PROGRAM FOR AIR QUALITY MANAGEMENT AND ACTION ON CLIMATE CHANGE

STATE OF PUEBLA

2021-2030

EXECUTIVE SUMMARY

PROAIRE PEACC

MEDIO AMBIENTE
SECRETARÍA DE MEDIO AMBIENTE Y RECURSOS NATURALES

INECC
INSTITUTO NACIONAL DE ECOLOGÍA Y CAMBIO CLIMÁTICO

COMISIÓN AMBIENTAL DE LA MEGALÓPOLIS

Gobierno de Puebla

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para Apoyar los Programas, Proyectos
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Gobierno de Puebla

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PRESENTATION

The care and preservation of the environment, as well as attention to climate change, are one of the priorities of the State Government, which is why this administration, through the Ministry of the Environment, Sustainable Development and Territorial Planning, addresses this problem. from a sustainable vision and the timely application of policies for the protection and preservation of natural assets.

Urban growth, the demand for goods and services, the overexploitation of natural resources, transportation, industrialization, the excessive use of fossil fuels, impact and deteriorate the quality of the air we breathe, which contributes to the increase of greenhouse gases and the exacerbation of climate change, in addition to the impact on the health of the population. Therefore, we must guarantee unrestricted observance of compliance with the Official Mexican Standards.

The Government of the State of Puebla in this regard, developed the “Air Quality Management and Action against Climate Change Program 2021-2030 for the State of Puebla” in coordination with the Environmental Commission of the Megalopolis (CAMe), and the validation of the Ministry of the Environment and Natural Resources (SEMARNAT) and the National Institute of Ecology and Climate Change (INECC).

This program is based on a diagnosis of the current air quality conditions and the potential effects of climate change and is the first of its kind to be developed at the national level, since it links air quality management with actions against climate change, resulting in a synergy to establish public policies, strategies, and joint lines of action.

It is important to note that the effectiveness and success of this program requires the commitment of all sectors involved, in an area of cooperation and multidisciplinary work. Therefore, it is necessary that the different sectors of society actively participate in its application, each contributing from their sphere and possibilities to guarantee the right of this and future generations to enjoy a prosperous and favorable environment for our condition and development.

CONTENT

1. STATE OF PUEBLA – CONTEXT AND GENERAL INFORMATION

The State of Puebla has a population of 6,583,278 inhabitants, 48% men and 52% women (INEGI, Population and Housing Census 2020). It comprises 217 municipalities and 8,029 urban and rural localities. The most populated municipalities are Puebla, Tehuacán, San Martín Texmelucan, San Andrés Cholula, Atlixco, San Pedro Cholula, Cuautlancingo, Amozoc, Huauchinango and Teziutlán.

The State is in the central region of the Mexican Republic with an area of 34,309.6 km^2, representing 1.7% of the country's surface. It is located between geographical coordinates:

- North 20°50'24"
- South 17°51'39" North latitude
- East longitude 96°43'29"
- West longitude 99°43'29".

The main elevations that correspond totally or partially to the State are the Pico de Orizaba Volcano (Citlaltépetl), the Popocatépetl Volcano, the Iztaccíhuatl Volcano and Malinche Volcano (Matlalcuéyatl).

The territorial extensions of the degradation processes in the State of Puebla represents 45.52%: 9.73% by wind erosion, 3.32% by physical degradation, 10.06% by water erosion, and 22.41 by chemical degradation.

In the State, 1.6 million hectares (45.9%) is forest area with several types of vegetation, such as coniferous and broadleaf forest, medium and low forests, and desert scrub. On the other hand, 1.9 million hectares (54.1%) are non-forest areas.

About 40.3% of the State's surface engages in agricultural activities, concentrated in the south-central region of the State.

The predominant climate is temperate and is distributed in the central part, from the east of the Sierra Nevada to the west of the Pico de Orizaba. Other climates are: warm climate, located in the north, northeast and southwest; semi-warm climate, located between the temperate and warm of the northern and central-southwest zones; semi-dry, in the south-southwest; dry, in the south and southeast of Tehuacán; semi-cold, at the slopes of the Sierra Nevada, the Pico de Orizaba and La Malinche; and cold, at the summits of the mountains and the volcanoes mentioned above. The average annual temperature in the State is 17.5°C; the average minimum temperature is 6.5 °C and occurs in the month of January; the average maximum temperature is 28.5 °C and occurs in the months of April and May.

The average rainfall of the State is 1,270 mm per year. The rains occur mainly between the months of March to October. The average hourly wind speed in the State of Puebla has slight seasonal variations over the course of the year. The windiest part of the year lasts approximately three months from mid-March to mid-June, with an average speed over 11.4 km/h. The windiest month of the year is April, with winds with an average speed of 12.8 km/h. Meanwhile, the month with lowest wind speed is August, with an average speed of 10 km/h.

The wind direction varies during the year. The west predominates during the period between mid-February and the end of October, with a higher percentage in the month of May. Meanwhile, in the period from late October to mid-February, northerly winds predominate.

About forest fires 303 events were registered in 2021, affecting an area of 7,916.36 ha, while in 2020 and 2019 257 and 347 fires

were registered affecting 10,566.70 ha. and 18,711.79 ha., respectively.

Regarding socioeconomic aspects, the population of the State of Puebla grew at an annual rate of 1.31% from 2000 to 2020, going from 5.78 to 6.58 million inhabitants in 2020. The registered population growth in the entity resulted in a higher density, going from 120 inhabitants per square kilometer in 1990, to 192 inhabitants/km^2 in 2020.

At the end of 2021, the employed population represented 95.1%.

The primary sector represents the 22% of the employed personnel, but it contributes only 4.69% of State GDP.

The secondary sector generates a third of the State GDP (33.9%) and occupies 25.9% of the employed personnel, the manufacturing sector participates with 71%.

Tertiary activities in the period 2010-2020 generated 61.8% of State GDP and 52.4% of jobs on real estate services and rental of movable and intangible property that contributed 24% of the State GDP of tertiary activities and is followed by retail trade with 16.2%, wholesale trade with 11.8% and transport, by mail and storage with 11.4%.

2. LEGAL FRAMEWORK, PLANNING INSTRUMENTS, AND CAPACITIES

The Air Quality Management and Action on Climate Change Program (ProAire PEACC in Spanish) of the State of Puebla 2021-2030 is based on a legal framework conformed by the Political Constitution of the United Mexican States; international treaties; federal laws and regulations; Official Mexican Standards; the Political Constitution of the Free and Sovereign State of Puebla; State laws and regulations on air quality and climate change mitigation and adaptation.

The federal legal framework on air quality is based on the General Law of Ecological Balance and Environmental Protection (LGEEPA), which provides that emissions of pollutants to the atmosphere must be reduced and controlled to ensure satisfactory air quality. From LGEEPA derives, among others, the Regulation on the Prevention and Control of Air Pollution and the Regulation on the Pollutants Release and Transfer Registry.

At the State level, legislation on air quality management is based on the Political Constitution of the Free and Sovereign State of Puebla, which indicates the right of every person to an environment adequate for their development, health, and well-being. The Law for the Protection of the Natural Environment and Sustainable Development regulates this right.

The Act establishes that policies and programs should be aimed at ensuring satisfactory air quality. It states that the State Environmental Authority must formulate a program to reduce the production, transport, marketing, and use of all substances that have been identified as harmful to the ozone layer and issue programs to control pollution from mobile sources and prevent environmental contingencies. This Law derives the Regulations on the Prevention and Control of Air Pollution; Environmental Audit; Ecological Planning; and, of Natural Protected Areas.

At the State level, climate change legislation is based on the Political Constitution of the Free and Sovereign State of Puebla, from which the Climate Change Law for the State of Puebla (LCCEP, in Spanish) is derived, aiming to protect this right and regulate actions for mitigation and adaptation to climate change; reduce the vulnerability of the population and ecosystems and promote the transition to a green economy that is competitive, sustainable and low carbon.

The Law establishes the following State policy planning instruments:

I. The State Strategy for Climate Change.
II. The Special Climate Change Program of the State of Puebla.
III. Municipal Climate Action Programs.

In compliance with the regulations, the State Environmental Authority coordinated the formulation of the State Climate Change Strategy 2021-2030 that has as objective: the establishment of the mitigation and adaptation actions to the effects of climate change; promote circular economy schemes; promote the transition towards an eco-centric and climate-just culture; and promote efficiency, sustainability and energy transition to contribute to the decarbonization of the priority sectors of the State and maximize the co-benefits to Puebla society.

3. CURRENT STATUS OF AIR QUALITY AND CLIMATE CHANGE

The State of Puebla has a State Atmospheric Monitoring Network (REMA in Spanish) with five monitoring stations. It began its operation in 2000, to record the pollutants in the atmosphere, and the meteorological conditions, allowing to identify their behavior in the of the Puebla Valley Metropolitan Zone (PVMZ), that comprises the municipalities of Amozoc, Coronango, Cuautlancingo, Puebla, San Andrés Cholula, and San Pedro Cholula.

The five monitoring stations of the REMA, distributed in the PVMZ are equipped exclusively with automatic monitoring equipment, and measure the criteria pollutants: suspended particles PM_{10} and $PM_{2.5}$, ozone (O_3), nitrogen dioxide (NO_2), carbon monoxide (CO), sulfur dioxide (SO_2). Likewise, they monitor meteorological parameters: temperature (T), wind speed (WS) and wind direction (WD), relative humidity (RH), barometric pressure (BP), precipitation (P), solar radiation (RS). Table 1 shows the stations referred to. The Government of the State of Puebla has a page to consult REMA's data (https://calidaddelaire.puebla.gob.mx/views/principal.php), which is also integrated into the National Air Quality Information System (SINAICA) and contributes to the national air quality report.

Table 1. Atmospheric Monitoring Stations of the REMA of Puebla

#	STATION	COORDINATES
1	Agua Santa (STA)	18.9874, -98.24967
2	Meritorious State Normal Institute (BINE)	19.0673, -98.22450
3	Nymphs Park (NINFAS)	19.0413, -98.21429
4	Technological University of Puebla (UTP)	19.0567, -98.15171
5	Velodrome (VELODROMO)	19.1158, -98.27766

Vehicle Inspection and Maintenance Program

The government of the State of Puebla, through the Environmental State Authority, implements again the Mandatory Inspection and Maintenance Program (IMP). The agreement was published in the Official Newspaper of the State of Puebla on October 17, 2022, after two years of being inactive. The agreement indicates that it is of general observance, of public order and social interest, to regulate the levels of polluting emissions from motor vehicles registered in the State of Puebla, in addition to those referring to ostensible pollution, which will be applicable to all motor vehicles circulating in the State of Puebla.

In addition to the IMP, Puebla also implemented the **Program of Modalities to the Circulation** (PMC), which applies to private service vehicles, commercial cargo, public transportation, executive vehicles, and taxis with holograms "Exempt", "00" and "0", will be free of all the modalities established in the PMC. In the case of vehicles that have obtained the hologram "1" or "2", regardless of the entity that issued it, operation is restricted to a weekday, **ONLY** when there are two **consecutive days of poor air quality**. This means more than 40 hours and in more than two REMA stations.

Air quality in the PVMZ

In terms of air quality, PM $_{10}$, $PM_{2.5}$ and ozone are the pollutants that exceed the air quality standards in the PVMZ, therefore the analysis focus on these pollutants, considering the current standard.

Ozone

Figure 1 shows that 2017 presented the highest number of days with poor air quality (155 days), followed by 2018 with 126 days. For 2021 tit was 24 days.

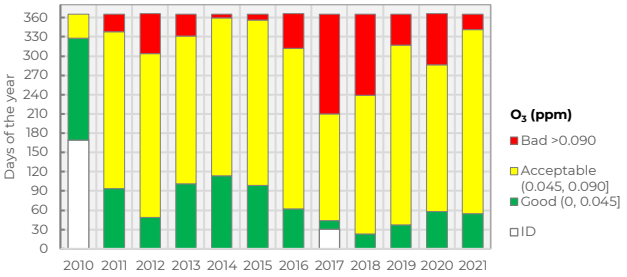

Figure 1. Distribution of days from 2010 to 2021 with good, acceptable and bad air quality in the PVMZ (ozone)

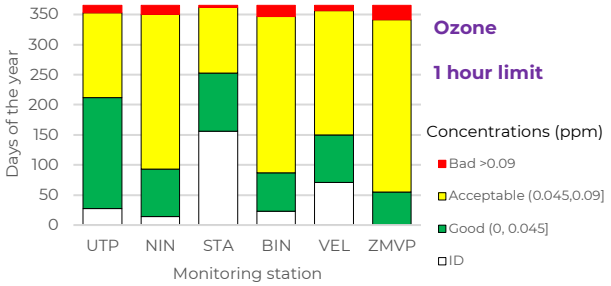

Figure 2. Distribution of days per season in 2021 with good, acceptable and bad air quality (ozone)

>0.090 ppm threshold of NOM-020-SSA1-2021,
ID there is insufficient data for air quality assessment.

PM_{10} particulate matter

As for PM_{10}, in 2021 there were 79 days with poor air quality, lower than those registered since 2012, except for 2020 when there were 76 days with poor air quality (See Figure 3).

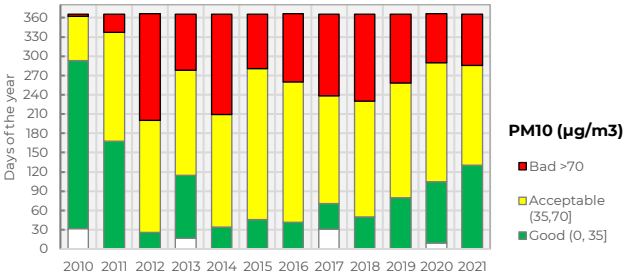

Figure 3. Distribution of days from 2010 to 2021 with good, acceptable and bad air quality in the PVMZ (PM_{10})

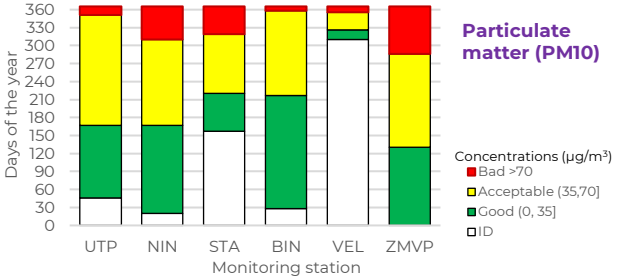

Figure 4. Distribution of days per season in 2021 with good, acceptable and poor air quality (PM_{10})

>70 µg/m³ umbral from NOM-025-SSAI-2021)

$PM_{2.5}$ particulate matter

In 2021, $PM_{2.5}$ only recorded six days with poor air quality across the PVMZ (Figure 5). Agua Santa (STA) station recorded four of the six days (Figure 6).

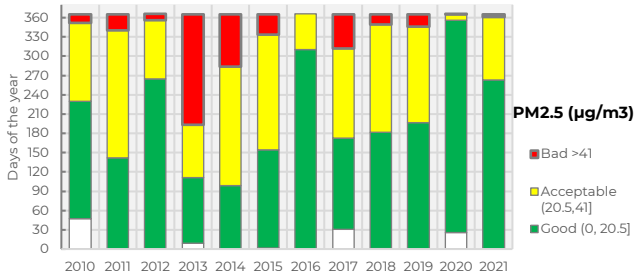

FIGURE 5. DISTRIBUTION OF DAYS FROM 2010 TO 2021 WITH GOOD, ACCEPTABLE AND POOR AIR QUALITY IN THE PVMZ ($PM_{2.5}$)

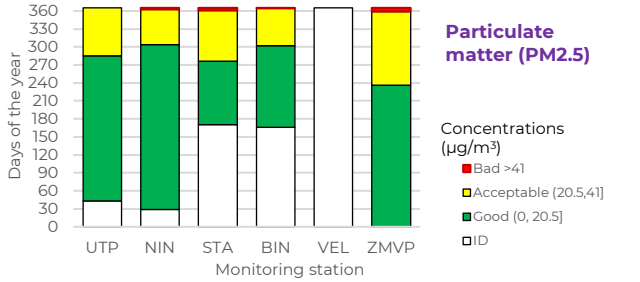

FIGURE 6. DISTRIBUTION OF DAYS PER SEASON IN 2021 WITH GOOD, ACCEPTABLE AND POOR AIR QUALITY ($PM_{2.5}$)

>41 µg/m³ umbral from NOM-025-SSAI-2021)

HISTORICAL CLIMATE ANALYSIS

The State of Puebla presents a diversity of climates greatly influenced by the characteristics of its terrain (CONABIO, 2011). Historical trends in climate variables were identified for ten climate change indexes, based on climate series of weather stations and grid.

The maximum (tmax), minimum (tmin) and average (tmean) temperatures show a statistically significant upward trend during the period 1950-2019. According to the annual averages, these variables have presented an increase of 0.5°C, 0.7°C and 0.6°C, respectively.

The precipitation data suggest that, although this variable shows an upward trend of 102 mm during the analyzed period, it is not statistically significant.

At the State level, most indicators showed a larger area with a tendency to decrease during the period 1980-2020, and only these were statistically significant. At the regional level, the proportion of the area of each region varies between the indicators and the direction of the trends identified.

The sum of the values of proportion of area of the State and the regions does not always reach 100%; in these cases, the missing proportion corresponds to areas where the results do not indicate a trend (Figure 7).

For **precipitation index**, 59% of the State area shows a tendency to decrease in the index of total annual precipitation on wet days (PRCPTOT, as shown in the charts); however, the trend is statistically significant in only 30% of the area with decrease.

