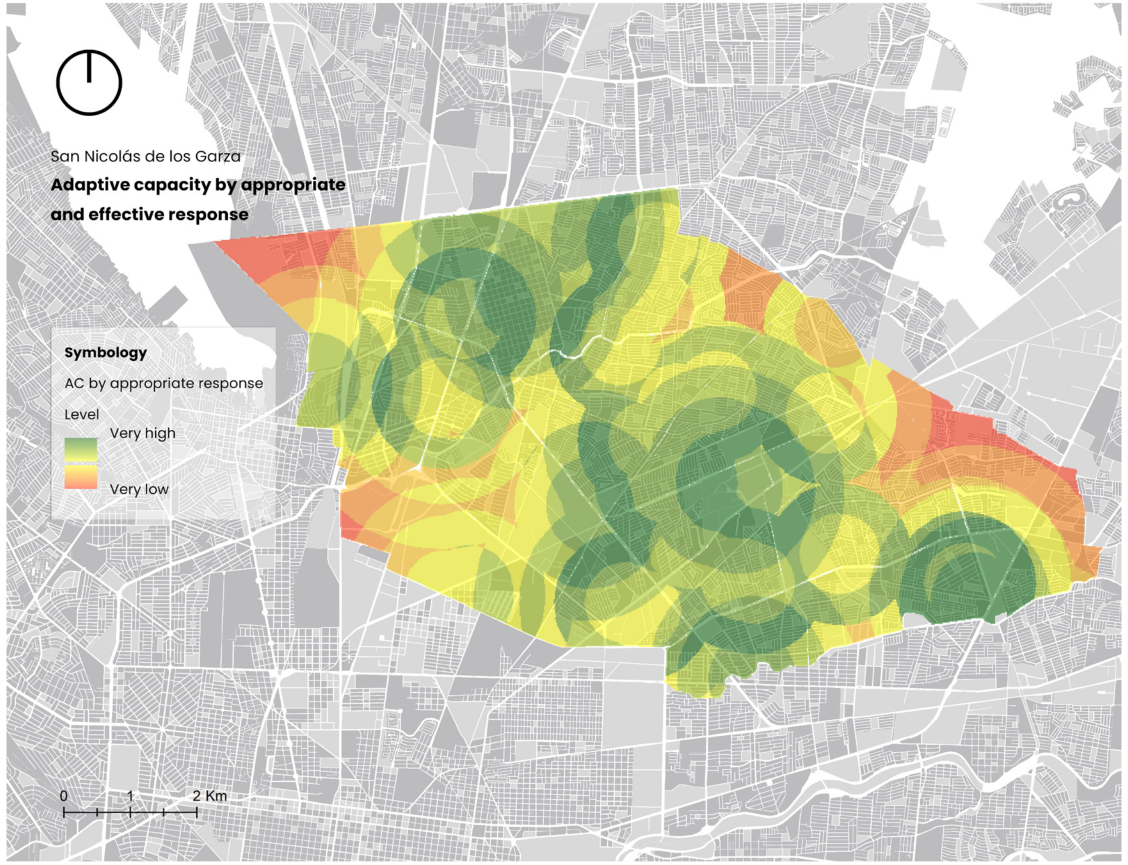
Source: Author's elaboration with data from the Municipal Government and Sentinel-2 image (2021).



Map 18. Adaptive capacity by socio-economic conditions of the population (education, health, housing, employment, and income) in SNG.

Source: Author's elaboration with data from the Census of Population and Housing, 2020 of INEGI, 2020.

Map 19 shows the access of the SNG population to medical units and various emergency services, justice and public security services, and health services. The districts with the lowest response capacity are the peripheral ones, and those with the highest coverage and access to the above are the central ones.



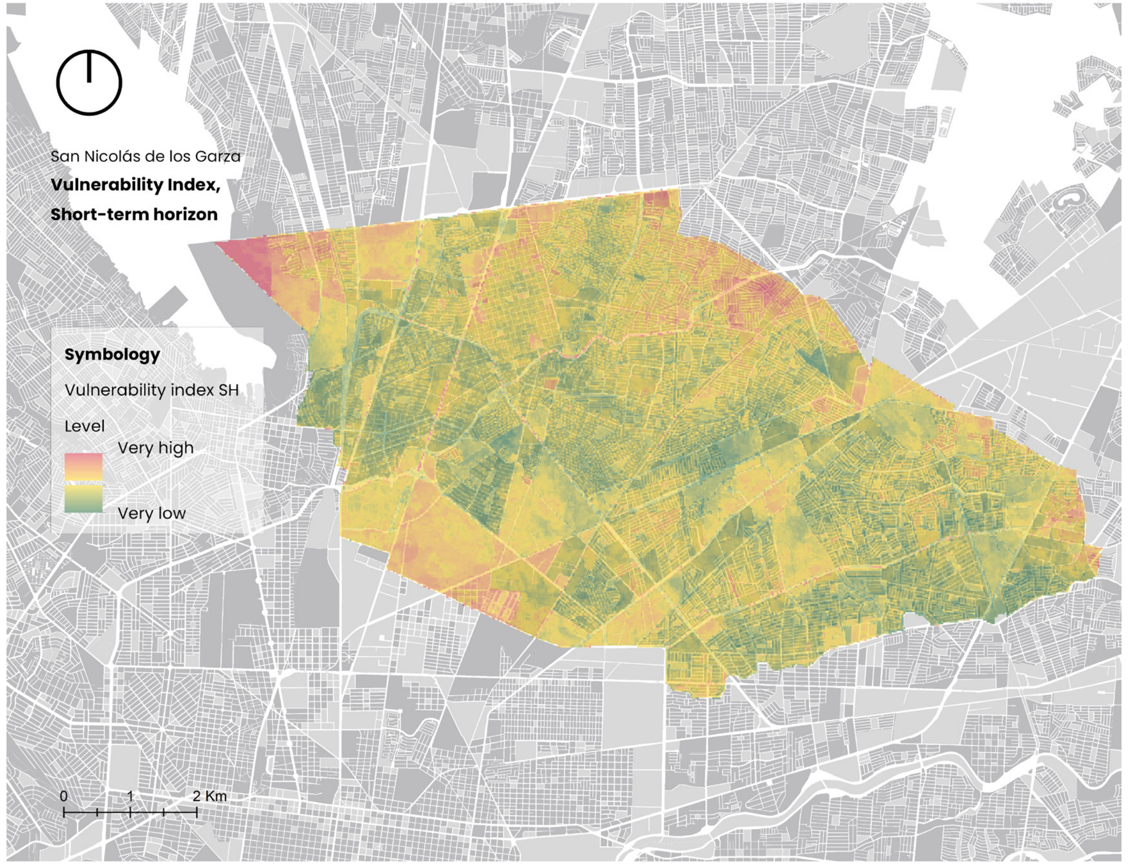
Map 19. Adaptive capacity for appropriate and effective response in SNG.

Source: Author's elaboration with data from the Atlas de Riesgos para el Municipio de San Nicolás de los Garza, Nuevo León, 2021 and DENUE (INEGI, 2023).

Climate vulnerability index for municipalities and districts

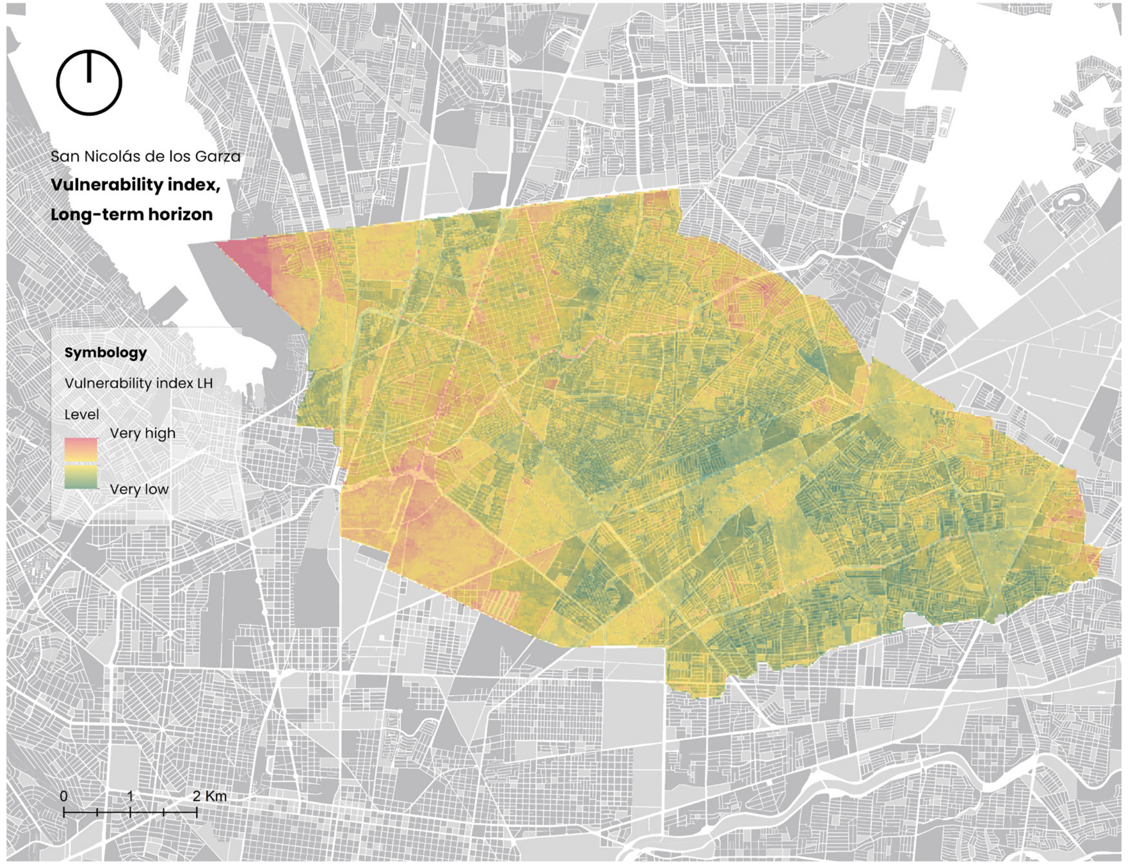
In the integration of the vulnerability index, the three factors described above (exposure, sensitivity, and adaptive capacity) were considered equally important, so that the final state of climate vulnerability was analysed cartographically by integrating each factor and then classifying the result on the same scale defined by natural disasters. To show the changes from the near horizon to the far horizon, the exposure factor was used for two future time horizons: short- and long-term..

Maps 20 and 21 integrate the differences in vulnerability to climate change within the districts to appreciate the detail and heterogeneity of the vulnerability assessment within these administrative districts.



Map 20. Vulnerability index, short-term horizon..

Source: Author's elaboration.