Approximately 73% of the State area shows evidence of the decrease in the **index of contribution** to the total precipitation of extremely wet days (R95P, as shown in the charts), of which, in 46% the trend is statistically significant.

23% of the surface of the State presents an increase, not statistically significant, in the values of the index of maximum **duration** of the dry period (CDD, as shown in the charts), while in 76% (42% with statistically significant trend) the values of this index present evidence of a tendency to decrease.

76% of the State presents evidence of a decreasing trend in the simple precipitation **intensity index** (SDII, as shown in the charts) (52% statistically significant), while in 27% the values increase. For temperature **indices**, in 40% of the State's surface, the maximum value of the maximum daily temperature (TXX, as shown in the charts) tends to increase between 1980 and 2020, although not statistically significant. On the other hand, in 27% of the State surface, this index shows a statistically significant downward trend. 50% of the surface of the State

presents a statistically significant tendency to decrease the minimum value of the minimum daily temperature (TNN, as shown in the charts).

In approximately 56% of the State there has been an increase in the number of summer days (ED, as shown in the charts), while in 26% a statistically significant trend was identified to decrease this index.

During the period 1980-2020, the number of frost days (FD, as shown in the charts) showed a decreasing trend in approximately 28% of the State area (23% significant and 5% not statistically significant). In ~5% of the area the trend suggests an increase in FD, although not significant. 57% of the area of the State has a decreasing trend in the daily thermal oscillation (DTR, as shown in the charts), 41% statistically significant, and in 43% there has been a non-significant opposite trend.

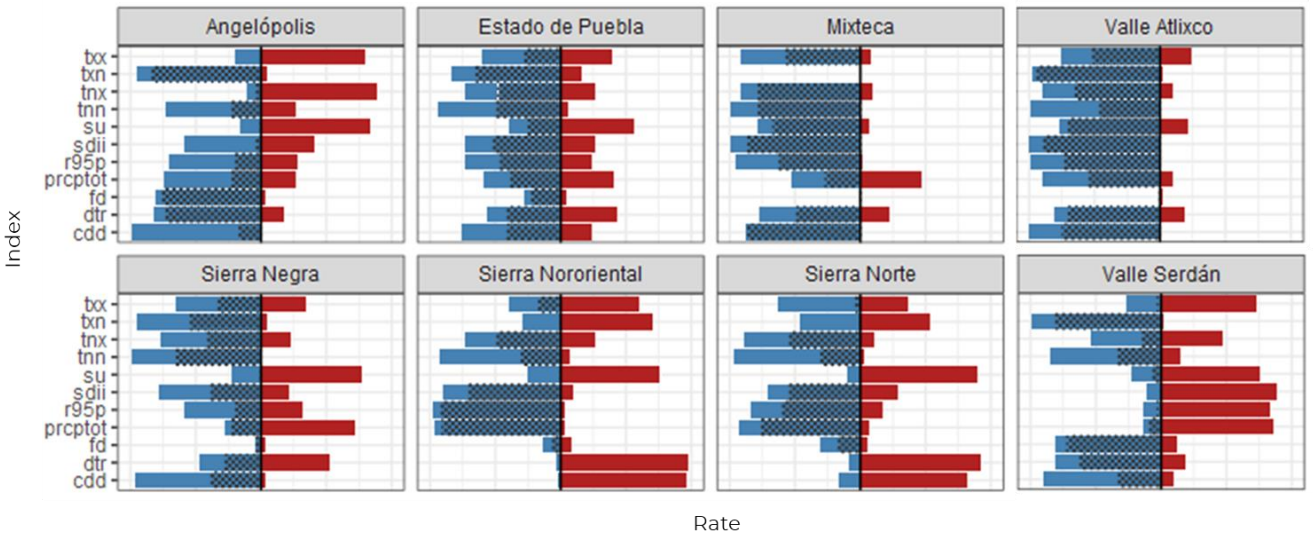

FIGURE 7. PROPORTION OF INDEX TRENDS IN THE STATE AND REGIONS OVER THE PERIOD 1980-2020

According to the meaning and statistical significance; blue: tendency to decrease, red: tendency to increase; The dotted area indicates that the trend is statistically significant.

Building up climate scenarios

Climate change scenarios are a plausible and often simplified representation of future climates, based on an internally coherent set of climate relationships, which are constructed to be used to understand the potential consequences of anthropogenic climate change, and often serve as input for impact simulations.

Since they are not forecasts and each of them represents an equally plausible and valid scenario, it is not feasible to use one for analysis or decision making. However, the substantial number of climate models available imposes the need to select a manageable number to conduct vulnerability and adaptation studies.

72 climate change projections were generated under the cross-comparison project Coupled Climate Model Intercomparison Phase 6 (CMIP6) incorporated into the IPCC Sixth Assessment Report (AR6), obtained from the WorldClim climate dataset (Table 2). Figure 8 shows the average values of the selected projections.

To characterize the State's exposure to climate change, it was analyzed the change (anomalies Δ) in the average values of the variables: a) maximum temperature (tmax), b) minimum temperature (tmin) and c)

precipitation (prec), of the 72 climate change projections, in relation to the reference period 1970 to 2000. The results were added spatially by averaging the values for the State territory. Table 3 presents the extreme change values, i.e., minimum, and maximum, of the variables according to their respective climate change projections.

Selection of projections for vulnerability assessment

Of the 72 climate change projections, eight were selected for vulnerability calculations based on the climate scenarios. Two shared socioeconomic trajectories (SSPs) were selected: a) SSP 5-8.5 and b) SSP 2-4.5, which comprise a high emissions scenario and a medium stabilization scenario, respectively, covering the range of possible trajectories (Lutz *et al*., 2016) and are among the most widely used by the climate community.

The horizon times that were a) near horizon of 2021-2040, and b) distant horizon 2061-2080, allowing the identification of problems in the short and long term. The global general circulation models that will be used will be a) the HadGEM3-GC31-LL and b) the MPI-ESM1-2-HR, since they provide a range of results for the State of Puebla.

Table 2. Elements that make up climate change projections

GENERAL CIRCULATION MODEL	SHARED SOCIO-ECONOMIC TRAJECTORY (SSP)	HORIZON TIME	VARIABLES
• CNRM-CM6-1 • HadGEM3-GC31-LL • INM-CM4-8 • MIROC-ES2L • MPI-ESM1-2-HR • MRI-ESM2-0	• ssp245 • ssp370 • ssp585	• 2021-2040 • 2041-2060 • 2061-2080 • 2081-2100	• Maximum temperature (tmax) • Minimum temperature (tmin) • Precipitation (prec)

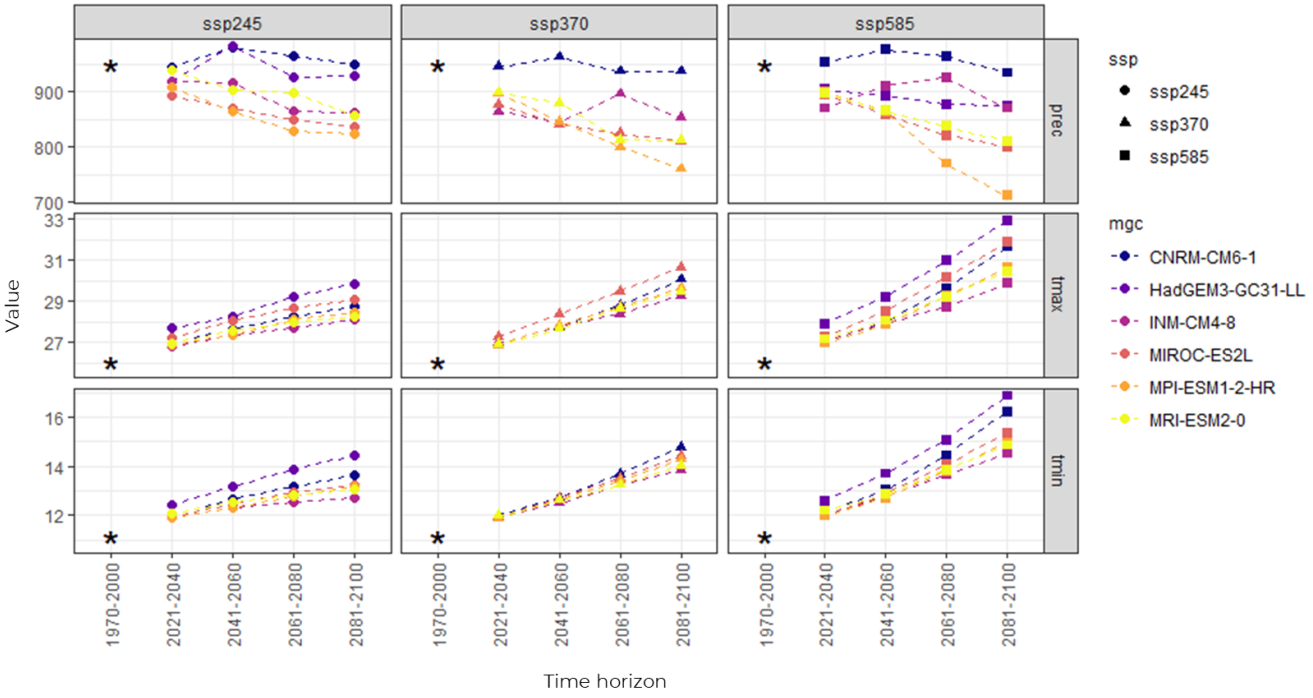

Figure 8. Average accumulated annual precipitation [mm], maximum and minimum temperature [°C] in the State for the reference period [*] and projected according to climate change projections.

TABLE 3. EXTREME CHANGE VALUES OF CLIMATE VARIABLES PROJECTED FOR THE STATE; PREC [MM], TMAX [°C], TMIN [°C].

VARIABLE	MGC	SSP	Min/Max	VALUE
2021-2040				
Prec	INM-CM4-8	ssp370	Min	-70.3
	CNRM-CM6-1	ssp585	Max	19.7
tmax	MPI-ESM1-2-HR	ssp370	Min	1.1
	HadGEM3-GC31-LL	ssp585	Max	1.8
tmin	INM-CM4-8	ssp245	Min	1.1
	HadGEM3-GC31-LL	ssp585	Max	2.3
2041-2060				
Prec	MIROC-ES2L	ssp370	Min	-92.7
	HadGEM3-GC31-LL	ssp245	Max	48.9
tmax	INM-CM4-8	ssp245	Min	1.5
	HadGEM3-GC31-LL	ssp585	Max	2.9
tmin	MPI-ESM1-2-HR	ssp245	Min	1.7
	HadGEM3-GC31-LL	ssp585	Max	3.6
2061-2080				
Prec	MPI-ESM1-2-HR	ssp585	Min	-164.0
	CNRM-CM6-1	ssp245	Max	30.1
tmax	INM-CM4-8	ssp245	Min	1.8
	HadGEM3-GC31-LL	ssp585	Max	4.3
tmin	INM-CM4-8	ssp245	Min	2.1
	HadGEM3-GC31-LL	ssp585	Max	5.3
2081-2100				
Prec	MPI-ESM1-2-HR	ssp585	Min	-221.1
	CNRM-CM6-1	ssp245	Max	16.1
tmax	INM-CM4-8	ssp245	Min	2.0
	HadGEM3-GC31-LL	ssp585	Max	6.1
tmin	INM-CM4-8	ssp245	Min	2.5
	HadGEM3-GC31-LL	ssp585	Max	7.3

4. ANALYSIS OF FACTORS AND SOURCES THAT AFFECT AIR QUALITY AND EXACERBATE CLIMATE CHANGE.

TRENDS IN THE MAIN FACTORS AFFECTING AIR QUALITY

Air quality in the State of Puebla is influenced by pressure factors, such as: population growth, the number of vehicles, the number of economic units, and energy consumption. Figure 9.

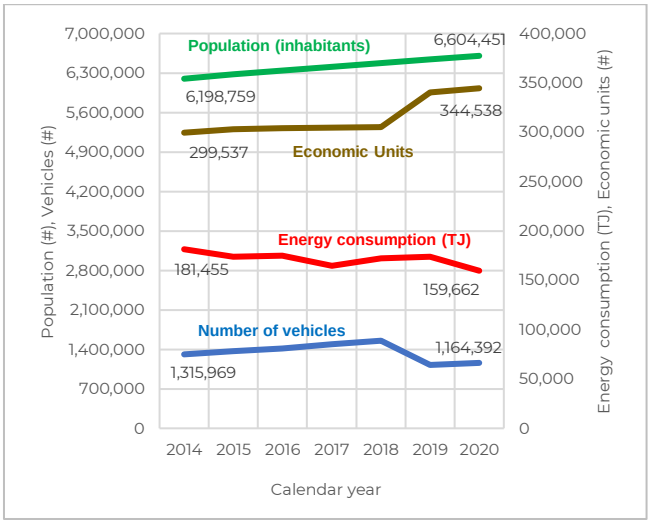

FIGURE 9. TREND OF THE MAIN PRESSURE FACTORS AFFECTING AIR QUALITY, 2014-2020

Manufacturing

According to the National Statistical Directorate of Economic Units (DENUE) published by INEGI, Puebla registered 53,452 industrial establishments in the manufacturing sector in 2021.

Most of the establishments are micro or small companies, given that more than 90% are companies that have up to 5 employees, almost 5% have between 6 and 10 employees, 2.7% occupy 11 to 30, and 0.8% from 31 to 50 people. In order of importance by the number of employees (51 to 100) we have medium-sized companies with 0.4%; and only 0.6% of manufacturing industries that require more than 100 are considered large companies and those that could be considered with a greater potential to generate polluting emissions.

Table 4 shows the municipalities with the largest number of manufacturing industries.

TABLE 4. MUNICIPALITIES WITH THE LARGEST NUMBER OF MANUFACTURING INDUSTRIES

METROPOLITAN AREA	MUNICIPALITY	MANUFACTURING ESTABLISHMENTS		
		NUMBER	PERCENTAGE	CUMULATIVE %
PuebAL-Tlaxcala	Puebla	7,539	14.1%	14.1%
Tehuacán	Tehuacán	3,787	7.1%	21.2%
	Ajalpan	2,455	4.6%	25.8%
PuebAL-Tlaxcala	San Pedro Cholula	2,068	3.9%	29.7%
	Tlacotepec de Benito Juárez	1,587	3.0%	32.6%
PuebAL-Tlaxcala	San Martin Texmelucan	1,158	2.2%	34.8%
	Amozoc	1,107	2.1%	36.9%
Teziutlán	Teziutlán	1,059	2.0%	38.8%
	Atlixco	935	1.7%	40.6%
	Altepexi	923	1.7%	42.3%
	San Salvador el Seco	886	1.7%	44.0%
	Tepeaca	852	1.6%	45.6%
PuebAL-Tlaxcala	Coronango	806	1.5%	47.1%
	Teopantlán	720	1.3%	48.4%
	Zautla	701	1.3%	49.7%
PuebAL-Tlaxcala	San Andres Cholula	697	1.3%	51.0%

Brick makers

Based on the results of the 2016 National Emissions Inventory, one of the main sectors in releasing pollutants, especially PM $_{10}$ and $PM_{2.5}$ particles, is the manufacture of bricks. 1,984 brick makers were registered, in the State of Puebla in 2020. About 96% are in 5 municipalities: 54.1% in San Pedro Cholula, almost 27% in Coronango, 8% in Juan C. Bonilla, 4.1% in Ajalpan, and 2.6% in Chignahuapan; see Table 5.

It is important to mention that confirming a certain number of brick makers is complicated, since most of them operate irregularly, and are constantly moving, in addition the level of informality with which they operate is remarkably high, making it difficult for the authorities to have a formal registry.

TABLE 5. BRICK FACTORIES REGISTERED BY MUNICIPALITY

MUNICIPALITY	BRICK MAKERS	
	NUMBER	PERCENTAGE
San Pedro Cholula	1,074	54.1%
Coronango	534	26.9%
Juan C. Bonilla	159	8.0%
Ajalpan	81	4.1%
Chignahuapan	51	2.6%
Other municipalities	85	4.3%
Total	**1,984**	**100.0%**

A strategic element to improve air quality is to reduce the emissions released by the brick manufacturing; the fuel used by brick includes firewood, which generates vast amounts of particulate matter, both PM_{10} and $PM_{2.5}$.

For example, considering that brick factories have an average production of 20,327 bricks per baking, and that in weight this is equivalent to 46.8 tons, then the burning fuel (wood) to produce this number of bricks can generate almost 20 kilograms of PM_{10}, a little more than 4 kilograms of VOC, among other contaminants.

Motor vehicles

In the period 2014 to 2020, the number of motor vehicles registered in the State of Puebla decreased, as so did the vehicle fuel consumption. The vehicle fleet in the reference period fell by 12% and the consumption of diesel and gasoline by 39%. (Fig 10).

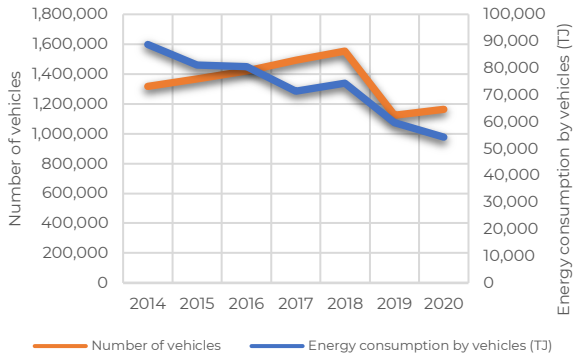

FIGURE 10. TRENDS IN THE NUMBER OF MOTOR VEHICLES AND THE ENERGY CONSUMPTION OF DIESEL AND GASOLINE, 2014-2020

Domestic sector

Of the total homes (1,714,877) located in the State of Puebla, it is estimated that 70% (1,206,942) use liquefied petroleum gas (LP gas) for cooking, almost 22% (374,888) use firewood or coal, more than 6% (108,155) use natural gas, and the remaining 1.5% use electricity for cooking, Table 6.