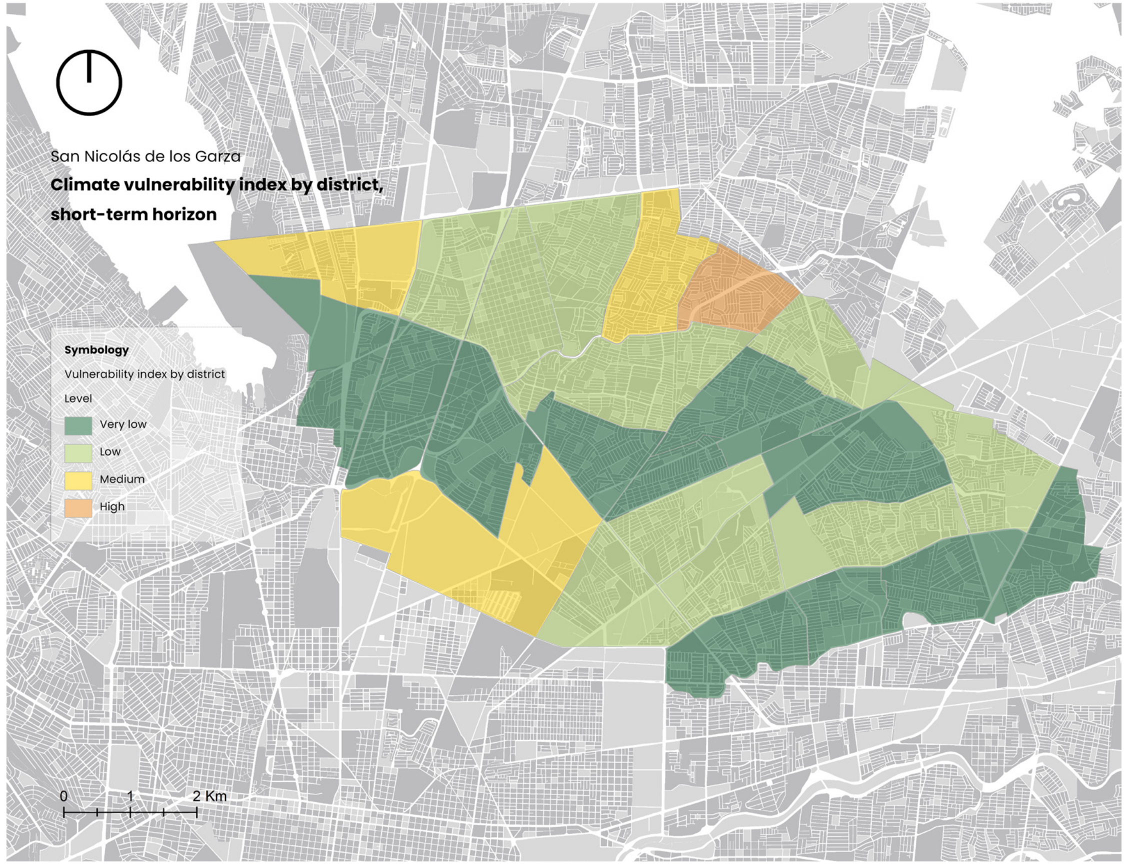


Map 21. Vulnerability index, long-term horizon.

Source: Author's elaboration.

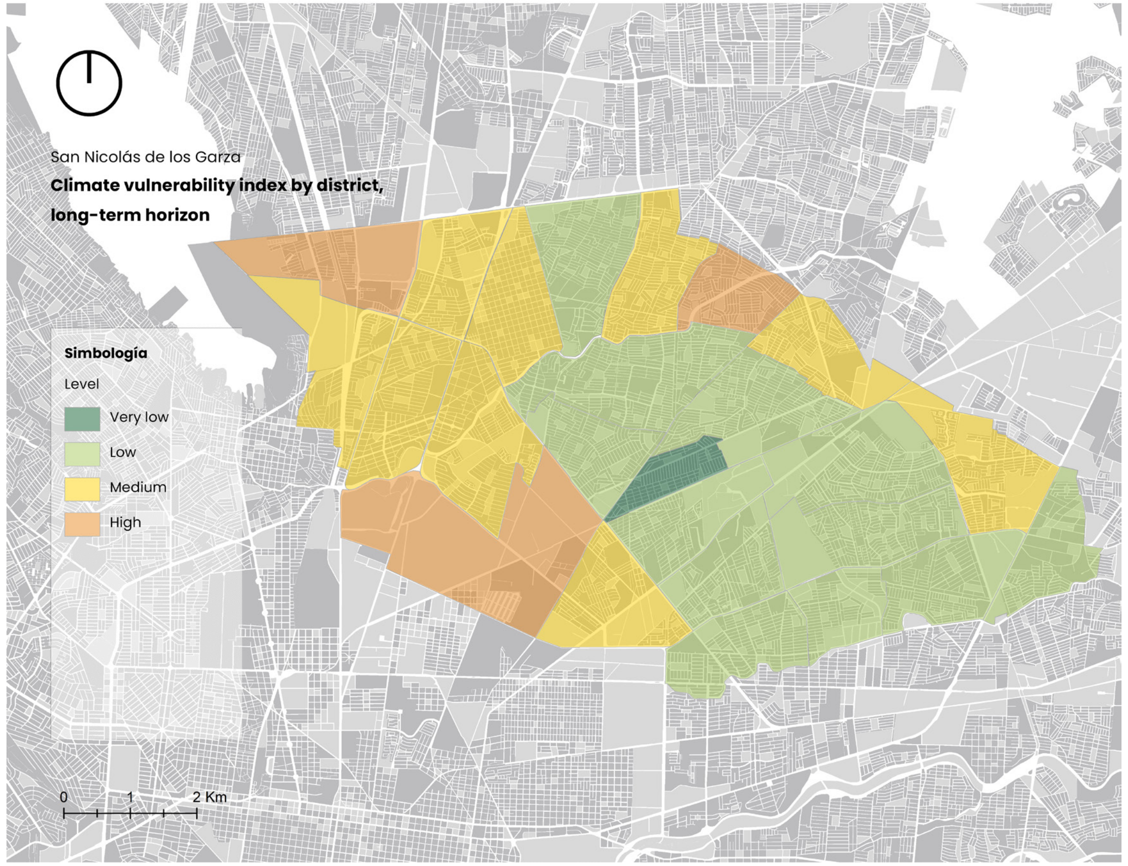
Maps 22 and 23 reflect the priority vulnerability condition assumed for most of the territory of each district, to guide those areas of SNG that need to implement greater adaptation measures to reduce their future climate vulnerability. The districts of Industrial, Balcones and Vicente Guerrero are those that would have the highest vulnerability in SNG under both horizons.

The final climate vulnerability maps allow for the identification of areas of higher or lower vulnerability to climate change to prioritise actions within the municipality. Very high climate vulnerability implies a combination of higher levels of exposure and sensitivity and lower levels of adaptive capacity. . A summary of the districts with the highest and lowest scores for each factor and the climate vulnerability indices for the two-time horizons is shown below.



Map 22. Vulnerability index by district, short-term horizon..

Source: Author's elaboration.



Map 23. Vulnerability index by district, long-term horizon.

Source: Author's. elaboration.

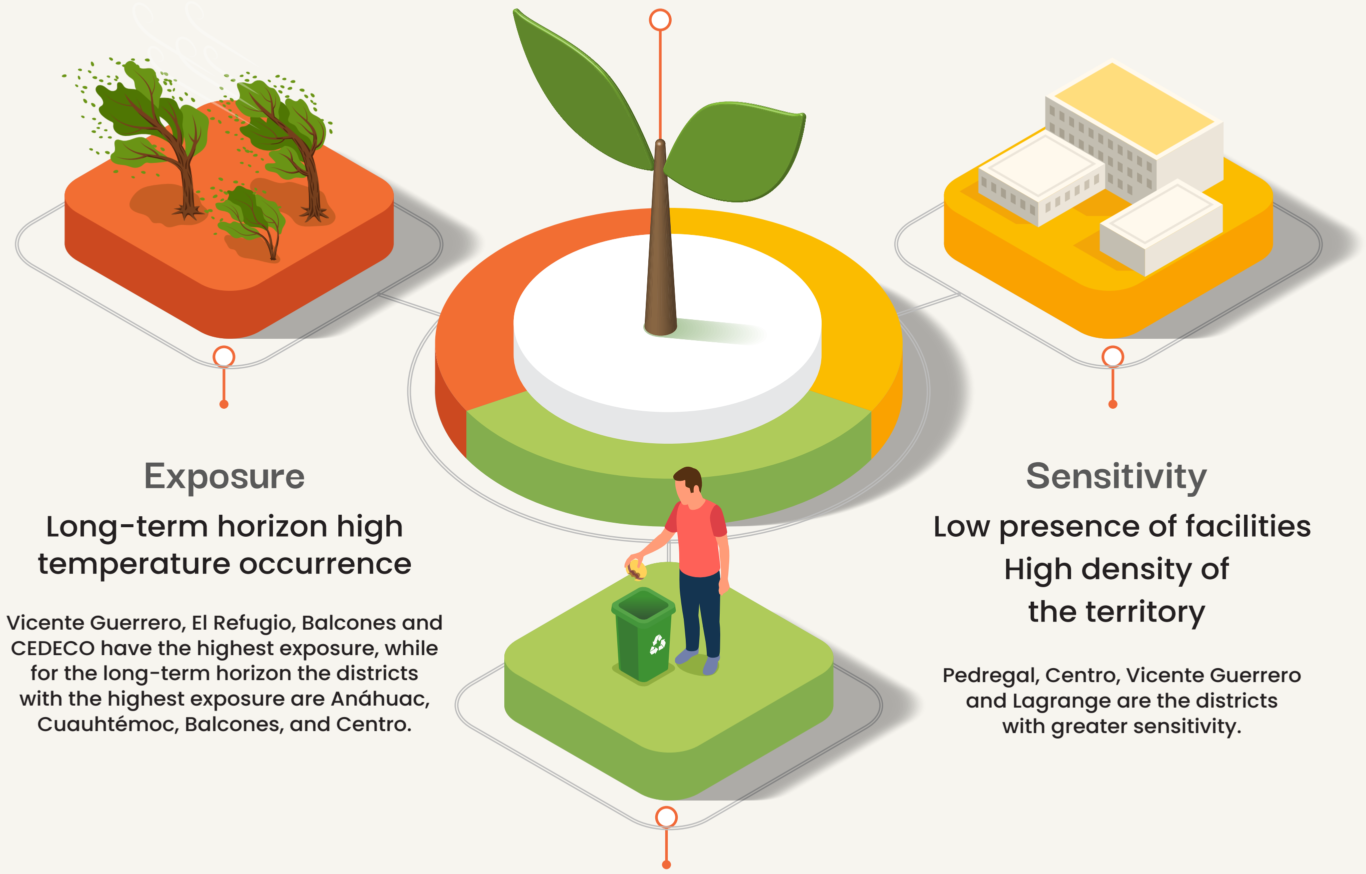
Ratios of districts according to the results of the exposure factors:

Factor	Horizon	Highest index districts	Lowest index districts
Exposure	Short-term (Near)	Balcones, CEDECO, El Refugio, Vicente Guerrero, Casa Bella y Centro	Los Morales, Talaverna, La Fe.
	Long-term (Far)	Balcones, Cuauhtémoc, Anáhuac.	Los Morales, Talaverna, La Fe, Andalucía.
Sensitivity		Lagrange, Pedregal, Vicente Guerrero, Balcones, Constituyentes, parte de Industrial y Residencial Anáhuac.	San Cristóbal, Los Morales.
Adaptive capacity		Centro, CEDECO, Casa Bella, Constituyentes, Pedregal, Lagrange, Del Paseo.	Industrial, San Cristóbal y Santo Domingo.
Climate Vulnerability Index	Short-term (Near)	Vicente Guerrero	Anáhuac, Del Vidrio, Los Morales, Talaverna, La Fe, Residencial Anáhuac, Cuauhtémoc, Jardines de Anáhuac, Pedregal, Del Paseo, Casa Blanca
	Long-term (Far)	Vicente Guerrero	Pedregal

Climate Vulnerability Index

Vulnerable municipal area will increase on the long-term horizon.

Vicente Guerrero, Balcones, Industrial, Residencial Anahuac have the highest climate vulnerability in both horizons. While Anahuac and Centro will have it in the long-term horizon.



Exposure

Long-term horizon high temperature occurrence

Vicente Guerrero, El Refugio, Balcones and CEDECO have the highest exposure, while for the long-term horizon the districts with the highest exposure are Anáhuac, Cuauhtémoc, Balcones, and Centro.

Sensitivity

Low presence of facilities
High density of the territory

Pedregal, Centro, Vicente Guerrero and Lagrange are the districts with greater sensitivity.

Adaptive capacity

Overcomes exposure and sensitivity.

Pedregal, CEDECO, Centro and Del Vidrio have the highest adaptive capacity, while those with the lowest adaptive capacity are Industrial, Balcones and San Cristóbal.

Part II

Climate Action Pathway

Climate Action Pathway

The Climate Action Pathway defines the policy orientations of the Strategy in terms of mitigation, adaptation and governance that will contribute to the achievement of both national and global objectives from a local perspective, considering the specific conditions and needs of the municipality.

To develop the climate action guidelines, existing climate and urban policies were first analysed and then evaluated using UN-Habitat urban planning tools to determine the feasibility of replicating or applying action lines from other instruments within the EMAC-SNG.

For this purpose, an assessment matrix was used to determine the feasibility of replicating the identified action lines in the higher level programmes. This matrix was based on the 5-D "Options Selection and Ranking Table" tool from UN-Habitat's Planning for Climate Change: A Strategic, Values-based Approach for Urban Planners - Toolkit (2014) and was adapted from the work of Park (2020) to assess five aspects of feasibility for each of the identified action lines.

Based on the analysis of existing instruments and policies at national or state level and the assessment of their applicability in this strategy, it was determined that the most feasible lines of action to be implemented at municipal level are those related to urban planning, risk management, governance, and communication. The second most feasible lines of action were those related to urban waste management, air emissions, financing, and monitoring of climate actions (Figure 17).

At the same time, key actors in civil society, academia, and state and local governments were contacted to obtain complementary information on the decision-making and climate actions currently underway in the municipality. In total, interviews were conducted with more than 20 agencies or academic institutions and nearly 40 experts, decision-makers, citizens, and members of civil society who participated in the consultation and shared their experiences and knowledge.

Lines of Action		Level 37	34	19
Integral Waste Management		3	---	4
Sustainable Mobility		2	3	1
Energy Efficiency		2	2	1
Integral Territorial Management		2	3	2
Integral Water Resources Management		4	5	3
Sustainable Management of Natural Resources		4	5	2
Integral Risk Management		3	3	1
Emissions Regulation		2	3	1
Climate Finance		4	1	1
Climate Governance		6	4	2
Innovation and Technology Transition		2	2	0
Communications		3	3	1

Figure 17. Number of action lines and sub-action lines by degree of local replicability of existing national, state, and municipal programme instruments.