The firewood as fuel is mainly used in low-income dwellings in rural communities and/or on the surroundings of urban areas; this practice represents a serious environmental and health problem, especially inside the dwelling houses, which mainly affects women and young children who spend more time inside the house.

With the burning of firewood in each house, it is estimated that more than 34 kg of PM_{10} particles and 4 kg of black carbon can be generated. Should the same energy be provided by LP gas or biogas, the emissions of PM_{10} and black carbon generated would be reduced by more than 98%.

TABLE 6. MAIN FUEL FOR COOKING IN THE STATE OF PUEBLA

TOTAL, HOUSING	NUMBER OF DWELLINGS BY TYPE OF FUEL USED FOR COOKING			
	FIRE-WOOD OR CHAR-COAL	TANK GAS (LP GAS)	PIPELINE NATURAL GAS	ELECTRI-CAL
1,714,877	374,884	1,206,942	108,155	24,896
100.0%	21.9%	70.4%	6.3%	1.5%

TABLE 7. AVERAGE EMISSIONS GENERATED PER HOUSEHOLD FROM ENERGY CONSUMPTION OF FIREWOOD, LP GAS AND BIOGAS

FUEL TYPE	POLLUTANT EMISSIONS PER DWELLING USING FIREWOOD (kg/year)						
	PM_{10}	$PM_{2.5}$	SO_2	CO	NO_x	COV	CN
*Firewood	34.18	32.91	0.98	399.37	11.74	88.02	3.91
Gas LP	0.31	0.31	0.06	2.56	4.49	0.16	0.02
Biogas	0.43	0.43	0.03	4.76	5.67	0.31	0.03

Note: EPA emission factors and national fieldwork on domestic combustion with firewood (In-field greenhouse gas emissions) were used to estimate emissions.
Trace gas and particle emissions from domestic and industrial biofuel use and garbage burning in central Mexico and Comparative performance of five Mexican grill-type cookstoves using water boiling tests).

STATE ENERGY BALANCE

The energy balance of the State of Puebla, baseline 2020, was elaborated correlating the sources and the contribution of energy, as well as the sectors of consumption, using the SANKEY methodology to visualize the transfers between processes of the loss or dispersion of energy.

From left to right in the Sankey there are six sections (Figure 11), the first with the title of "Origin", showing the production and energy inputs in Petajoules of 2020. The second section (Energetics) presents disaggregated the different energies that are produced and enter the State. The third (Power Generation) graphically presents the energies that, through power plants, are transformed into electricity. The fourth (Transmission & Distribution) resumes the flow of electricity that leaves the power plants and that is distributed through the electricity grid in the industrial, agricultural, residential, commercial, and public sectors for consumption, while the rest of energy

that is not incorporated into the flow "T & D" are consumed directly in the different sectors or leave the State of Puebla. The fifth (Sectors) incorporates various flows of energy and electrical energy for consumption of the various sectors, in the case of the residential, commercial, and public sector in 2020 its consumption of 50.7 PJ is covered with electricity, firewood, dry gas and LP gas, as can be seen in the diagram. The "Destination" section groups the energy flows distributed in the different sectors, consumption, losses, and energy to classify them into final consumption, losses, or output from the State of Puebla.

From the analysis of the Sankey diagram, it is observed that of the energy production of the State (58.2 PJ), about 42% corresponds to the production of crude oil and natural gas that leave the State of Puebla. Regarding the energy that enters the State of Puebla (174 PJ), almost all of it is used for final consumption (184.7 PJ) in the State.

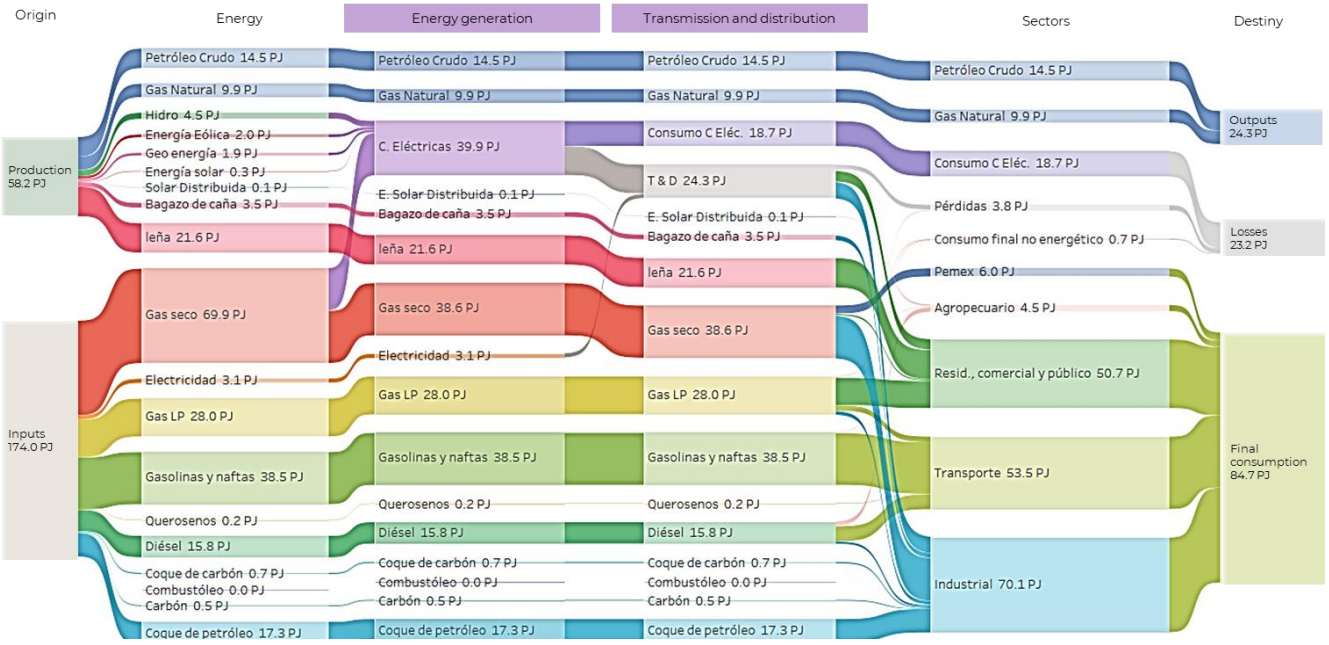

FIGURE 11. ENERGY BALANCE OF THE STATE OF PUEBLA, 2020.

UPDATE OF THE EMISSIONS INVENTORIES OF CRITERIA AND TOXIC POLLUTANTS, AND GHG AND ITS COMPOUNDS, BASE YEAR 2018 -2020.

The results of the State Emissions Inventory of Puebla 2020, shows that **43,620** tons of **PM_{10}** are annually generated. The sources or categories where measures can be implemented with a greater potential for reduction for this pollutant are domestic combustion, brick kilns, tillage, unpaved roads, open waste burning and agricultural waste burning.

Regarding **$PM_{2.5}$**, the release is about **30,758** tons; the measures with the greatest reduction potential are: domestic combustion, brick kilns, open waste burning and agricultural burning.

5,510 tons of **SO2**, **285,505** tons of **CO**, **140,700** tons of **NOx**, **626,292** tons of **VOCs**, 33,297 tons of **NH_3** are emitted.

The major contributions of anthropogenic emissions per pollutant are:

- The **PM_{10}** and **$PM_{2.5}$** particles, from the area sources, mainly from **brick kilns by burning wood** for the manufacture of bricks and from domestic combustion that includes **homes that use firewood** for cooking.
- **The SO_2** of the point sources, is generated in the **manufacture of cement and lime,** where petroleum coke is used as fuel.
- **CO** from mobile road sources is generated in the **internal combustion** of gasoline and diesel; and of the area sources,

it is generated mainly in **domestic combustion** by the **use of firewood**, followed in order of importance by the burning of biomass in the agricultural sector and in forest fires.

- The **NOx** and **CO** of mobile sources come from the massive number of **private cars** in circulation and the intensive use of **goods loading vehicles and motorcycles**.
- **VOCs** from area sources are delivered by domestic combustion due to the use of firewood, leaks generated by the handling and distribution of LP gas (including LP gas components not burned in domestic facilities) and the domestic use of solvents contained in everyday products such as flavorings, insecticides, among others.
- The **NH_3** of the area sources, is generated mainly in the waste of birds, pigs, and cattle.
- **CO_2** of the point sources is generated mainly in the processes of the **manufacture of cement and lime**, and it is followed by the generation of electricity by the burning of natural gas.
- Of the **CH_4** of the area sources, the main contribution is generated in **landfills** and from **livestock excreta**.
- The **N_2O** of the area sources is generated mainly in the **livestock emissions** category.
- **Toluene** from area sources is generated by burning **firewood** and using **solvent-based paint**.
- **Propane** from area sources comes almost entirely from the use and handling of LP gas, which includes **components of unburned LP gas in domestic facilities**.
- **Benzene** from area sources is generated almost entirely by the **burning of firewood for domestic use.**

Scenarios for reducing emissions.

The baseline will allow us to evaluate the expected emission reductions by applying the mitigation measures of the Air Quality Management and Action on Climate Change Program 2021-2030.

Figures 12 and 13 shows the scenarios where the reduction of PM2.5 and CO2e emissions of all the measures in the Program are met.

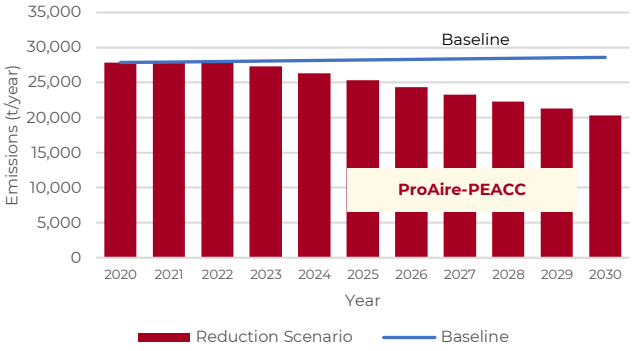

Figure 12. PM2.5 BASELINE VS Reduction Scenario

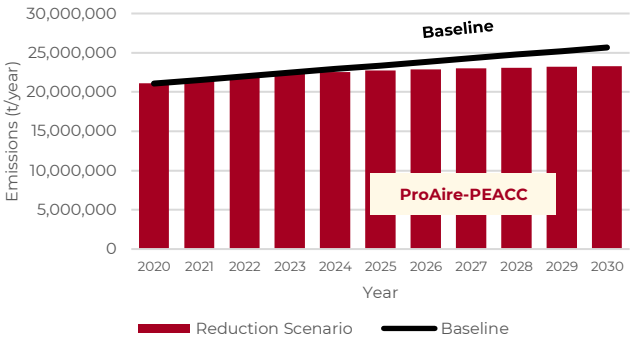

Figure 13. CO_2 Baseline vs Reduction Scenario

Emissions corresponding to the Government of the State of Puebla, reporting year 2020

The National Emissions Registry (RENE) is a public policy instrument that allows compiling the necessary information on the emission of Compounds and Greenhouse Gases of the different productive sectors to give traceability, evaluate trends and establish national strategies to reduce emissions. For the State of Puebla Government, emissions of **69,961.65 t CO_2** were estimated in the base year 2020; this is considering 68 official facilities. Exceeding 25,000 tons of CO_2annually in all operations (Article 6 LGCC Regulation), the government subsector, is considered Subject to Report before the National Registry of Emissions.

5. EFFECTS ON PEOPLE AND ECOSYSTEMS

ASSESSMENT OF MORTALITY PREVENTED BY REDUCING AIR POLLUTION

This assessment is to provide the authorities and the interested public information on the health and economic benefits that would be obtained if the levels of $PM_{2.5}$ in the PVMZ were reduced to the values established in NOM-025-SSA1-2014 (This standard was considered in force in the base year of calculation 2019).

The analysis considered the increase in cases of premature mortality for four causes of disease: cardiovascular, cardiopulmonary, lung cancer, and ischemic heart disease.

The baseline year was 2019, the year before COVID-19 pandemic, considering a pattern of emissions and typical exposure of previous years.

The Health Impact Assessment methodology (INE, 2012; Medina et al., 2009) consists of four stages.

The results are presented in Figure 12. In the municipality of Puebla, 224 cases of cardiovascular diseases (8% of baseline cases), 216 cases of cardiopulmonary diseases (13% of baseline cases), 123 cases of ischemic heart diseases (15% of baseline cases) and 12 cases of lung cancer could be avoided in 2019 (26% of baseline cases), giving a combined total of **575 avoidable mortality cases**.

The results of the two additional scenarios: a) considering the limit of the NOM of $PM_{2.5}$ updated in 2021 (NOM-025-SSA1-2021), whose limit for chronic exposure is 10 µg/m 3, and b) considering the corresponding value recommended by the WHO of 5 µg/m^3 are presented in Figure 14.

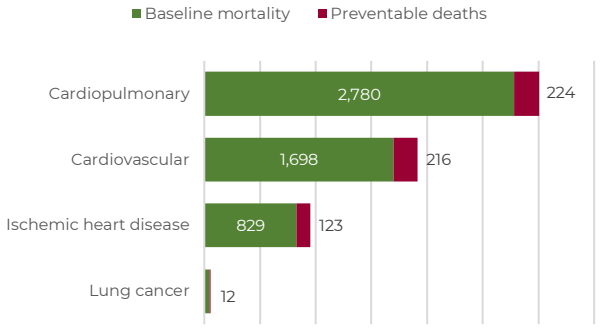

FIGURE 14. CASES OF AVOIDABLE DEATHS DUE TO SPECIFIC CAUSE OF DISEASE IN THE MUNICIPALITY OF PUEBLA, AND THEIR CONTRIBUTION TO BASELINE INCIDENCE ACCORDING TO THE NOM IN FORCE IN 2019

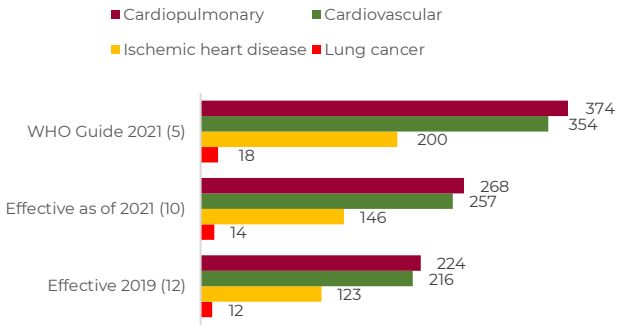

FIGURE 15. CASES OF PREVENTABLE DEATHS DUE TO SPECIFIC CAUSE OF DISEASE IN THE MUNICIPALITY OF PUEBLA ACCORDING TO THE NOM IN FORCE IN 2019, THE NOM UPDATED IN 2021 AND THE WHO RECOMMENDATION

The cases of avoidable mortality due to the four analyzed causes, in the scenario of the NOM updated in 2021 would arise up to 683, while in the scenario of the WHO recommendation would tend to 947. These figures would represent an increase of 19% and 65% of avoidable mortality compared to the scenario of compliance with the current NOM.

For the economic evaluation of cases of avoidable mortality in the municipality of Puebla, only cardiopulmonary diseases and lung cancer were counted. Cases of mortality from cardiovascular, ischemic heart and lung cancer were not counted since they

share disease codes with cardiopulmonary diseases, and there would be a risk of doubled counting.

The economic assessment of avoidable mortality cases was performed using a statistical value of life from a meta-analysis of the United States adjusted for admission to Mexico. The value used in this evaluation was **$ 33,898,679 pesos** of 2019.

Considering the above, the economic valuation of the 236 cases of avoidable mortality in the municipality of Puebla results in an economic value of $ 8,000 million pesos.

These results are complemented by data provided by the Air Quality Directorate of STATE ENVIRONMENTAL AUTHORITY, where the annual cost of treating acute respiratory infections in the PVMZ was estimated in about 670 million for the exposure to PM_{10}.

IMPACTS ON THE SPATIAL DISTRIBUTION OF ZOONOTIC DISEASES BY CLIMATE CHANGE

This section presents the areas of vulnerability of high consensus for two zoonotic diseases, Dengue and Chagas (American trypanosomiasis).

This analysis was conducted from geolocated variables, literature, sensitivity, exposure, and adaptive capacity. Eight scenarios were modeled from the combination of four population projections and two climate change projections.

Results for Dengue

The following figures show the area and percentage of the regions of the State under the three vulnerability classes according to the eight climate change projections.

For all projections of the close horizon (ch), i.e., 2021-2040, the Mixteca and the Northeastern Sierra present a greater proportion of their territory with high vulnerability. Projections for the distant time horizon, i.e., 2081-2100, are not consistent across regions. According to the general circulation model HadGEM3 and SSP 245, the Mixteca and Sierra Negra are the ones with the highest proportion of their surface with high vulnerability, while, according to SSP 585 of this model, the Sierra Northeast and Sierra Negra are the ones with this condition, Figure 16.