Source: Author's elaboration.

Table 3. List of stakeholders participating in the EMAC-SNG consultation.

Source: Author's elaboration.

Sector	Department / Institution	Area
State Government	Secretariat of Environment of Nuevo León	Integrated Waste Management Department
		Climate Change Policy Department
		Directorate for the State Register of Greenhouse Gas and Compound Emissions
Decentralised and Parastatals	Parks and Wildlife of Nuevo León	General Directorate
		Directorate of Operations
	Integrated System for the Ecological Management and Processing of Waste (SIMEPRODE)	General Directorate
	Water and Drainage Services of Monterrey (SADM)	Project Management
Municipal Government	Secretariat of Public Services	-
	Technical Secretariat	Strategic Project Management
		Environmental Protection and Climate Change Unit
	Directorate General for Health	-
	Municipal Directorate of Civil Protection	-
Research and academic institutions	Colegio de la Frontera Norte (COLEF)	Academy
	Universidad Autónoma de Nuevo León (UANL)	Research Centre for Sustainable Development
		Academy
	Instituto Tecnológico y de Estudios Superiores de Monterrey (ITESM)	Water Centre for Latin America and the Caribbean
		Academy
	Mario Molina Centre for Strategic Studies on Energy and the Environment (CMM)	Project Management
		Air Quality Directorate
Non-governmental Organizations	Pronatura NE	Regional Directorate
	Sociedad Sostenible A. C.	Directorate General
		Institutional Development Management
	Parque Ecológico Chipinque	Conservation Management
	Sextante, S. A.	Management
	Agua Capital, A. C.	Management
	Citizen Observatory of Air Quality in the Metropolitan Area of Monterrey (OCCAMM)	-

Strategic guidelines for climate action

The public policy guidelines that constitute the EMAC-SNG Climate Action Pathway are structured around three thematic axes, each of which contains its own strategies, differentiated by theme: Environment, Urban, Energy and Services. Each strategy is organised around a set of policy lines, which are used to formulate specific actions to be implemented through concrete projects (Figure 18).

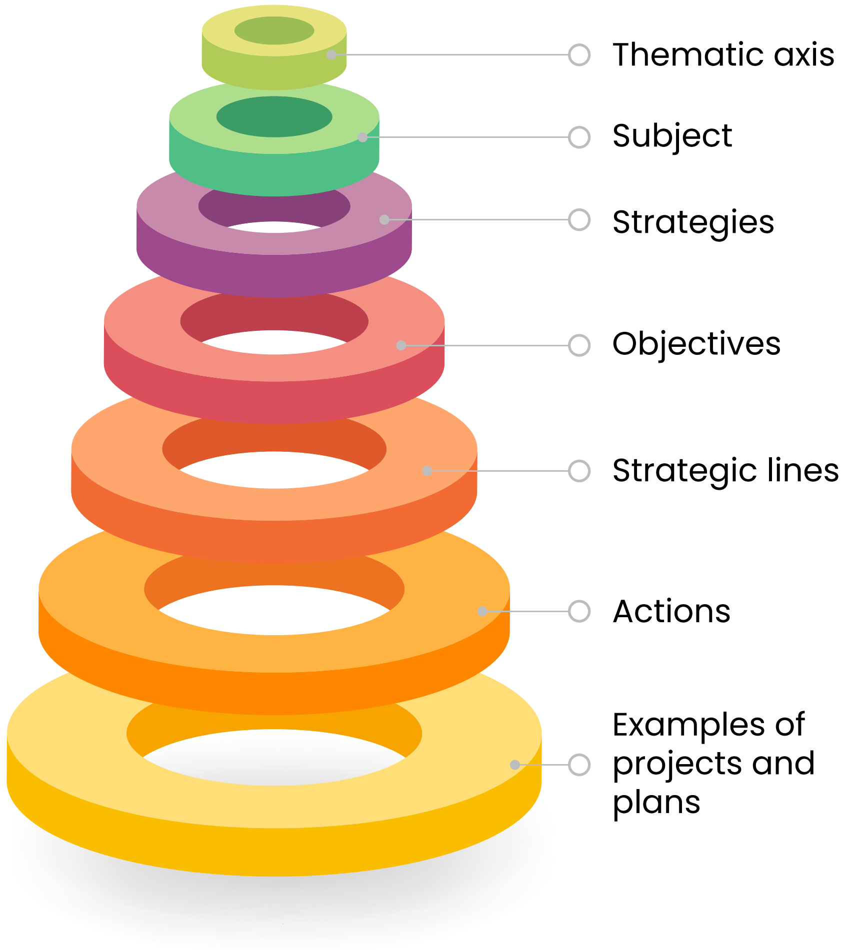


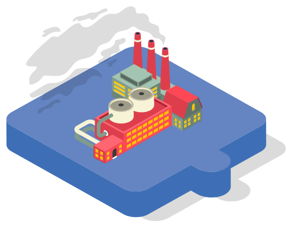
Figure 18. Hierarchical structure of the EMAC-SNG public policy components.

Source: Author's elaboration.

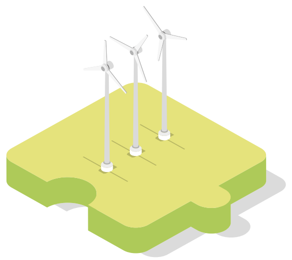
Within this structure, the EMAC-SNG directs the policies for combating climate change based on 15 strategies, which group together a total of 39 strategic lines, which in turn include 181 actions, all designed in accordance with the needs, challenges and opportunities identified in the technical participatory diagnosis of this instrument (Figure 19).