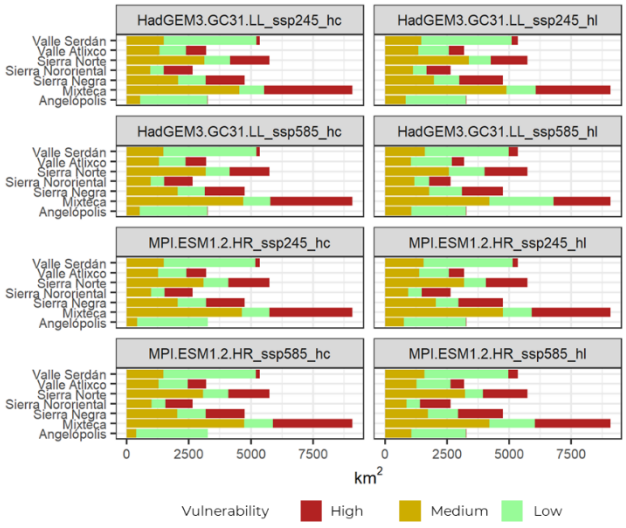

FIGURE 16. AREA BY DENGUE VULNERABILITY CLASS FOR THE REGIONS OF THE STATE ACCORDING TO THE EIGHT CLIMATE CHANGE PROJECTIONS

Results for Chagas

For all time horizons and shared socioeconomic pathways, Sierra Negra is the region whose surface presents a higher proportion of high vulnerability, while Angelópolis is the one with the lowest proportion under this class, Figure 17.

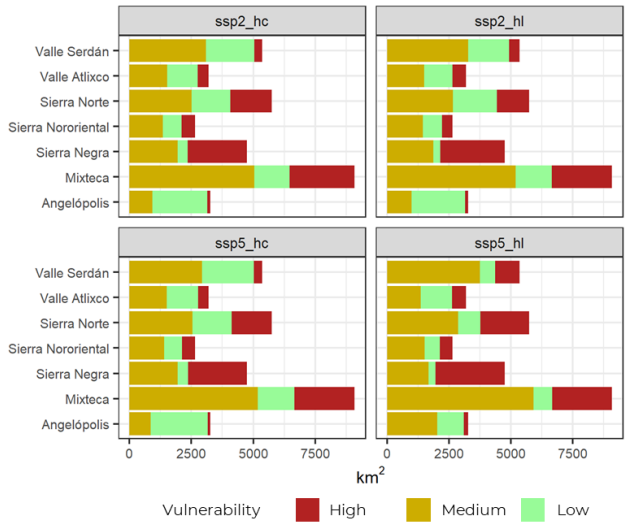

FIGURE 17. AREA BY VULNERABILITY CLASS TO AMERICAN TRYPANOSOMIASIS FOR REGIONS OF THE STATE.

VULNERABILITY OF THE BIODIVERSITY SECTOR TO CLIMATE CHANGE

Climate change and biodiversity loss are two of the most pressing Anthropocene issues humanity is facing. The impacts on biodiversity of climate change, together with other threats, have already been observed and the damages and losses caused to terrestrial ecosystems are and greater than estimated (IPCC, 2022).

From the records of 962 species of terrestrial vertebrates and 5,054 species of vascular plants obtained from the Global Biodiversity Information Facility, 399 species belonging to 17 biological groups were selected as Key Elements of the Territory representative of the biodiversity sector. For these species, the current vulnerability was calculated under the eight climate change projections, as well as an integrated vulnerability that considers in a single value of the eight possible exposures.

Six criteria were considered to construct the three components that make up vulnerability. Table 9 indicates the components, the criteria, and the contribution of their values for the vulnerability calculation, e.g. -:+ indicates that the lower the criterion value, the greater the contribution.

The quantitative values of vulnerability obtained were classified to obtain three classes: 1=Low, 2=Medium and 3=High.

TABLE 9. CRITERIA FOR CALCULATING THE VULNERABILITY OF THE BIODIVERSITY SECTOR

COMPONENT	CRITERION	CONTRIBUTION	SOURCES / DESCRIPTION
Sensitivity	Habitat diversity	-:+	Number of different ecosystems (Sayre et al., 2020) intersected by the surfaces of current climatic suitability.
	% of the area of the State with current climate suitability	-:+	Climate suitability maps constructed from the records obtained from the Global Biodiversity Information Facility, using species distribution models.
	Risk category	+:+	Official Mexican Standard NOM-059-SEMARNAT-2010.
	Endemism	+:+	Official Mexican Standard NOM-059-SEMARNAT-2010 and the "Enciclovida" platform.
Exposition	Loss of climate suitability	+:+	Maps generated with species distribution models for the eight climate change projections.
Adaptive capacity	Territorial conservation instruments	+:+	NPA y ADVC.

The proportion of species by group and vulnerability class varies between different climate change projections. In general, the projections of the distant time horizon (2018-2100), especially under the ssp585 scenario, are those with the highest number of species considered highly vulnerable, while those corresponding to the general circulation model (MGC) MPI-ESM1-2-HR for the near time horizon (2021-2040) are the ones with the most species with low vulnerability, regardless of the SSP.

According to the integrated vulnerability, most of the species evaluated have medium vulnerability (45.1%), 26.3% of the species have high vulnerability (105), and 28.6% (114) low vulnerability. Raptors and parrots are the animal groups with the highest proportion of highly vulnerable species, while cycads are the most vulnerable plant group (Figure 18). Soricids, motmots and feline species have only medium vulnerability,

while trogons, raptors and parrots do not have species with low vulnerability.

By pooling the integrated climate suitability data of individual species, it is possible to identify areas where the projected future climate will not be suitable for the species.

According to the eight climate change projections, ~4800 km^2 of the State's surface will lose climate suitability for 86 to 162 species. The Mixteca, Sierra Negra and Sierra Norte are the regions with the largest areas of loss of climatic suitability (~1906, 1452 and 913 km^2 respectively).

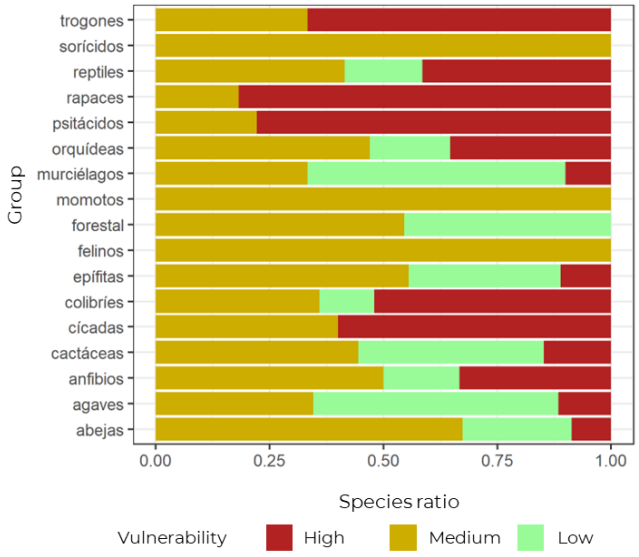

FIGURE 18. PROPORTION OF SPECIES BY VULNERABILITY CLASS AND GROUP.

These areas represent an important input for the design and establishment of territorial conservation instruments with a focus on climate change, as well as for the increase of connectivity through corridors that allow the dispersion of these towards certain areas, ideally under some protection scheme, with suitable climatic conditions in the future.

FOREST SECTOR VULNERABILITY TO CLIMATE CHANGE

Forests play a crucial role in climate regulation due to their ability to absorb and fix CO_2 and offer important environmental services. The State of Puebla has a forest area equivalent to 45% of its territory ~1,573,464 ha (CONAFOR, 2022), distributed mainly in three large groups: forests, jungles, and scrubs.

The current vulnerability was calculated, and under eight climate change projections, of six plant communities selected as key elements of the territory (TCE) representative of the forest sector: a) Oyamel forest (BA in Spanish and shown in Figure 19), b) Mountain mesophilic forest (BM in Spanish and shown in Figure 19), c) Pine, oak, pine-oak and oak-pine forest (BPQP in Spanish and shown in Figure 19), d) Crasicaule scrub (MC in Spanish and shown in Figure 19), e) Rosetophyll desert scrub (RDS in Spanish and shown in Figure 19), and f) Low deciduous forest (LDF)[1]. To construct the three elements of the vulnerability, 10criteria were considered. Table 10 presents the components, criteria, and the contribution of their values to the vulnerability calculation, e.g. -: + indicates that the lower the value of the criterion, the greater the contribution.

The quantitative values of vulnerability obtained were classified using the k-means method to obtain three classes of vulnerability: 1=Low, 2=Medium3=High.

Apart from the crasicaule scrub, most of the surface of plant communities is represented by medium vulnerability, according to all climate change projections. Most of the surface of the crasicaule scrub presents low vulnerability in all the projections considered, which positions it as the least vulnerable community to climate change.

[1] Acronyms (as they are in Spanish) were used in Figure 19.

TABLE 10. CRITERIA FOR CALCULATING THE VULNERABILITY OF THE FOREST SECTOR

COMPONENT	CRITERION	CONTRIBUTION	SOURCES / DESCRIPTION
Sensitivity	Patch size	-:+	Calculated from PDCV.
	Patch altitudinal range	-:+	Calculated from the digital elevation model (1 km).
	Proximity index	-:+	Calculated from PDCV using the spatialEco package (Evans, 2021).
	Shape index	+:+	Calculated from PDCV (McGarigal and Marks, 1995).
	Fire risk	+:+	Intersection between the PDCV and CONAFOR's forest fire risk mapping.
	Road density	+:+	National Road Network (INEGI, 2021).
Exposition	Loss of environmental suitability surface	+:+	Area of loss of environmental suitability projected in the future, through species distribution models.
Adaptive capacity	Instruments of territorial conservation and payment for environmental services	+:+	NPA, ADVC, PSA. (1)

(1) Each element constitutes a criterion.

Low deciduous forests have an exceptionally low level of exposure in all projections considered, so the contribution of this component to projection vulnerability is negligible. Therefore, it is the only plant community that does not present high vulnerability in any of the projections.

The rosetophile desert scrub presents practically no high vulnerability according to the projection MPI-ESM1-2-HR_ssp585_2021-2040, while a third of its surface is considered of high vulnerability under the projection HadGEM3-GC31-LL_ssp585_2081-2100.

Pine, oak, oak-pine, and pine-oak forests present high vulnerability in all projections while, in general, most of the mesophilic forest area is represented by a medium level of vulnerability.

Abies forests are the plant community with the highest proportion of highly vulnerable area, reaching the highest values (~48 and 81%) for the distant time horizon and ssp585.

According to the results of the integrated vulnerability, 18% of the State's forest area has a high vulnerability, 68% medium vulnerability and 14% low vulnerability. Figure 19 presents the integrated vulnerability of each plant community.

The oyamel forest is the plant community with the lowest presence in the State, however, 54% of its surface has a high vulnerability to climate change. This could mean the loss of more than 9,000 hectares of oyamel forest, the second most important wood at the State level for timber production (CONAFOR, 2019).

The low deciduous forests are the plant community with the highest State representation, the connectivity of the low deciduous forest is remarkably high, which partly explains that 86% of the surface has medium vulnerability, 13% low vulnerability and only 1,174 hectares high vulnerability.

Most of the area of pine, oak, pine-oak, and oak-pine forests presents medium vulnerability values, except for the forests of the Mixteca region that present high vulnerability values.

The crasicaule scrub (CM) is the plant community with the highest proportion of area classified as low vulnerability (49%), however, the entire surface of the Angelópolis region presents high vulnerability.

Rosetophilous desert scrub (RDS) is distributed in six of the seven regions of the State, only absent in the Atlixco Valley. Approximately half of its surface has medium vulnerability values; in the regions Angelópolis, Mixteca and Sierra Norte presents the highest proportion of surface with high vulnerability.

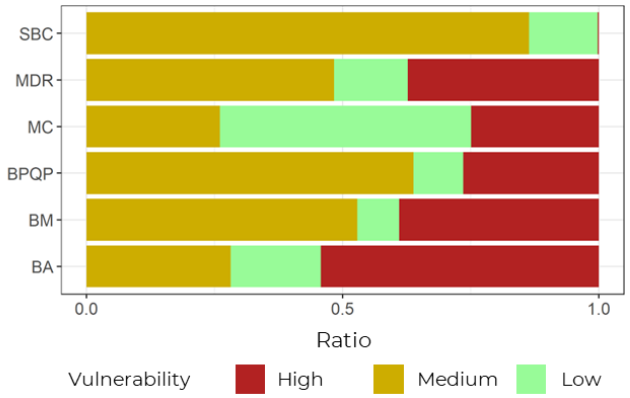

FIGURE 19. PROPORTION OF PLANT COMMUNITY AREA BY INTEGRATED VULNERABILITY CLASS.

WATER SECTOR VULNERABILITY TO CLIMATE CHANGE

The State's aquifers were selected as key elements of the water sector. The vulnerability of the sector to climate change was calculated considering eight criteria and eight projections of climate change using the formula:

Vulnerability = (Exposure + Sensitivity) - Adaptive capacity

Table 11 shows the components, the criteria, and the contribution of these values to vulnerability estimation, e.g. -:+ indicates that the lower the value of the criterion the greater the contribution.

The vulnerability was classified into three classes: 1=Low, 2=Medium and 3=High.

To ease the interpretation of the results, the layer "High consensus vulnerability" was built, to identify those areas where all projections agree that the vulnerability will be high.

TABLE 11. CRITERIA FOR ESTIMATING THE VULNERABILITY OF THE WATER SECTOR

COMPONENT	CRITERION	CONTRIBUTION
Sensitivity	% of aquifer surface identified as potential recharge zone.	-:+
	Dependence of municipalities on groundwater.	+:+
	Negative average annual availability of aquifers.	-:+
	Population growth by SSP.	+:+
Exposure	Δ precipitation (↓) according to 8 CC projections.	+:+
	Δ maximum temperature (↑) according to 8 CC projections.	+:+
Adaptive capacity	% of treated water from municipalities.	+:+
	Number of treatment plants in operation.	+:+

The proportion of vulnerability classes obtained for the State territory are extremely similar, varying slightly in their spatial distribution between projections. The projection under which the highest proportion of high vulnerability is projected is HadGEM3-GC31-LL_ssp245_2081-2100.

In 113 out of the 217 municipalities of the State there is a high consensus of vulnerability of aquifers. These municipalities host cities such as Tehuacán (248,716 inhabitants), Amozoc (77,106 inhabitants), Tecamachalco (28,679 inhabitants), Acajete (20,923 inhabitants) and Ciudad de Libres (15,536 inhabitants), which depend on groundwater for the supply of public-urban water. Irrigation District 030 (Valsequillo) on the Valleys of Tecamachalco, Tlacotepec and Tehuacán is also located on the area of greatest consensus of high vulnerability.

All the analyzed climate change projections show that more than 70% of the surface of the Northeastern Sierra region has a medium vulnerability. Six projections do not show surface with "high vulnerability". This makes the region the least vulnerable of the seven regions of the State.

Sierra Norte region presents is a medium vulnerability, with a high coincidence in the projections. This makes the area the less vulnerable, it includes the municipalities of Chignahuapan, Zacatlán and Tepetzintla, municipalities with a high forest coverage and an important tradition of forest management.

The Valle Serdán is the region where there is the greatest consensus to consider it as "high vulnerability" area. The eight projec-

tions show that at least 50% of the territory has a condition of high vulnerability of its aquifers.

For the Angelópolis region, where the largest population in the State is located, all projections show that the area with "high vulnerability" is in the eastern portion, in the municipalities of Nopalucan, Acajete, Tepeaca, Tepatlaxco de Hidalgo, Amozoc, Mixtla, Santo Tomás Hueyotlipan, Tlanepantla, Tepeyahualco de Cuauhtémoc and Tochtepec.

The Atlixco Valley region has in the eight projections more than 75% of its surface classified as "low vulnerability", the area with high consensus of "high vulnerability" is located southeast of the region, on the border with the Mixteca region, coinciding with the political-administrative limits of Ahuatlán. In the Mixteca region, projections show that 70% of the surface is classified as "medium vulnerability", however, there is also agreement that approximately 22% has "high vulnerability", especially in the southern part, adjacent to the State of Oaxaca.

The Sierra Negra region, as well as the Mixteca, Valle Serdán and Angelópolis regions, has a critical area classified as "high vulnerability". About 40% of the surface can be considered "high vulnerability". This includes the municipalities of Tehuacán, the main urban area of the region and second largest in the State of Puebla, San Antonio Cañada, Altepexi, Yehualtepec, Tlacotepec de Benito Juárez and some areas of the municipalities of Ajalpan, Zinacatepec.

Agricultural vulnerability to climate change.

Currently, 43.2% of the territory of the State of Puebla has agricultural land use, 84% of temporary and 16% of irrigation (INEGI, 2017).
According to the Agrifood Atlas 2012-2018 (SIAP, 2018) the State stands out at the national level in the production of sesame, green alfalfa, amaranth, blueberry, oatmeal grain, eggplant, broccoli, coffee cherry, zucchini, sugar cane, barley, onion, cauliflower, peach, raspberry, strawberry, tomato, lettuce, fodder corn, grain corn, orange, nopalitos, potato, pear, banana, rose, grain sorghum, green tomato, grapefruit and grape fruit.

Agroclimatic aptitude of maize cultivation in the State of Puebla

To have an approximation to the change of yield of the maize crop in the State of Puebla, an analysis was addressed from the change in the agroclimatic aptitude of the crop with the climate change scenarios. A literature search was conducted regarding the parameters of climatic suitability for the optimal yield of the maize crop, specifically temperature and precipitation.

The zoning of parameters for Accumulated Precipitation and Average Temperature was obtained, and the historical climate data (1979-2000) of WorldClim version 2.1 were used.

The different aptitudes were classified with respect to the current agricultural area: total, irrigated, and temporary agriculture; the total and percentage area was obtained for each municipality of the State of Puebla.

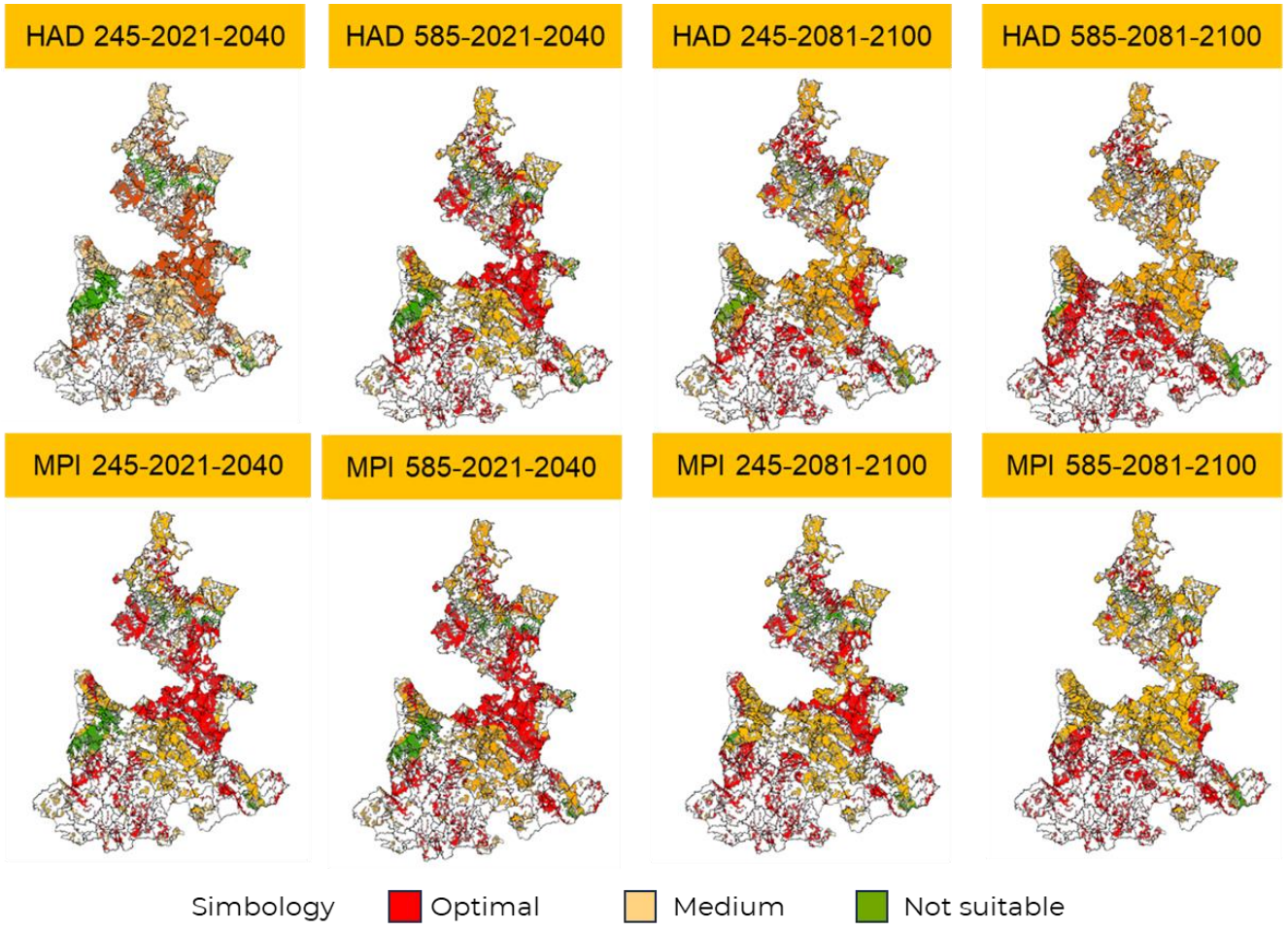

FIGURE 20. CLIMATE APTITUDE MAP USING CLIMATE CHANGE SCENARIOS FOR MAIZE CULTIVATION.

RESULT OF THE CLIMATIC SUITABILITY OF THE MAIZE CROP

For the current scenario, 91% of the area used for agriculture meets at least one condition of temperature or precipitation (77.6% in temporary mode and 13.4% in irrigation), and only 8.6% meets both conditions (6.3% in temporary and 2.3% in irrigation).

As seen in Figure 18, for all regions there is an increase in areas where neither of the two variables will be present. This decrease in aptitude may be accompanied by a decrease in performance and associated with an increase in losses due to disaster events.

Strategies should be developed to minimize environmental impacts, and options for agricultural expansion or intensification should be analyzed. Support and investment should continue in regions where production is temporary to promote climate change mitigation and adaptation strategies to reduce its impacts. Strategies should integrate different forms of production (e.g., conservation agriculture, agroforestry, etc.), migration of crops to varieties that better withstand future conditions, and land-use planning.

VULNERABILITY IN AGRICULTURE DUE TO WATER STRESS

According to STATE ENVIRONMENTAL AUTHORITY, 85% of the State of Puebla's territory has a potential to be affected by some degree of drought. This is due to variability

in precipitation, low soil moisture, elevated temperatures, and evapotranspiration of vegetation, especially in arid and semi-arid areas of Puebla. This year 2022 the State of Puebla was affected by a drought in 73 municipalities.

The analysis of vulnerability in agriculture due to water stress shows that 73 municipalities of Puebla out of the 217, present high vulnerability: 16 in the Angelópolis region, 18 in the Mixteca region, 5 in the Sierra Negra, 9 in the Sierra Norte, 12 in the Atlixco Valley, and 13 in the Serdán Valley. In general, measures to reduce the vulnerability of these municipalities are aimed at reducing sensitivity and increasing adaptive capacity. To reduce sensitivity to water stress in agriculture, measures must be implemented to:

- Increase the resistance of natural vegetation to water stress, through restoration.
- Decreased soil erosion.
- Promote more resilient production conditions such as the use of perennial crops.
- Improve the condition of aquifers.

To increase adaptive capacity, it is necessary to:

- Promote the generation of risk management instruments. Many of the municipalities do not have municipal Risk Atlas.
- Promote vegetation conservation areas (e.g., Natural Protected Areas, Payment for Environmental Services)
- Promote the organization of producers to receive technical assistance to improve the way they use land and agricultural practices and improve their access to programs such as agricultural development.
- Access to insurance against weather events.

VULNERABILITY IN AGRICULTURE DUE TO FLOODING

Floods, as well as other disasters, involve several factors that can affect their frequency and intensity. Climate change is increasing extreme rainfall, which is an important part of the factors that can trigger a flood. River flooding is likely to exacerbate the intensity and frequency of extreme flooding.

The analysis of vulnerability in agriculture to floods shows that 41 municipalities of Puebla out of the 217, have high vulnerability: 3 in the Angelópolis region, 25 in the Mixteca region, 3 in the Sierra Negra, 1 in the Sierra Norte, 7 in the Atlixco Valley and 2 in the Serdán Valley.

In general, measures to reduce the vulnerability of these municipalities focus at reducing sensitivity and increasing adaptive capacity. To reduce sensitivity to the problem of flooding in agriculture, measures must be implemented to:

- Increase vegetation coverage in watersheds. Especially in the high areas and restoration of riparian vegetation.
- Reduce soil erosion.
- Promote more resilient production conditions such as the use of perennial crops.
- Improve hydraulic infrastructure.
- Rehabilitate and properly operate water treatment plants.

To increase adaptive capacity, measures must:

- Promote the generation of risk management instruments. Many of these municipalities do not have a Municipal Risk Atlas.
- Promote vegetation conservation areas (e.g., Natural Protected Areas, Payment for Environmental Services)
- Promote the organization of producers to receive technical assistance to improve the way they use land and agricultural practices and improve their access to programs such as agricultural development.
- Access to insurance against weather events.

6. Design of policies, strategy, action lines, and goals to improve air quality and address climate change

The strategies, measures, and actions lines (AL) were selected considering:

- Impact on the emission of GHG and its compounds, and criteria pollutants, according to the emissions inventory.
- Constructive collaboration between air quality and climate change.
- Cost-effectiveness.

To do this, five axes were classified, and each one was divided into strategies, as it can be seen in Figure 21:

- Prevention, regulation, control, and mitigation of emissions
- Air quality management
- Socio-Environmental Conservation Objects (OCSA in Spanish) and adaptation to climate change
- Environmental health
- Knowledge management

Each strategy contains various measures and actions, as described below.

AXES	Axis 1 Prevention, control and mitigation of emissions	Axis 2: Air Quality Management	Axis 2: Air Quality Management	Axis 4: Environmental Health	Axis 5: Knowledge Management
STRATEGIES	1. Mobility and sustainable transportation 2. Industry, commerce and services 3. Reduction of emissions from biomass and waste combustion 4. Energy efficiency	5. Strengthening air quality management	6. Biodiversity adaptation 7. Forestry adaptation 8. Agricultural Adaptation 9. Hydric Adaptation 10. OCSA	11. Environmental health	11. Training 12. Communication and dissemination 13. Research
MEASURES	19	3	31	7	9
ACTIONS					

Strategy 1. Mobility and sustainable transport

Measure 1.1. Development of an electromobility program for the transport sector.
AL-1.1.1. The State Environmental Authority in coordination with the responsible authorities, will evaluate the relevance the gradual replacement of RUTA vehicle fleet with electric vehicles, with or without catenary.
AL-1.1.2 The State Environmental Authority in coordination with the responsible authorities will evaluate the relevance the gradual substitution of public passenger transportation for electric vehicles.
AL-1.1.3 The State Environmental Authority will evaluate the relevance of implement a program for replacing taxis (traditional and digital services) reaching the end of their useful life and those to enter circulation for the first time, with hybrid or electric vehicles. The goal is that by 2030 approximately 20% of taxis will be low emission.
AL-1.1.4 The State Environmental Authority will evaluate the relevance the implement the replacement of private cars with hybrid or electric vehicles through incentives.

Measure 1.2. Reduction of emissions in heavy cargo and passenger transport.
AL-1-2-1 The State Environmental Authority will promote, in coordination with the Secretary of Mobility and Transportation of the State, financial institutions, transportation groups and owners of cargo trucks, the gradual replacement of units in circulation, with emphasis on the oldest ones.
AL-1.2.2. Will encourage the installation of particle traps in diesel vehicles.
AL-1.2.3 Will review and update the legal framework regarding vehicle renewal.
AL-1.2.4 Strengthen coordination with the Secretariat of Communications, Transportation, and Infrastructure for compliance with the verification of emissions from freight transportation with federal license plates circulating in the state.

Measure 1.3. Emission reductions in light private transport.
AL-1-3-1 The State Environmental Authority will manage before CAME and SEMARNAT the regulatory improvement of the Mexican Official Standard NOM-016-CRE-2016 (Quality specifications for petroleum products).
AL-1.3.2 Manage before CAME and SEMARNAT the revision and prompt publication for public consultation of the draft update of the Mexican Official Standard NOM-042-SEMARNAT-2003.
AL-1-3-3 Will strengthen the vehicle emissions verification program.
AL-1.3.4 IT will incorporate, if relevant, regulatory changes to microbus or bus passenger transportation to integrate environmental criteria in the application for permits or renewal of concessions.

1.4. Encourage and manage remote work (home office).
AL-1.4.1 The State Environmental Authority based on its relevance, will implement the development of a work at home program for public servants of the government of the state of Puebla, as well as promote with private companies that encourage remote work.
AL-1.4.2 Will promote a program of staggered and compact schedules in which the government, educational institutions and the private sector participate.
AL-1.4.3 Will extend virtual procedures in government offices to reduce the number of trips made by citizens.

Measure 1.5. Inclusive pedestrian city.
AL-1-5-1 The State Environmental Authority, with the participation of the Secretariat of Mobility and Transportation and municipalities, will conduct studies to determine areas or streets that can be converted into pedestrian and low emission zones.
AL-1.5.2 Will conduct the necessary works and adaptations in the urban spaces destined to pedestrian zones.

AL-1.5.3 Will extend number and use of bicycle lanes.

Measure 1.6. Control of emissions in the use of motorcycles.
AL-1.6.1 The State Environmental Authority with the participation of SEMARNAT, municipalities, motorcycle manufacturers, will elaborate a diagnosis on the number, type and use of motorcycles circulating in the State of Puebla.
AL-1.6.2 Will manage before SEMARNAT the elaboration of a NOM that establishes the maximum permissible limits applicable to new motorcycles, considering minimum limits of the EURO 3 type, and publish verification criteria.
AL-1.6.3 Will promote to establish an incentive program for the acquisition of electric motorcycles and achieve a goal that at least 33% of the motorcycle fleet in circulation by 2030 will be electric.

Strategy 2. Industry, commerce and services

Measure 2.1. Emission reductions in the industrial sector,
AL-2.1.1 The State Environmental Authority will establish a quality control system for receiving the information provided by the industry to classify the emissions more accurately being generated.
AL-2.1.2 The State Environmental Authority will establish agreements with the federal government to select strategic industries for technical visits and collect the necessary information for the possible implementation of specific emission reduction actions for each industry.
AL-2.1.3 The State Environmental Authority in coordination with the federal government will establish agreements with industrialists to install emission control equipment or improvements in processes where feasible.
AL-2.1.4 Develop an economic and technical feasibility study to use another fuel that is less polluting than sugarcane bagasse.
AL-2.1.5 Advocate with SEMARNAT for the entry into force and application of the Mexican Official Norm Project PROY-NOM-170- SEMARNAT-2017.
AL-2.1.6 The state environmental authority will establish agreements with the federal government to explore the feasibility of providing technical advice to improve production efficiencies and reduce emissions.

Measure 2.2. Reducing emissions in the brick production sector.
AL-2.2.1 The State Environmental Authority with the participation of the Secretary of Economy of the State of Puebla, urban development, and environmental areas of the municipalities, BANOBRAS, SEMARNAT, and INECC, will prepare a feasibility diagnosis that will provide the necessary elements to identify community sites where to locate new kilns and additional support to reduce the social gap of the families that work in the sector. In addition to encouraging the creation of brick kiln cooperatives.
AL-2.2.2 Will develop a program the installation of modern community kilns.
AL-2.2.3 Updating of the registry of brick kilns operating in the State, including the type of kiln, type of fuels and emissions generated.
AL-2.2.4 Continue efforts to develop and publish a state environmental technical standard that regulates brick manufacturing activities.
AL-2.2.5 Design and implement measures to avoid the use of highly polluting fuels.
AL-2.2.6 Establish and implement a plan to diversify the sector by promoting and applying subsidies to transition to brick manufacturing that does not require the use of kilns and burning of fuels.
AL-2.2.7 Review and update of urban development programs to include criteria that allow for the regulation of the installation of brick kilns in industrial parks or sites specifically designated for this purpose.
AL-2.2.8 Establish of training programs that provide additional tools to brick kiln workers and their families.

Measure 2.3. Reduction of volatile organic compounds (VOCs) in household products and architectural coating.
AL-2.3.1 The State Environmental Authority will manage the development and publication of a local standard to regulate VOC content in the paint industry.
AL-2.3.2 Manage the prompt publication of NOM-123-SEMARNAT-1998 before SEMARNAT and CAMe.
AL-2.3.3 Elaborate the development of general guidelines for the purchase of consumables with low VOC content by the state and municipal governments.
AL-2.3.4 It will gradually establish the use of paints with low or zero VOC content.

Measure 2.4. Reduction of emissions in the distribution and use of domestic LP gas.
AL-2.4.1 The environmental authority shall establish agreements between municipal governments with associations and LP-Gas companies for the implementation of dry disconnection devices in installations and LP-Gas delivery vehicles.
AL-2.4.2 Will promote the development and dissemination of a manual that contemplates the maintenance of the system of joints that integrate the connection of the tank that stores the fuel to the stove and/or water heaters, in addition to the basic maintenance of burners and other components of the combustion system.
AL-2.4.3 Will establish a program to expand the use of magnetic induction cooktops.
AL-2.4.4 The state environmental authority will develop a strategy to guide the change in the use of LP gas to electric or solar energy, be it water heaters or solar panels.
AL-2.4.5 Will promote changes in state and municipal regulations so that new residential buildings contain magnetic induction stoves, solar water heaters and solar panels.

Measure 2.5. Installation of vapor recovery systems in service stations in the State of Puebla.
AL-2.5.1 The gas station union through agreements with the State Environmental Authority will install of vapor recovery systems in service stations in the state of Puebla, starting with the municipality of Puebla, where 180 out of the 565 operating stations in the state are located.
AL-2.5.2 Manage before the ASEA, the update of the NOM-004-ASEA-2017, to incorporate the state of Puebla within the spatial scope of application of such standard.
AL-2.5.3 Establish that all new service stations have vapor recovery systems.
AL-2.5.4 Manage before the Energy Regulatory Commission, the update of NOM-CRE-016 2016 Petroleum Products Quality Specifications, to adjust the current zoning of the state of Puebla.

Measure 2.6. Distribution of less volatile gasoline in the PVMZ.
AL-2.6.1 As it is a federal competence, the State Environmental Authority will request before the CAMe to PEMEX the supply of gasoline in the Puebla Valley Metropolitan Zone (PVMZ) with a maximum of 9 psi in the period from March 16 to August 31.