Thematic axis

Environmental Protection Mitigation



Urban Resilience Adaptation



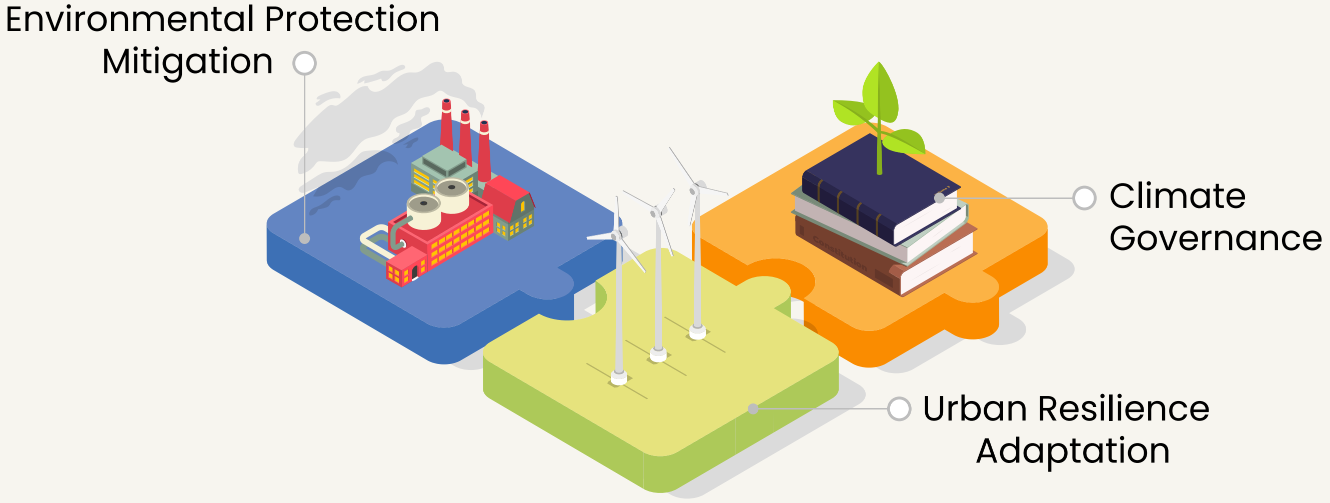
Climate governance

Strategy

Thematic axis		Strategy
Environmental Protection Mitigation	E1	Air quality monitoring
	E2	Atmospheric pollution control
	E3	Liveability guidance
	E4	Promoting energy efficiency
	E5	Better management of public services
Urban Resilience Adaptation	E6	Conservation of ecosystems and wildlife
	E7	Restoring environmental services
	E8	Management of hydro-climatic risks
	E9	Adequacy of supplementary water supply
Climate governance	E10	Information for decision making
	E11	Standards and regulations
	E12	Institutional strengthening
	E13	Urban management
	E14	Communication and environmental education
	E15	Building citizenship

Figure 19. Structure of the thematic axes of the EMAC-SNG.

Source: Author's elaboration.



The implementation of these strategies and their respective strategic lines and actions have been designed considering the existing dynamics at the administrative, political, and territorial levels of the AUM, so that they not only complement each other, but also the existing programmes, policies and projects of the municipality and the State of Nuevo León. They are complementary to what is proposed in the San Nicolás de los Garza 2030 City Vision (UN-Habitat, 2021), the Portfolio of Strategic Projects for the San Nicolás de los Garza 2030 Vision (UN-Habitat, 2021) and the San Nicolás de los Garza Public Space Strategy (UN-Habitat, 2023).

The actions proposed in each thematic axis are suggested in such a way that they could be implemented in a prioritised manner, either by the municipality or in collaboration with organisations, academic institutions, or government agencies at the state or federal level.

To summarise, the Climate Action Pathway and its respective axes are characterised as follows.

Environmental Protection – Mitigation

Focused on environmental protection, this thematic axis is composed of 5 strategies, which together comprise 11 strategic lines, bringing together a total of 39 actions aimed at avoiding and sequestering 1 184 082 tCO_2e by 2030, as well as 3 211 476 tCO_2e by 2050 and 6 593 801 tCO_2e by 2070, with the goal of achieving carbon neutrality by 2100.

Among the proposed actions, those focused on reducing emissions from activities and sectors within the municipality's jurisdiction stand out. Specifically, they focus on reducing direct emissions from combustion and indirect emissions from inefficient use of energy and other activities that handle substances or particles, through five main strategies:

	Air quality monitoring
	Atmospheric pollution control
	Liveability guidance
	Promoting energy efficiency
	Better management of public services

Urban Resilience – Adaptation

This axis proposes 68 actions that focus on the search for urban resilience by reducing exposure and sensitivity to climate change in the municipality and strengthening its adaptive capacity. The guidelines integrate approaches such as watershed management, protection of environmental services, integrated risk management with a preventive approach, nature-based solutions (NBS), ecosystem-based adaptation (EbA) and community-based adaptation (CBA) measures.

The policy proposals consider the competencies of the SNG municipality based on four main strategies, which group 15 strategic lines with their respective actions:

	Conservation of ecosystems and wildlife
	Restoration of environmental services
	Hydroclimatic risk management
	Adequacy for additional water supply

Climate governance

This thematic axis is based on the principle that actions related to climate change, and in particular the building of response capacities, are a matter for the entire society of San Nicolás de los Garza. Seventy-four cross-cutting actions are proposed to promote the implementation of the EMAC-SNG, based on the following strategies:

	Information for decision-making
	Standards and regulations
	Institutional strengthening
	Urban management
	Communication and environmental education
	Building citizenship

EMAC-SNG focuses more than 40% of its strategies on the Climate Governance Axis, with 33% of the Strategic Lines and 41% of the Actions belonging to this axis. Meanwhile, the Environmental Protection and Urban Resilience Axes cover 33% and 27% of resources, with 28% and 39% of Strategic Lines and 21% and 38% of Actions respectively.