Strategy 3. Reduction of emissions in the burning of biomass and waste

Measure 3.1. Regulation and control of agricultural burning and implementation of good tillage practices.
AL-3.1.1 The State Environmental Authority will continue to promote good agricultural practices that allow the development of agroecological production systems and sustainable practices of "cut, chop, and reincorporate" (and not "slash and burn").
AL-3.1.2 Will monitor the application of the General Law for the Prevention and Integral Management of Waste, Article 100 of which prohibits open burning of waste.
AL-3.1.3 Cooperate with SEMARNAT and SADER in monitoring compliance with the Mexican Official Standard NOM-015-SEMARNAT/SAGARPA-2007.
AL-3.1.4 Elaborate the development of a state technical standard to regulate agricultural burning, as outlined in the 2012-2020 Air Quality Management Program for the State of Puebla.

Measure 3.2. Reduction, prevention, and control of emissions in solid waste management.
AL-3.2.1 The State Environmental Authority in coordination with PROFEPA, the STATE ENVIRONMENTAL AUTHORITY, shall monitor compliance with NOM-083-SEMARNAT-2003.
AL-3.2.2.2 Update the diagnosis of waste disposal in the State, identifying waste burning and inadequate disposal practices, as well as practices where there is control of biogas emissions and their reuse.
AL-3.2.3 Establish a program for the closure of all final disposal sites that operate as open dumps.

AL-3.2.4 In coordination with municipal authorities, establish schemes to expand the coverage of waste collection to reduce inappropriate waste disposal.
AL-3.2.5 Design and implementation of a permanent campaign to disseminate information and raise awareness among the population about the health and environmental effects of waste burning.
AL.3.2.6 The state environmental authority will strengthen the application of circular economy criteria, within its state comprehensive waste management program.

Measure 3.3. Reducing emissions from domestic fuel-wood consumption.
AL-3.3.1 The State Environmental Authority shall strengthen the gradual replacement of traditional cookers with improved cookers and/or magnetic induction cooker systems. On an average of 10 thousand per year
AL-3.3.2 Establish agreements with academic institutions in the state to design and certify low-cost improved cookers, appropriate to local needs.
AL-3.3.3.3 The State Environmental Authority will support the installation of cookstoves in localities with a high rate of marginalization, as well as training for their maintenance and, where appropriate, self-construction.
AL-3.3.4 Design of promotion and awareness-raising campaigns aimed at families that use firewood to inform about the problems caused to the health of families by exposure to the emissions generated in its burning and the benefits in the economy and in their quality of life, using other technological options.
AL-3.3.5 Foster coordination with civil society organizations and participating institutions, such as the Pan American Health Organization, to broaden capacities for the promotion and installation of improved cookstoves.
AL-3.3.6 The State Environmental Authority shall establish of a monitoring and verification program for the installation and use of improved cookstoves.

Measure 3.4. Best Practices for Fire Management and Wildfire Prevention.
AL-3.4.1 The State Environmental Authority will participate with CONAFOR and SADER in fire management actions in livestock and agricultural burns, during periods of higher occurrence of fires and higher concentrations of atmospheric pollutants (winter and dry season).
AL-3.4.2 Support CONAFOR in the strengthening of the capacities and equipment lor land tenants and forest communities that support the best practices for fire management.
AL-3.4.3 Strengthen participation in the permanent working group between CONAFOR, CONANP, SADER, BIENESTAR and PROFEPA, for the analysis and periodic evaluation of proposed actions for fire prevention.
AL-3.4.4 Together with CONAFOR, it will promote the design awareness campaigns aimed at the population on the risks of forest fires and how to prevent them.
AL-3.4.5 Support compliance with the provisions of the Mexican Official Standard NOM-015-SEMARNAT/SAGARPA-2007.

Strategy 4. Energy efficiency

Measure 4.1. Environmental Audit and Sustainable Building Certification Program.
AL-4.1.1 The State Environmental Authority with the participation of the Secretariat of Planning and Finance, the Energy Agency of the State of Puebla, the local Chamber of Commerce, universities, commercial centers, and civil society organizations, will develop and implement the criteria for a Sustainable Building Certification Program based on similar experiences such as those of Mexico City and other sustainability certification systems.
AL-4.1.2 Define dissemination schemes for buildings that obtain certification through digital media and the Secretariat's channels.
AL-4.1.3 Will promote the establish economic incentives for companies that achieve certification under the Program.

Measure 4.2. Energy efficiency in government buildings (municipalities/State).
AL-4.2.1 The State Executive with the participation of the State Environmental Authority, the Energy Agency of the State of Puebla, the Secretariat of Planning and Finance and the various agencies of the government of the State of Puebla, will design the GHG emissions reporting mechanism for centralized and decentralized bodies of the State of Puebla, as well as each of the City Councils.
AL-4.2.2 Review significant emission sources (direct/indirect), as well as select government buildings and facilities to intervene.
AL-4.2.3 Develop an energy diagnosis per building and establish targets, measures, and budget.
AL-4.2.4 Define concepts, objectives, and rationale for calculating GHG emissions from government buildings through capacity building of government agencies,
AL-4.2.5 Manage a program/scheme and procedures outlining the steps that each agency (decentralized/centralized) must follow to estimate the GHG emissions of their operations, with the aim that each agency will have a guide appropriate to the operations they carry out and that they will have a better understanding of the reasons for doing so.
AL-4.2.6 Compliance with emission reduction targets over time through good practices in buildings and energy efficiency projects for intervention in each establishment subject to the program.
AL-4.2.7 Compliance with federal obligations under the National Emissions Registry.

Measure 4.3. Green incentives for the acquisition of solar heating systems or photovoltaic systems in micro, small and medium companies (MiPyMEs).
AL-4.3.1 The Energy Agency of the State of Puebla, with the participation of the State Environmental Authority, the Secretariat of Planning and Finance, construction companies, the National Chamber of the Construction Industry, companies, and institutions supplying solar, photovoltaic and photothermal energy equipment, will coordinate for the publication of results and benefits of the "Green Incentives" Program for MSMEs.
AL-4.3.2 Evaluate and disseminate the scope of the Program.
AL-4.3.3 Diffusion of benefits and procedures with the steps that each interested party must follow to apply to the Program of "Green Incentives" and in its case, the extension to residential units in agreement to the Strategy of Efficiency and Energy Transition of the State of Puebla.
AL-4.3.4 Perform the execution of campaigns and trainings with information about the benefit of the adoption of technologies and practices of energy efficiency in the residential and commercial sectors.
AL-4.3.5 Will extend the Catalogue of Suppliers of the Energy Sector in Puebla (CAPROSEP in Spanish) through the diffusion and promotion of its registry to supplier companies of photovoltaic and photothermal solar energy in the State of Puebla. Disseminate this catalogue so that the population has access to dependable, opportune, and easy consultation information.
AL-4.3.6 Disseminate public policy instruments associated to the promotion of renewable energy such as the Fund for Energy Transition and Sustainable Use of Energy (FOTEASE in Spanish) for projects or programs that diversify and enrich the options for the fulfilment of the goals in terms of clean energy and energy efficiency.

Strategy 5. Strengthening air quality management

Measure 5.1. Redesign PVMZ air quality monitoring.
AL-5.1.1 The State Environmental Authority, with the participation of CAMe, SEMARNAT, INECC and academia, will conduct characterization studies of atmospheric monitoring stations.
AL-5.1.2 Conduct studies to identify pollution-sensitive areas and install equipment in them.
AL-5.1.3 Conduct studies to install air quality monitoring stations in other cities in the State.
AL-5.1.4 Will extend the air quality monitoring system in the State of Puebla.
AL-5.1.5 will evaluate the relevance to develop a monitoring system with low-cost measurement systems for microenvironment and personal exposure studies.
AL-5.1.6 Will promote studies to document the impact of atmospheric pollution, especially ozone, in rural areas and protected natural areas.
AL-1.5.7 Advocate with SEMARNAT to update NOM 156.
AL-5.1.8 Establish a system to disseminate the information generated on air quality.

Measure 5.2. Keep updated the State Emissions Inventory of Pollutants, and GHG and its Compounds.
AL-5.2.1 The State Environmental Authority, with the participation of CAMe, SEMARNAT and INECC, will identify local authority studies and actions to improve the estimates made in the most emitting categories.
AL-5.2.2 Coordinate with municipal governments to generate information from them and improve the estimation of emissions at the municipal level.
AL-5.2.3 Agree on studies or actions to be conducted to improve the data sources that feed the development of emission inventories and the sources of financing.
AL-5.2.4 Update the emission inventories for the years 2024, 2026, 2028 and 2030.
AL-5.2.5 With the development of new inventories, perform a recalculation of previously developed emission inventories from the base year.
AL-5.2.6 Allocate more resources to the area in charge of developing emission inventories.

Measure 5.3. Development of an Atmospheric Environmental Contingency Program of the PVMZ.
AL-5.3.1 The State Environmental Authority with the participation of CAMe, SEMARNAT, INECC and the National Institute of Public Health will form a working group and establish a schedule.
AL-5.3.2 Establish activation levels for ozone, PM2.5 and PM10 contingencies in accordance with CAMe.
AL-5.3.3 Update the actions to be applied by each of the actors included in the program, as well as the corresponding start and end times.
AL-5.3.4 Publish the Atmospheric Environmental Contingency Program for the PVMZ in the official gazette or equivalent.

Strategy 6. Biodiversity adaptation

Measure 6.1. Increase in the network of territorial conservation instruments establishing NPA or ADVC.
AL-6.1.1 CONANP, with the participation of the State Environmental Authority, will prioritize sites to promote the establishment of NPAs and ADVC.
AL-6.1.2 Establish contact with stakeholders in the prioritized territories.
AL-6.1.3 Define the potential of each territory with respect to relevant stakeholders.
AL-6.1.4 Realize workshops with stakeholders to define management plans.
LA-6.1.5 Priorities will be reselected with respect to sites with little potential for socioeconomic reasons.

Measure 6.2. Establishment of UMA.
AL-6.2.1 The State Environmental Authority, with the participation of Puebla's Secretariat for Rural Development, CONANP, SEMARNAT, municipal and agrarian authorities, will prioritize species and/or sites to promote the establishment of Environmental Management Units (UMA in Spanish).
AL-6.2.2 Establish contact with the interested actors.
AL-6.2.3 Realize together with stakeholders, workshops to identify needs and feasibility.
AL-6.2.4 Will prepare a management plan for the UMAs.

Measure 6.3. Implementation of species reintroduction programs.
AL-6.3.1 The State Environmental Authority with the participation of Puebla's Secretariat for Rural Development, CONANP, SEMARNAT, municipal and agrarian authorities, select priority species for reintroduction according to their exposure to climate change.
AL-6.3.2 Identify impacted sites, mainly near or within ANP, ADVC and/or UMA.
LA-6.3.3 Together with allies, they will promote reintroduction programs for key species, preferably through participatory restoration, tracking and monitoring processes.

Measure 6.4. Establishment of species assisted migration programs (reduction of species exposure to climate change).
AL-6.4.1 The State Environmental Authority with the participation of Puebla's Secretariat for Rural Development, CONANP, SEMARNAT, PROFEPA, will identify the prioritized species with greater exposure to climate change.
AL-6.4.2 Identify sites with homologous climates to the current ones, preferably in sites within or near ANP, ADVC and UMA.
AL-6.4.3 Encourage the establishment of nurseries and hatcheries in localities close to reintroduction sites.
AL-6.4.4 Establish community breeding-reintroduction and monitoring programs.
AL-6.4.5 Provide technical support to implement an assisted migration program.
LA-6.4.6 They will provide technical support to establish monitoring programs for production, breeding, reintroduction and assisted migration programs.

Measure 6.5. Decrease in extraction and land use change by agave monocultures.
AL-6.5.1 Puebla's Secretariat for Rural Development with the participation of the State Environmental Authority, the Secretary of Economy of Puebla, SEMARNAT, CONAFOR, PROFEPA, CONANP, SADER, will contribute to define good practices in the cultivation and extraction of agave mezcalero.
AL-6.5.2 Support the elaboration of good practice guides.
AL-6.5.3 Identify artisanal producers.
AL-6.5.4 Distribute guides among artisanal producers.
AL-6.5.5 Conduct workshops on good practices among producers and event promoters.
AL-6.5.6 Promote that the organizers of mezcal fairs highlight the participation of producers whose product is sustainable throughout the production chain.
AL-6.5.7 Monitor compliance with current regulations regarding changes in land use.

Measure 6.6. Sustainable productive diversification through identification of new markets for species and/or products.
AL-6.6.1 Puebla's Secretariat for Rural Development with the participation of the State Environmental Authority, Secretariat of Economy of Puebla, SEMARNAT, PROFEPA, CONAFOR, SADER, will conduct an analysis of the potential of key elements for the creation of new sustainable markets.
AL-6.6.2 Will define support to producers willing to participate in new markets.
AL-6.6.3 Apply a support program based on potentiality.
AL-6.6.4 Support fairs and events to foster fair and sustainable trade.

Measure 6.7. Management, control, and eradication of invasive alien species.
AL-6.7.1 The State Environmental Authority, with the participation of CONABIO, CONANP, shall conduct a study on the impacts of invasive alien species in the state and measures for their management, control, or eradication.
AL-6.7.2 Identify the sites with the greatest impact and the species involved.
AL-6.7.3 Prioritize sites for action.
AL-6.7.4 Support the development of specific management, control and eradication programs by species and site.

Measure 6.8. Increase recognition of the importance of conserving sustainable ecosystems and landscapes.
AL-6.8.1 Puebla's Secretariat for Rural Development with the participation of the State Environmental Authority, Secretary of Economy of Puebla, SADER, will identify good beekeeping and meliponiculture practices.
AL-6.8.2 Identify individuals and societies with experience in good practices related to beekeeping and meliponiculture.
AL-6.8.3 Determine support and procedures for producers that apply good practices.
AL-6.8.4 Encourage fairs and exchange of experiences to promote interest in different sectors (e.g., livestock).
AL-6.8.5 Register producers who will receive support.
AL-6.8.6 Implement a program to support the beekeeping-meliponicole sector.

Strategy 7. Forest Adaptation

Measure 7.1. Implementation of a State Strategy for Agroforestry Production.
AL-7.1.1 PUEBLA'S SECRETARIAT FOR RURAL DEVELOPMENT with the participation of the Welfare Secretariat, SEMARNAT, SADER, Forest Development Promoter in Puebla, INIFAP, the State Environmental Authority, Secretariat of "Bienestar" of Puebla (SBP), will strengthen the State Agroforestry Production Strategy that considers current regional socio-environmental conditions and under climate change scenarios and that favors sustainable production and consumption practices and the conservation of natural resources.

AL-7.1.2 Will conduct a feasibility and viability study of the Strategy to ensure the profitability of the products, and the social acceptance of the Strategy.
AL-7.1.3 Implement and promote the State Agroforestry Production Strategy throughout the State.
AL-7.1.4 Develop and implement a monitoring and evaluation system for the State Agroforestry Production Strategy.

MEASURE 7.2. Establishment of gene banks of forest and non-forest species.
AL-7.2.1 The State Environmental Authority, with the participation of CONAFOR, INIFAP and local communities, shall prepare the studies required by the competent authority to obtain the corresponding authorization and permits.
AL-7.2.2 Evaluate the relevance of building and equipping a plant germplasm bank that houses important, at-risk, endemic, native, threatened, rare and endangered seeds.
AL-7.2.3 Evaluate the relevance of providing the plant gene bank with permanent human and monetary resources.
AL-7.2.4 Evaluate the relevance the collection and maintenance of the state's plant genetic material.

Measure 7.3. Increase in forest area under Payment for Environmental Services (PES) schemes.
AL-7.3.1 The State Environmental Authority with CONAFOR and companies and associations in the state of Puebla shall identify entities that promote ecosystem conservation through PES.
AL-7.3.2 Identify potential candidates to receive support through PES schemes.
AL-7.3.3 Provide technical and financial support to potential candidates in the preparation of applications, by channeling them to certified technicians so that they can jointly prepare the application.
AL-7.3.4 Provide technical support during the time the PES support is received.

Measure 7.4. Urban greening.
AL-7.4.1 The State Environmental Authority, with the participation of the Infrastructure Secretariat of the State of Puebla, Municipal Institute of Planning, municipal authorities, urban population, Civil Society Organizations, will make a diagnosis of the norms, programs, projects at federal, state and municipal levels that support or can support the implementation of green infrastructure actions as mitigation and adaptation measures to climate change, and sustainable urban development.
AL-7.4.2 Will implement the chosen actions with the support of experts.
AL-7.4.3 Establish a participatory monitoring and evaluation system to measure the effectiveness and permanence of the implemented green infrastructure.

Measure 7.5. Urban Forests.
AL-7.5.1 The State Environmental Authority with the participation of CONAFOR, Municipal Authorities, Municipal Planning Institutes, will conduct an inventory of green areas and their trees in the urban localities of the State of Puebla to update the green areas/inhabitant's indicator.
AL-7.5.2 Prepare a diagnosis to identify potential sites for reforestation, restoration or afforestation of urban forests.
AL-7.5.3 Design and implement a regional strategy for reforestation, restoration, and urban afforestation with a focus on the management and expansion of urban forests, as a strategy to mitigate the negative effects of climate change, and favor equality and equity of the population.
AL-7.5.4 Design and implement an awareness campaign on the importance of urban forests for the population's health and ecosystem conservation.
AL-7.5.5 Establish a maintenance and monitoring program for urban forests as educational, recreational and biodiversity conservation spaces.