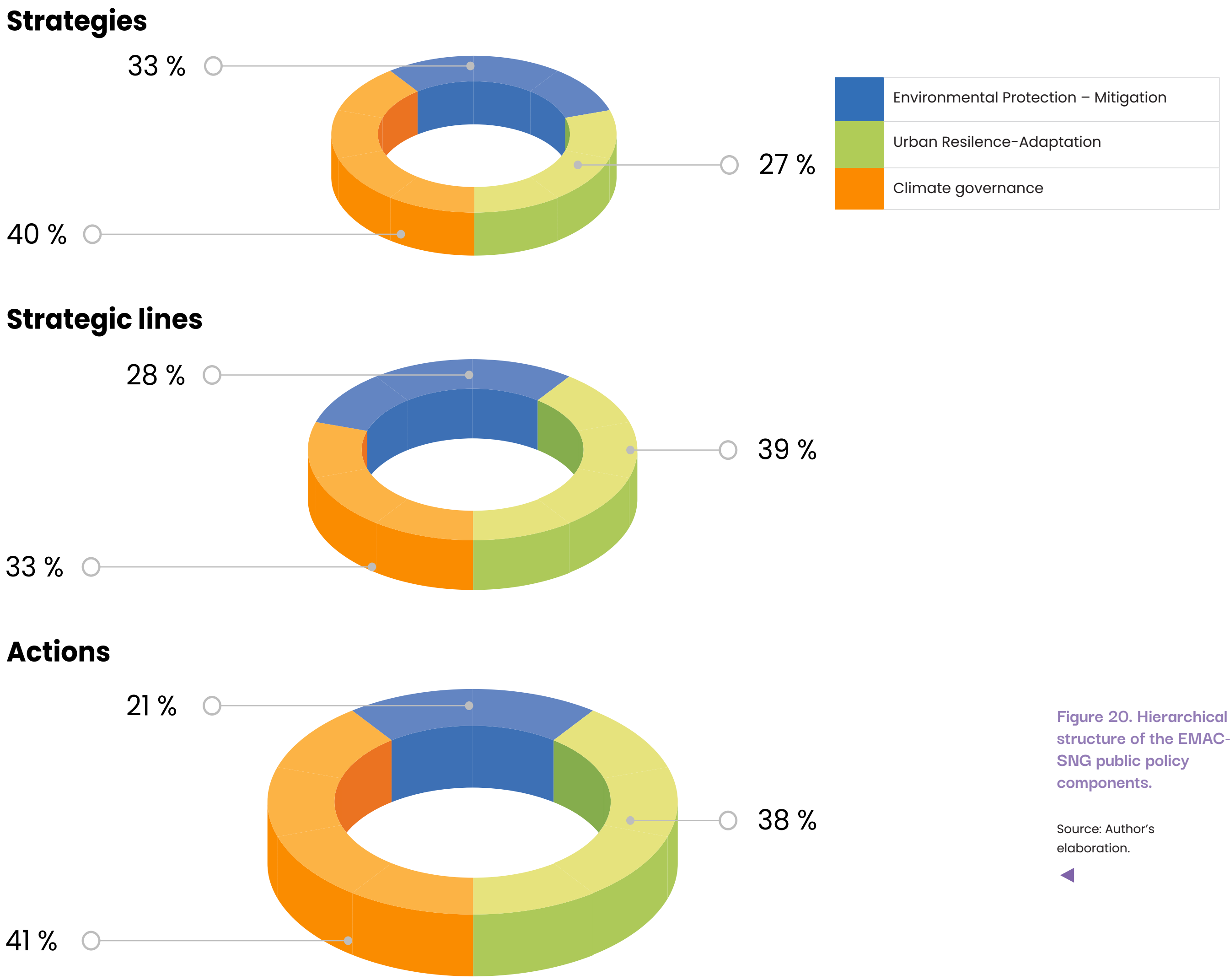


Figure 20. Hierarchical structure of the EMAC-SNG public policy components.

Source: Author's elaboration.

In summary, the set of strategies, lines and actions represent an innovative and highly adaptable way to address the environmental and climate challenges of the municipality, thanks to its comprehensive and prospective vision of the local administrative and political dynamics.

EMAC-SNG monitoring Elements

Finally, the Municipal Strategy for Climate Action of San Nicolás de los Garza foresees the monitoring of the implementation of the Climate Action Pathway, for which a list of indicators is presented.

The main objective of these indicators is to allow the municipality to assess, in different scenarios, the degree of progress in the implementation of strategic lines and local actions, as well as their contribution to national goals. These indicators are based on urban monitoring schemes developed by UN-Habitat, adapted from the Mexican experience in the Thriving Cities Initiative (UN-Habitat, INFONAVIT & SEDATU, 2018) and on global monitoring indices such as the New Urban Agenda Monitoring Framework (UN-Habitat 2017), the Global Indicators Framework for the Sustainable Development Goals (2015) and the Global Urban Monitoring Framework (UN-Habitat, 2022).

It also includes indicators from the National System of Environmental Indicators (SNIA, 1993), which aims to provide n concise information on changes and the state of the environment and natural resources.

A total of 61 indicators have been developed, which can be used by the municipality in its internal performance monitoring and control mechanisms. These indicators are aligned with the specific actions in each of the thematic axes of the Strategy, with 16 indicators proposed for the Environmental Protection – Mitigation axis, 17 for the Urban Resilience – Adaptation axis, and 28 for the Climate Governance axis.

It also proposes a methodology to monitor progress by calculating the effective emission reductions that could be achieved through the implementation of the Climate Action Pathway. This will enable the municipality to estimate its contribution to global emission reductions, evaluate its performance and report to other national or international platforms.

References

World Bank (2016). CURB Tool: Climate Action for Urban Sustainability. https://www. worldbank.org/news/ infographic/2016/09/22/ curb-tool-climate-action-for-urban-sustainability.

Mario Molina Centre for Strategic Studies on Energy and Environment (CMM) (2019). Analysis of PM2.5 pollution in the City of Monterrey, Nuevo León, focusing on the identification of strategic control measures. http://aire. nl.nl.gob.mx/docs/reports/An%C3%A1lisis_ de_la_ Contaminaci%C3%B3n_PM2_5_Monterrey.pdf

Mario Molina Centre for Strategic Studies on Energy and Environment (CMM) (2021). Study for the redesign of Monterrey's air quality monitoring network. http:// aire.nl.gob.mx/docs/ reports/Report_final_SMCA_ AMM_31mar2021.pdf

National Centre for Disaster Prevention (CENAPRED). (2021). Sistema de Consulta de Declaratorias. Atlas Nacional de Riesgos. http://www. atlasnacionalderiesgos.gob.mx/apps/Declaratorias/

National Water Commission (CONAGUA). (2022). Monitor de Sequía en México. https://smn.conagua. gob.mx/en/climatologia/monitor-de-sequia/ monitor-de-sequia-en-mexico.

United Nations Framework Convention on Climate Change (UNFCCC) (1992). United Nations Framework Convention on Climate Change.

COP27 Presidency and UN-Habitat (2022). COP27 Presidency Sustainable Urban Resilience for the next generation (SURGe). https://unhabitat.org/cop27-presidency-sustainable-urban-resilience-for-the-next-generation-ge

Monterrey Metropolitan Water Fund (FAMM). (2028). Plan Hídrico Nuevo León 2050. http://famm.mx/ wp-content/uploads/2018/10/Plan-H%C3%ADdrico- NL-2050.pdf

García, E. (1973). Climates. Modificaciones al sistema de clasificación climática de Köppen (para adaptarlo a las condiciones de la República Mexicana). Institute of Geography-UNAM.

Government of Mexico and Ministry of Environment and Natural Resources (SEMARNAT). (2020). Nationally Determined Contribution: Mexico. https://unfccc. int/ sites/default/files/NDC/2022-06/NDC-Esp-30Dec. pdf.