Measure 7.6. Restoration and reforestation of ecosystems vulnerable to climate change.
AL-7.6.1 The State Environmental Authority with the participation of municipal authorities, CONAFOR, CONANP, will conduct a socio-environmental study to identify potential sites for the restoration of forest ecosystems vulnerable to climate change, considering the capacity for carbon fixation and rainwater infiltration, as well as socio-environmental benefits for the population.
AL-7.6.2 Generate and implement a regional strategy for restoration and revegetation that considers local communities and native peoples with a gender perspective and substantive equality.
AL-7.6.3 Acquire native species, relevant to the forestry sector and resistant to climate change.
AL-7.6.4 Prepare selected sites for restoration and reforestation actions.
AL-7.6.5 Conduct inclusive and gender-focused reforestation activities to strengthen carbon sinks and aquifer recharge.
AL-7.6.6 Establish a permanent program of maintenance and monitoring of the health and state of the vegetation of the intervened areas.

Strategy 8. Agricultural Adaptation

Measure 8.1. Study on the suitability of different important crops in the State of Puebla in the face of the risks of the impacts of climate change.
AL-8.1.1 The Puebla's Secretariat for Rural Development with the participation of the State Environmental Authority, SADER, INAES, will prioritize the agricultural products to be studied (either by cultural, productive, or profitable relevance).
AL-8.1.2 Generate suitability maps by crops with current and future climate conditions to know the change in their distribution in the State's agricultural soils.
AL-8.1.3 Conduct studies on forms of agricultural production (traditional, regenerative, agroforestry, agroecological) to determine which are the forms that better comply with sustainability, the environment and suitability for crops.
AL-8.1.4 Prepare a study on value chains of selected products to find solutions and strengthen them by identifying the actors.

Measure 8.2. Strengthening insurance coverage against extreme weather events for the agricultural sector.
AL-8.2.1 The Puebla's Secretariat for Rural Development with the participation of the SADER, Agroasemex, Ministry of Finance and Public Credit}, will realize alliances with sections of the federal government in the construction of insurance and financing to the field (FIRA) in Spanish.
AL-8.2.2 Establish alliances with agricultural and rural insurance funds, which are civil associations of producers that with their own resources provide agricultural insurance services.
AL-8.2.3 Realize alliances with private insurance companies with experience in insurance construction.
AL-8.2.4 Establish alliances with international organizations such as the United Nations Development Program (UNDP) with experience in the construction of pilot climate insurance programs.

Measure 8.3. Expand State coverage of Ecological Land Management Programs and Territorial Planning and Urban Development Plans.
AL-8.3.1 The state environmental authority with the participation of the municipal governments of Puebla, SEMARNAT, SEDATU, will coordinate the establishment of bases for the joint development of the territorial and environmental planning processes that make compatible and complement the formulation and the provisions of the regulations on ecological, territorial and urban development matters.
AL-8.3.2 Elaborate and/or update the State's Ecological Land Management Program (PEOT in Spanish).
AL-8.3.3 To elaborate and/or update the Plan of Territorial Ordering and Urban Development (POTyDU) of the State.
AL-8.3.4 They will technically support to elaborate the Program of Ecological Ordering of the Local Territory (POETL) in the municipalities that lack it.
AL-8.3.5 They will technically support to update the POETL in the municipalities that have it.
AL-8.3.6 They will technically support to elaborate the Territorial Ordering and Urban Development Plans in the municipalities that lack it.
AL-8.3.7 They will technically support to update the Territorial Ordering and Urban Development Plans in the municipalities that have them.
AL-8.3.8 Establish enforcement measures through environmental impact assessment.

Measure 8.4. State soil strategy for sustainable agriculture in the face of the risks of climate change impacts.

AL-8.4.1 The SDR with the participation of the State Environmental Authority, SADER, INIFAP, will develop strategies for the sustainable use of the soil through an agroeco-

logical approach that contributes to conserving biodiversity, health, soil functions and its productivity.
AL-8.4.2 Will design technical assistance programs with the participation of farmers, technicians, and the private sector, for sustainable soil management that includes sustainable production and conservation plans at the micro-basin, sub-basin, or basin level.
AL-8.4.3 Implement technical support programs with the participation of farmers, technicians, and the private sector, for sustainable soil management that includes sustainable production and conservation plans at the micro-basin, sub-basin, or basin level.
AL-8.4.4 Establish incentive programs to guarantee the sustainable management of agricultural soils within the framework of climatic and socio-ecological conditions at regional level.
AL-8.4.5 Reduce the excessive use of fertilizers through the establishment of regional programs with optimal dosage recommendations and the use of synchronized split applications based on the nutritional requirements of crops (time) and adequate application techniques (place).
AL-8.4.6 Promote the Implementation reduced tillage systems according to the use capacity or soil unit and encourage practices for the retention and reincorporation of plant residues to the soil that increase the organic matter content and contribute to the reduction of agricultural burns, including the green harvesting of sugarcane.
AL-8.4.7 Conserve or increase the soil's capacity to capture, infiltrate and store water through practices and technologies appropriate for each socio-ecological context, such as polyculture, conservation irrigation, retention of harvest residues, cover crops, adaptation of planting dates, crop rotation, terraces, blind pits, among others.
AL-8.4.8 Facilitate technical accompaniment for the rehabilitation of degraded soils based on local experiences, the programs of the Secretariat and projects developed in collaboration with academia and national and international organizations.
AL-8.4.9 Coordinate the participation of academics, producers, and technicians in the compilation of information and development of materials that integrate practices and techniques for the sustainable management of soils and the restoration of degraded soils available at local level, for their dissemination among farmers.
AL-8.4.10 Establish and implement indicators for regional monitoring of sustainable soil management practices and integrated restoration of degraded soils, with the participation of diverse stakeholders, for the annual follow-up of results during minimum periods of 5 to 10 years.

Strategy 9. Water Adaptation

Measure 9.1. Sustainable water management in agriculture.
AL-9.1.1 The Puebla's Secretariat for Rural Development with the participation of CONAGUA, IMTA, CECADESU-SEMARNAT, the State Environmental Authority, Watershed Advisory Councils, will design the strategy that considers rainwater harvesting and use systems in agricultural practices that cover the soil with stubble to conserve moisture for a longer time, the installation of more efficient irrigation systems, filters to recharge aquifers, the use of "fog trapping" devices to condense vapor and store water, and the maintenance of dam systems.
AL-9.1.2 Realize a campaign to disseminate the sustainable water management strategy in agriculture.

Measure 9.2. High efficiency irrigation systems.
AL-9.2.1 The Puebla's Secretariat for Rural Development with the participation of the State Environmental Authority, Municipal Authorities, IMTA, CONAGUA, Basin Advisory Councils, will promote a feasibility analysis on irrigation systems in the Puebla regions.
AL.9.2.2 They will carry out a feasibility analysis on irrigation systems in the regions of Puebla.
AL-9.2.3 Identify sites, crops, and beneficiary producers to implement the strategy.
AL-9.2.4 Provide technical assistance to the benefited producers on the use and maintenance of the irrigation system.
AL-9.2.5 Implement the high efficiency risk systems strategy.
AL-9.2.6 Will conduct a monitoring in the implementation sites on the reduction of water use.

Measure 9.3. Reactivation and operational optimization of wastewater treatment plants (increase in the treated volume of wastewater).
AL-9.3.1 The State Water Commission with the participation of the Operator System for clean water services and drainage of Puebla (SOAPAP in Spanish), the State Environmental Authority, CONAGUA, IMTA, The Puebla's Secretariat for Rural Development, municipal authorities, Basin Advisory Councils, will update the inventory and diagnosis of the State's municipal wastewater treatment plants (WWTP), in order to determine their actual treatment capacity, as well as to identify potential sites for installing new WWTP and alternative wastewater treatment systems.
AL-9.3.2 Based on the results of the diagnosis and a cost-effectiveness study, support the rehabilitation of the treatment plants that require it.
AL-9.3.3 Support the construction of new WWTP in the sites identified in the diagnosis.
AL-9.3.4 Promote the installation of alternative wastewater treatment systems in rural areas.
AL-9.3.5 Impulse at a regulatory level, the installation-inclusion of biogas capture and use systems in new WWTPs.
AL-9.3.6 Impulse the installation-inclusion of systems for the capture and use of biogas generated in WWTPs.

Measure 9.4. Natural and induced aquifer recharge.
AL-9.4.1 The State Water and Sanitation Commission, with the participation of the State Environmental Authority, municipal authorities, IMTA, CONAGUA, Basin Advisory Councils, will select implementation sites for managed aquifer recharge (MAR), prioritizing those aquifers that already present overexploitation and water stress.
AL-9.4.2 Select the most appropriate artificial recharge technique.
AL-9.4.3 Promote to elaborate an executive project for each selected site where the artificial recharge of the aquifer will be conducted.
AL-9.4.4 Implement the artificial recharge of aquifers in the selected sites.
AL-9.4.5 Monitor the piezometric level of the intervened sites, as well as the quality of the water used for the artificial recharge of the aquifer (NOM-014-CONAGUA-2003) and the water extracted from the wells near the intervened zone to ensure that the aquifer is not being contaminated (NOM-003-CNA-1996).

Measure 9.5. Rainwater collection and storage systems (SCALL in Spanish).
AL-9.5.1 The State Environmental Authority, with the participation of the Welfare Secretariat, RD, municipal authorities, IMTA, CONAGUA, and operating agencies, shall develop a statewide strategy for the implementation of SCALL at the household, school, and work center levels, with emphasis on urban areas with high water demand and rural areas with high marginalization.
AL-9.5.2 Conduct a financial, social, and environmental feasibility analysis of the designed strategy.
AL-9.5.3 Promote rainwater harvesting in rural areas, with the support of local authorities and civil society organizations, as a measure to protect human health and the environment.
AL-9.5.4 Encourage, through current construction regulations, that homes, schools, and workplaces in urban areas install SCALL for human use.
AL-9.5.5 Develop and build SCALL in accordance with national guidelines and regulations in force.
AL-9.5.6 Provide technical advice and training for the adequate use and maintenance of the systems.
AL-9.5.7 Annually monitor the installed SCALL.

Measure 9.6. Separate drainage and permeable pavement in urban location.
AL-9.6.1 Secretariat of Infrastructure of the State of Puebla, with the participation of the State Water and Sanitation Commission, Drinking Water and Sewerage Operating Agencies, and municipal authorities, will analyze and identify the applicable legal framework and propose mechanisms to align policies for the construction of new sustainable water infrastructure.
AL-9.6.2 Perform a diagnosis of the sewerage systems in the cities and municipalities of the State of Puebla, from a climate change and vulnerability approach.

AL-9.6.3 Will design and publish a statewide strategy for the construction of separating drains and installation of permeable pavement in urban localities.
AL-9.6.4 Will elaborate a financial, social, and environmental feasibility analysis of the designed strategy and the potential sites to intervene.
AL-9.6.5 Train the personnel of the Infrastructure Secretariat of the State of Puebla, and municipal counterparts, on the use and correct placement of permeable pavement.
AL-9.6.6 Will train the personnel of the State Commission of Water and Sanitation of the State of Puebla and municipal Operative Organisms on the care and maintenance of the pluvial drainage.
AL-9.6.7 Establish alliances with CONAGUA, SCT and SEDATU to promote the construction of sustainable and resilient urban infrastructure.
AL-9.6.8 Construct separate drainage and sewerage systems in selected cities.
AL-9.6.9 Re-carpet and place permeable pavement in areas with high infiltration potential within urban localities.

Measure 9.7. Payment for water environmental services.
AL-9.7.1 The State Environmental Authority with the participation of CONAFOR and Puebla's Secretariat for Rural Development, will identify entities that promote the conservation of ecosystems through the Payment for Environmental Services.
AL-9.7.2 Identify potential candidates to receive support from PES schemes.
AL-9.7.3 Support potential candidates in the elaboration of applications.
AL-9.7.4 Provide technical accompaniment during the time PES support is received.

Measure 9.8. Improvement of agronomic management practices.
AL-9.8.1 The Puebla's Secretariat for Rural Development with the participation of the State Environmental Authority, municipal authorities, INIFAP, CONCYTEP, State Committee of Plant Health, will conduct a diagnosis on volumes and types of agricultural inputs used for fertilization, management and control of plagues and weeds in the agricultural zones of the State.
AL-9.8.2 Identify alternative management schemes to reduce the quantity and/or environmental impact of applied inputs, achieving similar or better control of the respective pests.
AL-9.8.3 Identify sites and producers to participate based on the diagnosis and identified alternative management schemes.
AL-9.8.4 Provide technical advice to producers on alternative management schemes.
AL-9.8.5 Monitor and systematize information obtained from producers and sites where management changes are implemented.
AL-9.8.6 Publish systematized information in the pages of the Government of Puebla.

Strategy 10. OCSA Measures

Measure 10.1. Amphibian Conservation Plan.
AL-10.1.1 The State Environmental Authority with the collaboration of SEMARNAT, will prioritize species according to their population status, habitats, behavior, and vulnerability to climate change.
AL-10.1.2 Identify relevant perennial and seasonal aquatic habitats.
AL-10.1.3 Reduce the use of pesticides in areas with influence on relevant aquatic habitats.
AL-10.1.4 Encourage the establish a UMA for captive breeding of priority species in conjunction with communities and stakeholders.
AL-10.1.5 Identify candidate sites for reintroduction or translocation of species, considering exposure to climate change.
AL-10.1.6 Reintroduce and/or translocate individuals to identified sites.
AL-10.1.7 Monitor reintroduced or translocated populations under an adaptive management approach.
AL-10.1.8 Control and eradicate invasive species in relevant habitats and candidate sites for reintroduction or translocation.

Measure 10.2. Orchid Conservation Plan.
AL-10.2.1 The Puebla's Secretariat for Rural Development with the participation of the State Environmental Authority, SEMARNAT, PROFEPA, will conduct a prioritization of orchids according to their population status, life histories and vulnerability to climate change.
AL-10.2.2 Support the establishment of a UMA for the in vitro reproduction of orchids in conjunction with communities and stakeholders.
AL-10.2.3 Identify candidate sites for reintroduction or translocation of species, considering exposure to climate change and presence of pollinators.
AL-10.2.4 Reintroduce and/or translocate individuals to identified sites.
AL-10.2.5 Monitor reintroduced or translocated populations.
AL-10.2.6 Identify major illegal harvest and trade sites.
AL-10.2.7 Strengthen inspection and surveillance to combat illegal harvesting.

Measure 10.3. Habitat management for bee fauna.
AL-10.3.1 The Puebla's Secretariat for Rural Development with the support of the State Environmental Authority, SADER, CONABIO, municipal governments, will identify a palette of plant species as floral resources, considering phenology and climatic suitability under climate change projections.
AL-10.3.2 Identify specific soil conservation practices to allow nesting.
AL-10.3.3 Identify potential sites for the establishment of melliferous plant communities in urban, peri-urban, and rural contexts, both agricultural and unmanaged.
AL-10.3.4 Identify suitable vegetation arrangements for different contexts.
AL-10.3.5 Support the design of an environmental education program on bees, pollination, and their relationship with climate change.
AL-10.3.6 Broadcast the implementation of the habitat management strategy to increase the diversity of bees and other pollinators.
AL-10.3.7 Generate baseline information on bee populations at implementation sites.
AL-10.3.8 Conduct monitoring of bee populations at implementation sites.

Measure 10.4. Bat Protection Plan.
AL-10.4.1 The Puebla's Secretariat for Rural Development with the collaboration of the State Environmental Authority, SEMARNAT, SADER, CONABIO, will identify caves and other relevant bat roosting sites in the State.
AL-10.4.2 Promote the protection of caves and other relevant roosting sites in the State.
AL-10.4.3 Encourage productive practices of agaves and their derived products that are friendly to bats.
AL-10.4.4 Support producers to identify and obtain certifications of bat-friendly processes.
AL-10.4.5 Manage the implementation of an environmental education program on bats and the ecosystem services they provide.

Measure 10.5. Protection of cacti and bushes.
AL-10.5.1 The Puebla's Secretariat for Rural Development with the collaboration of the State Environmental Authority, SEMARNAT, SADER, PROFEPA, will encourage a cattle stabling program.
AL-10.5.2 Strengthen inspection and surveillance to combat illegal extraction and exploitation.
AL-10.5.3 Identify species of cactaceae with high economic value in the national and international market.
AL-10.5.4 Promote the establishment of UMA for the propagation of identified species in conjunction with communities and stakeholders.
AL-10.5.5 Provide support to producers for the commercialization of identified species in the national and international markets.

Strategy 11. Environmental health

Measure 11.1. Updating and implementation of the Epidemiological Surveillance Program.
AL-11.1.1 The State Environmental Authority with the participation of the Directorate of Protection against Sanitary Risks (DPRIS in Spanish) of the Puebla Ministry of Health,

federal agencies, and academic institutions, will coordinate the signing of a collaboration agreement between the State Environmental Authority and the DPRIS of the Ministry of Health.
AL-11.1.2 Shall form a committee of experts in air pollutants and health effects.
AL-11.1.3 Determine the daily morbidity and mortality of acute and chronic effect indicators in the general population and vulnerable groups in the PVMZ and share this information with the State Environmental Authority.
AL-11.1.4 Establish a program that generates continuous and systematic information on specific damages to the health of the population related to exposure to atmospheric pollutants.

Measure 11.2. Daily generation of epidemiological information on selected conditions from sentinel health centers.
AL-11.2.1 The Secretariat of Health of the State of Puebla, with the participation of the Federal Secretariat of Health, ISSSTE, Social Security, private health institutions and the State Environmental Authority, will select the sentinel health centers.
AL-11.2.2 Train personnel at sentinel health centers to adequately record, daily, conditions related to exposure to atmospheric pollutants.
AL-11.2.3 Share with the State Environmental Authority information on cases of illnesses related to chronic and acute exposure to air pollutants.
AL-11.2.4 Generate air quality indicator values for pollutants measured in the air quality monitoring network.
AL-11.2.5 Develop time series graphs with daily air quality indicators and the number of cases of both acute and chronic exposure.