Government of Mexico and Ministry of Environment and Natural Resources (SEMARNAT). (2022). Nationally Determined Contribution. https://unfccc.int/sites/ default/files/NDC/2022-11/Mexico_NDC_UNFCCC_ update2022_FINAL.pdf

Government of Nuevo León, Monterrey Metropolitan Environmental Fund, Clean Air Institute (2021). Inventario de Emisiones Atmosféricas del Área Metropolitana de Monterrey [executive report]. https://famm.mx/ archivos/inventario_emisiones_ amm.pdf

Government of Nuevo León. (2017). Informe de Calidad del Aire y Meteorología del Área Metropolitana de Monterrey (months January-December) del Sistema Integral de Monitoreo Ambiental del Estado de Nuevo León. http://aire.nl.gob.mx/rep_mensual.html

Government of Nuevo León. (2018). Informe de Calidad del Aire y Meteorología del Área Metropolitana de Monterrey (months January-December) del Sistema Integral de Monitoreo Ambiental del Estado de Nuevo León. http://aire.nl.gob.mx/rep_mensual.html

Government of Nuevo León. (2019). Air Quality and Meteorology Report of the Metropolitan Area of Monterrey (January-December) of the Integrated Environmental Monitoring System of the State of Nuevo León. http://aire.nl.gob.mx/rep_mensual.html

Government of Nuevo León. (2019). Air Quality and Meteorology Report of the Metropolitan Area of Monterrey (January-December) of the Integrated Environmental Monitoring System of the State of Nuevo León. http://aire.nl.gob.mx/rep_mensual.html

Government of Nuevo León. (2021). Reporte de Calidad del Aire y Meteorología del Área Metropolitana de Monterrey (January-December) del Sistema Integral de Monitoreo Ambiental del Estado de Nuevo León. http://aire.nl.gob.mx/rep_mensual.html

Government of Nuevo León. (2022b). Registro de Emisiones y Transferencia de Contaminantes del Sistema Integral de Monitoreo Ambiental del Estado de Nuevo León. http://aire.nl.gob.mx/sig_retc.html

Government of the Municipality of San Nicolás de los Garza. (2021). Atlas de Riesgos de San Nicolás de los Garza, Nuevo León [unpublished manuscript].

Government of the Municipality of San Nicolás de los Garza. (2021). Municipal Development Plan 2021-2024, Nuevo León.

Government of the Municipality of San Nicolás de los Garza. (2022a). Plan Municipal de Desarrollo Urbano [version for public consultation].

UNAM Institute of Atmospheric Sciences and Climate Change. (2022a). RCP 8.5 scenario adjusted to Mexico for the near or near-term future horizon (2021-2040). Unit of Informatics for Atmospheric and Environmental Sciences (UNIATMOS).

UNAM Institute of Atmospheric Sciences and Climate Change. (2022b). RCP 8.5 scenario adjusted to Mexico for the far future or long-term horizon (2081-2100). Computer Unit for Atmospheric and Environmental Sciences (UNIATMOS).

UNAM Institute of Atmospheric Sciences and Climate Change. (2022c). RCP 8.5 scenario adjusted to Mexico for the medium to medium-term future horizon (2040-2060). Unit of Informatics for Atmospheric and Environmental Sciences (UNIATMOS).

UNAM Institute of Engineering. (2014). Isoyetas, validated by CENAPRED in 2016 to be integrated in risk studies at national level.

National Institute of Ecology and Climate Change (INECC) (2019). National Atlas of Vulnerability to Climate Change. Mexico. INECC. https:// atlasvulnerabilidad. inecc.gob.mx/page/fichas/ ANVCC_LibroDigital.pdf

National Institute of Statistics and Geography (INEGI). (2008). Climatic units of Mexico. https://idegeo.centrogeo.org.mx/layers/geonode%3Aunidadesclimaticas_gw84

National Institute of Statistics and Geography (INEGI). (2020). Population and Housing Census, Main results by AGEB and urban block.

National Institute of Statistics and Geography (INEGI). (2023). National Statistical Directory of Economic Units (DENUE).

UN-Habitat and Government of San Nicolás de los Garza. (2021a). San Nicolás de los Garza City Vision 2030. https://onuhabitat.org.mx/documento-de-vision-de-ciudad-de-san-Nicolás-de-los-garza-2030

UN-Habitat and Government of San Nicolás de los Garza. (2021C). Portfolio of Projects Towards the Vision of San Nicolás de los Garza 2030. https://onuhabitat.org.mx/ cartera-de-proyectos-estrategicos-sng2030

UN-Habitat, INFONAVIT and SEDATU. (2018). CPI Report - Extended Monterrey Urban Agglomeration. https://publicacionesonuhabitat.org/onuhabitatmexico/cpi/extended/MTY_web.pdf

UN-Habitat (2020). The New Urban Agenda in Spanish. https://publicacionesonuhabitat.org/onuhabitatmexico/Nueva-Agenda-Urbana-Ilustrada.pdf

United Nations (UN). (2016). Quito Declaration on Sustainable Cities and Human Settlements for All. United Nations Conference on Housing and Sustainable Urban Development: Habitat III. https://www.un.org/es/ conferences/habitat/quito2016.

Ministry of Environment and Natural Resources (SEMARNAT) and Secretary of Sustainable Development of Nuevo León. (2016). Programa de Gestión para Mejorar la Calidad del Aire del estado de Nuevo León. ProAire 2016—2025

The Economics of Ecosystems and Biodiversity (TEEB) (2011). TEEB Manual for Cities: Ecosystem Services in Urban Management. The Economics of Ecosystems and Biodiversity.

UN-Habitat and United Nations Environment Programme (UNEP) (2018). Climate Change Vulnerability Assessment Manual. https://unhabitat.org.mm/wp- content/uploads/2019/03/VA-Manual_ENG_Full- Version_resized.pdf

United Nations Framework Convention on Climate Change (UNFCC) (1997). Kyoto Protocol to the United Nations Framework Convention on Climate Change. https://unfccc.int/es/node/2409

United Nations Framework Convention on Climate Change (UNFCCC) (2015). Paris Agreement. https://unfccc.int/sites/default/files/spanish_paris_agreement.pd

United Nations Office for Disaster Risk Reduction (UNDRR) (2015). Sendai Framework for Disaster Risk Reduction 2015-2030. https://www.undrr.org/publication/ sendai- framework- disaster- risk-reduction-2015-2030.


LA
PROEZA
OXXO

UN-HABITAT
FOR A BETTER URBAN FUTURE

SNG 2030