Measure 11.3. Economic evaluation of the health impacts of morbidity and mortality cases.
AL-11.3.1 The State Environmental Authority, with the participation of the Secretary of Health of the State of Puebla and research institutes, will select the pollutants and health conditions to be evaluated.
AL-11.3.2 Select exposure response functions that quantitatively relate contaminant concentrations to the increase in morbidity and mortality.
AL-11.3.3 Evaluate the exposure of the population based on air quality data recorded in the monitoring network of the PVMZ.
AL-11.3.4 Characterize cases of mortality and morbidity attributable to air pollution.
AL-11.3.5 Monetize cases of mortality and morbidity attributable to air pollution.

Measure 11.4. Promotion of epidemiological studies.
AL-11.4.1 The DPRIS, with the participation of the State Environmental Authority, universities, and research centers, will promote funding to the academic and research sectors for the development of epidemiological studies that quantitatively relate changes in the exposure of the susceptible population with changes in morbidity and mortality indicators in the state.
AL-11.4.2 Support the publication of epidemiological studies in scientific journals to ensure their quality.

Measure 11.5. Improving indoor conditions to reduce the incidence of American trypanosomiasis and dengue.
AL-11.5.1 Municipal governments, with the participation of the State Welfare Secretariat and the State Health Secretariat, shall support the installation of mosquito nets in doors and windows.
AL-11.5.2 Replacement of dirt floors with concrete floors.
AL-11.5.3 Plastering of walls and ceilings.
AL-11.5.4 Painting walls and ceilings white.

Measure 11.6. Improving peri domiciliary conditions to reduce the incidence of American trypanosomiasis and dengue.
AL-11.6.1 Municipal governments, with the participation of the State Welfare Secretariat and the State Health Secretariat, shall support the cleanup of material accumulations.
AL-11.6.2 pruning of vegetation adjacent to the domicile.
AL-11.6.3 Elimination and/or capping of containers that accumulate water.
AL-11.6.4 Construction of corrals to restrict the movement of domestic fowl.
AL-11.6.5 Restriction of free-range mobility.
AL-11.6.6 Control of feral dog populations.

Measure 11.7. Reduction of the incidence of American trypanosomiasis and dengue.
AL-11.7.1 The State Environmental Authority, with the participation of municipal governments, the State Welfare Secretariat, and the State Health Secretariat, will elaborate a methodological development of models for early detection.
AL-11.7.2 Determine their technical and financial feasibility.
AL-11.7.3 Implement the implementation of the early warning system.

Strategy 12. Capacity Building

Measure 12.1. Strengthening capacities, knowledge, and ownership of PROAIRE-PEACC actions.
AL-12.1.1 The State Environmental Authority with the participation of the Coordination of Social Communication of the state of Puebla, PROAIRE-PEACC Core Committee, Civil Society Organizations, municipal authorities, will map and characterize the key actors of different sectors that can be potential beneficiaries, involved in the dialogue tables and the implementation of the strategies and measures of PROAIRE-PEACC.
AL-12.1.2 Identify the profile of each key actor to link it with their needs that can be addressed by the activities that integrate PROAIRE-PEACC.
AL-12.1.3 Promote a guiding document that will allow strategically directing the Program's activities towards the population sectors with greater aptitude and territories with feasibility.
AL-12.1.4 Develop a strategy to link capacity building workshops with mechanisms for ownership of results and concrete actions of PROAIRE-PEACC.
AL-12.1.5 Will follow up and evaluate the perception prior and after the implementation of dialogue roundtables and capacity building actions and workshops in the different sectors of the population that reflect the Program's ownership.
AL-12.1.6 Identify the needs in terms of capacity building, infrastructure, and technology of the different sectors to reduce the emission of GHG and other pollutants.
AL-12.1.7 Collaboratively define the next steps to address identified needs.
AL-12.1.8 support the participatory elaboration and application of a protocol or guide of minimum requirements to ensure the inclusion of women and vulnerable people (intersectionality) in all actions, workshops, dialogue tables and strategies implemented from PROAIRE-PEACC.

Measure 12.2. Design and implementation of an environmental awareness strategy.
AL-12.2.1 The State Environmental Authority, with the participation of the SEP of the state of Puebla, experts in pedagogy, CSOs specialized in environmental education, and academics, will design awareness campaigns aimed at the public for sustainable water management in the context of climate change.
AL-12.2.2 Support the implementation of awareness campaigns on proper water management that promote the recognition of water resources as a vital element for food security, health, ecosystem protection, and biodiversity.
AL-12.2.3 Generate dissemination and communication materials on the importance and recommendations for sustainable agricultural production in the local context and climate change.
AL-12.2.4 Will facilitate spaces for dialogue between producers that implement good agricultural production practices and conventional producers, for the exchange of experiences, knowledge and local techniques that contribute to mitigate and adapt to climate change.
AL-12.2.5 Support the design of a communication strategy aimed at all sectors of Puebla, on the potential impacts of climate change projected in the territory and the actions proposed in the PEACC for mitigation and adaptation to climate change.
AL-12.2.6 Support the implementation of the communication and dissemination strategy through different media (SPOT on radio, social networks, posters, among others), to inform and raise awareness among the people of the territory about the impacts of climate change and the relevance of co-responsibility for the implementation of the actions proposed in the PEACC.
AL-12.2.7 Support the implementation of outreach campaigns with society on the effects of poor air quality and the actions proposed in the PROAIRE to contribute to the improvement of the air quality index.

AL-12.2.8 Will support the printing of materials resulting from the communication strategy and the implementation of training for schoolteachers on the use of the materials.

Measure 12.3. Promoting education on best practices and local solutions in the agricultural sector.
AL-12.3.1 The Secretary of Education of the State of Puebla with the participation of the Agricultural Technological High School, Puebla's Secretariat for Rural Development, INIFAP, SADER, SEMARNAT, and the State Environmental Authority will collaboratively identify priority lines of research for the improvement of practices and solutions in the agricultural sector.
AL-12.3.2 Establish and implement research schemes and strategies in collaboration with the agricultural technological high schools and decentralized technological universities.
AL-12.3.3 Support the establishment of demonstration plots together with high schools and universities.
AL-12.3.4 Organize meetings and exchanges of experiences between male and female producers, where the venues are the sites with demonstration plots.
AL-12.3.5 Systematize and analyze the information gathered through these meetings.

Strategy 13. Communication and dissemination

Measure 13.1. Implementation of information and dissemination campaigns for the prevention of zoonoses.
AL-13.1.1 The State Environmental Authority with the participation of the municipal governments, State Welfare Secretariat and State Health Secretariat, will design a strategy for the implementation of the information campaign for the prevention of zoonosis for different media and target audiences.
AL-13.1.2 Create the contents of the information campaign for the prevention of zoonosis.
AL-13.1.3 Support the implementation of the information campaign for the prevention of zoonosis.
AL-13.1.4 Update campaign contents periodically.

Measure 13.2. Strengthening the communication on air quality, from a didactic and socialization approach.
AL-13.2.1 The State Environmental Authority, with the participation of municipal governments, the State Welfare Secretariat, and the State Health Secretariat, will collaboratively define with professionals and specialists the key messages about air quality and health effects.
AL-13.2.2 Generate visual and didactic tools that allow the understanding of key messages by different people in society.
AL-13.2.3 Create a virtual space in the REMA portal through which the population can link and exchange ideas for social participation in air quality issues.

Measure 13.3. Socialization of PROAIRE-PEACC through specific strategies that consider digital gaps, multiculturalism, and linguistic diversity, as well as factors that limit access to information.
AL-13.3.1 The State Environmental Authority, with the participation of state and municipal governments, ejido and communal commissioners, CSOs, primary, secondary, and high schools, universities, will map official platforms and social networks to disseminate the Program.
AL-13.3.2 Define in a collaborative manner the key and clear messages about the Program, as well as the methodology used for its socialization.
AL-13.3.3 Generate different dissemination materials that are adapted to different local contexts.
AL-13.3.4 Publish and update the dissemination materials generated.
AL-13.3.5 Will translate the Program (or executive summary thereof) into the different linguistic variants so that it may be consulted with the native peoples and communities of Puebla.
AL-13.3.6 Support the implementation of workshops and fairs to disseminate the Program in communities without Internet access.

Measure 13.4. Permanent campaign of culture and water saving.
AL-13.4.1 The State Environmental Authority with the collaboration of the communication area of the government of Puebla, will design the strategy of the water culture and saving campaign for different media and target audiences.
AL-13.4.2 Create content in accordance with the target audience.
AL-13.4.3 Will support the implementation of the water culture and saving campaign.
AL-13.4.4 Update the contents of the water culture and saving campaign every year.
AL-13.4.5 Update the campaign strategy.

Measure 13.5. Strengthening of communication campaigns to issue recommendations to reduce the risk in the population, through the air quality and health index.
AL-13.5.1 The State Environmental Authority with the collaboration of the Ministry of Health and the Coordination of Social Communication of the State of Puebla, will arrange the issuance of bulletins and spots with the media operating in the state.
AL-13.5.2 Elaborate bulletins with continuous and reliable air quality data from the air pollutant monitoring network.
AL-13.5.3 Permanently publish the air quality situation through the air quality and health index in accordance with the specifications of NOM-172-SEMARNAT-2019 and issue the corresponding recommendations to the susceptible population to reduce their risk of presenting health effects.

Strategy 14. Research

Measure 14.1. Strengthening the development of research and technological development projects.
AL-14.1.1 The State Environmental Authority with the collaboration of the Social Communication Coordination of the State of Puebla, ProAire-PEACC Core Committee, Civil Society Organizations, local universities, and research centers, CONCYTEP, INECC and CONANP, will continue with the policy of establishing collaboration agreements with research centers and higher education institutions to develop a joint research agenda related to climate change and air quality issues.
AL-14.1.2 Develop research related to the impacts of climate change on the Key Elements of the Territory.
AL-14.1.3 Conduct studies to reduce uncertainty in the preparation of inventories of C&GHG emissions, criteria pollutants, and toxic substances.
AL-14.1.4 Develop research on atmospheric chemistry for the Puebla region aimed at reducing O3 and PM2.5 concentrations.
AL-14.1.5 Support the elaboration of research projects that allow the development of an air quality forecasting and modeling system.
AL-14.1.6 Realize personal exposure studies in dwellings where biomass is burned.

Determination of targets and scenarios for the reduction of criteria pollutants, GHG and its compounds, and Short-Live Climate Pollutants for the period 2030, baseline 2020 in tons of CO_2 equivalent.

One of the main goals of ProAire-PEACC, is to improve the quality of the air that is breathed in the localities of the State; to do so, a series of measures were grouped into three strategies. It is estimated that by 2030, 29% of emissions of $PM_{2.5}$ and ozone precursors will be reduced, by 26% of NO_X, and 18% of VOCs. See Table 12.

TABLE 12. EMISSION REDUCTION

STRATEGIES	EMISSIONS (tons)											
	PM_{10}	$PM_{2.5}$	SO_2	CO	NO_X	COV	NH_3	CO_2	CH_4	N_2O	CN	CO_2eq
Strategy 1. Mobility and Sustainable Transport	589	485	151	38,464	9,873	4,221	81	882,717	97	21	129	890,920
Strategy 2. Industry, commerce, and services	5,994	4,466	2,142	5,379	4,381	6,747	5	366,749	288	58	303	390,120
Strategy 3. Reduction of emissions in the burning of biomass and waste	4,651	3,366	111	25,335	1,002	5,852	267	721.761	12,058	43	358	1,072,772
*Total reduction	11,234	8,317	2,404	67,768	15,256	16,820	353	1,971,227	12,443	122	790	2,351,812
	28%	30%	44%	24%	26%	20%	1%	11%	13%	9%	28%	11%

*The percentage reduction is with respect to total emissions of anthropogenic origin.

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COST-BENEFIT ANALYSIS OF SELECTED MEASURES

The measures for which the cost-benefit analysis was conducted are:

- Development of an electromobility program for the transport sector.
- Reduction of emissions from heavy cargo and passenger transport.
- Inclusive pedestrian city.
- Control of emissions for motorcycles.
- Reduction of emissions in the industrial sector.
- Reduction of emissions in the brick production sector.
- Reduction of emissions from domestic fuelwood consumption.
- Reduction of agricultural burning and implementation of good tillage practices.
- Best practices for fire management and fire prevention.
- Energy efficiency in government buildings.

These were selected considering that there is a measurable reduction goal and that the costs are tangible and quantifiable with relative ease.

NEGATIVE COST-BENEFIT MEASURES

For measures related to emission reductions by replacing passenger, cargo and motorcycle transport vehicles with electric vehicles and vehicles with updated emission control technologies (Euro VI and EPA 10 types), the cost-benefit analysis indicates that at the prices of $tCO_2$and adopted, the benefits do not cover the costs in the analyzed period.

It can be assumed that this result is a combination of the following factors:

- Unaffordable prices of vehicles.
- Excessive costs of charging centers for electric cargo and passenger transport vehicles.
- High maintenance costs per unit of the BRT transport.
- The number of units to replace in the planning horizon.

In the case of the measure for the reduction of emissions in the brick production sector, the benefits also do not cover the estimated costs, largely due to the number of units to be replaced.

For the replacement of public passenger transport in confined lanes (ROUTE), an additional exercise was conducted assuming the renovation of the current units by trol-

leybuses like those recently been put into operation in Mexico City.

Since these units have batteries that allow them to move without the need for catenary for up to 100 kilometers, it was assumed the replacement without the requirement to build the catenaries, the same investment in charging centers, the same cost of recharging and a 50% lower maintenance cost compared to electric buses. The result was also negative, although the cost-benefit ratio improved significantly.

Extraordinarily positive cost-benefit measures

The proposed measures for the reduction of emissions in the industrial sector, in the distribution and use of LP gas and in the reduction of agricultural flaring and implementation of good tillage practices, the benefits far outweigh the projected costs. However, it should be noted that the proposed actions consist of studies and dissemination campaigns whose cost is incurred only in the year of grubbing-up. On the other hand, it should be noted that these proposed actions assume that the conclusions and recommendations they reach will be implemented and will produce the reduction of tCO_2 emissions expected as a goal.

Positive cost-benefit measures

For measures to reduce pollutant emissions from the construction of bicycle paths, domestic consumption of firewood, best practices for fire management and fire prevention and reduction of emissions in government buildings, the proposed actions and goals are effective so that the cost-benefit ratio is positive, that is, the benefits considerably and reasonably exceed the costs incurred.

7. COMMUNICATION, FUNDING AND REPORTING

Communication

To meet the objective of PROAIRE-PEACC 2021-2030, it is important to promote the interest and participatory engagement of society. This will allow the collective implementation of the strategies defined to contribute to the care of the environment, the protection of the health and well-being of the population. In this sense, socialization activities were conducted throughout the elaboration of the Program, including meetings with the Core Working Group and dissemination and feedback workshops with society. The perceptions of the citizens who attended the workshops are highlighted, emphasizing those factors that trigger poor air quality and its consequences at the health and well-being level, as well as the effects of the loss of key elements in the face of climate change. Finally, a series of key lines of action are proposed to increase involvement in the execution of the Program.

Funding sources

There are several sources of financing that can favor the realization of the proposed measures, particularly those that involve the acquisition of goods or equipment for the protection of the atmosphere and climate change, such as:

- Banco Nacional de Obras y Servicios Públicos, S.N.C.
- Banobras-FAIS Program.
- National Infrastructure Fund (FONADIN).
- Sectoral Programs (Federal Program of Support for Mass Transport (Protram), Promagua, Proresol).
- Nacional Financiera, S.N.C.
- Global Environment Facility (GEF).

- Green Climate Fund (GCF).
- German Society for International Cooperation, GIZ.
- UK Partnering for Accelerated Climate Transitions (UK PACT).
- Green Recovery Challenge Fund
- Agence Française de Développement (AFD).
- Latin America and Caribbean Investment Facility – LACIF.
- French Global Environment Facility (FFEM).
- Spanish Agency for International Development Cooperation (AECID).

Monitoring, reporting and verification of actions

The monitoring of the Program is a relevant effort, which faces different challenges, such as the lack of information available from official sources, insufficient budgets for ever-increasing needs and attention to the structural causes of air pollution and the burning of fossil fuels or deforestation or degradation of soils and resources that serve as carbon sinks and help stabilize and reduce greenhouse gases in the atmosphere. In this way, it will seek to establish and maintain the generation of information that allows to account for the progress of the specific action lines, on the risks that could limit or prevent the development of PROAIRE-PEACC 2021-2030 in a timely manner, as well as on the general indicators that will account for the expected results and their impact on key areas derived from its implementation.

To this end, there is a logical framework exercise that made it possible to identify indicators, goals, and responsible actors.

Risks and mitigation strategies identified for the effective implementation of the Program.

Based on the logical framework, five priority risks were identified that could affect the implementation of the Program:

1) Lack of sufficient funding.
2) Poor coordination with the main key actors of public, private, and social order.
3) Poor leadership and governance.
4) Inefficient application and compliance with environmental regulations.
5) Inefficient monitoring and follow-up.

In order to mitigate the risks that could affect the effective and timely implementation of the program, State Environmental Authority will maintain periodic communication through the Sustainable Development Committee of the Government of the State of Puebla, Inter-secretarial Commission on Climate Change of the State of Puebla, as well as the involvement of key actors for the implementation of this program.

PROGRAM FOR AIR QUALITY MANAGEMENT AND ACTION ON CLIMATE CHANGE STATE OF PUEBLA

2021-2030

Secretaría de
Medio Ambiente,
Desarrollo Sustentable y
Ordenamiento Territorial
Gobierno de Puebla