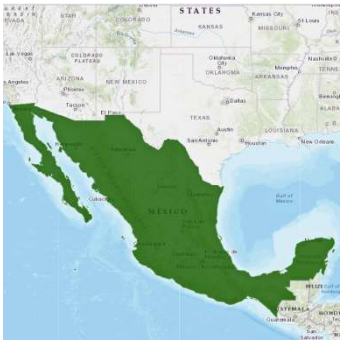
MEXICO



Source: esri

General

Mexico - officially the United Mexican States - is a federal republic in the southern part of North America. It is bordered in the North by the United States, in the South and West by the Pacific Ocean, in the Southeast by Guatemala, Belize and the Caribbean Sea, and in the East by the Gulf of Mexico. Mexico has an area of 197 Mha (million hectares), with in 2022 a population of 128 million, or 0.65 persons per ha (Wikipedia and United Nations, 2022).

Climate and geography

The Tropic of Cancer effectively divides the country into temperate and tropical zones. Land north of the 24th parallel experiences cooler temperatures during the winter months. South of the 24th parallel, temperatures are fairly constant year round and vary solely as a function of elevation. This gives Mexico one of the world's most diverse weather systems. Areas south of the 24th parallel with elevations up to 1,000 m (the southern parts of both coastal plains as well as the Yucatán Peninsula), have an annual median temperature between 24 to 28 °C. Temperatures remain high throughout the year, with only a 5 °C difference between winter and summer median temperatures. Both Mexican coasts, except for the south coast of the Bay of Campeche and northern Baja, are also vulnerable to serious hurricanes during summer and fall. Although low-lying areas north of the 24th parallel are hot and humid during summer, they generally have lower annual temperature averages (from 20 to 24 °C) because of more moderate conditions during the winter. Many parts of Mexico, particularly the North, have a dry climate with sporadic rainfall while parts of the tropical lowlands in the South average more than 2,000 mm of annual precipitation (source: Wikipedia).

Mexico is crossed from North to South by two mountain ranges, which are the extension of the Rocky Mountains from northern North America. From East to West at the centre, the country is crossed by the Trans-Mexican Volcanic Belt also known as the Sierra Nevada. A fourth mountain range, the Sierra Madre del Sur, runs from Michoacán to Oaxaca. As such, the majority of the Mexican central and northern territories are located at high altitudes. Three major urban agglomerations are located in the valleys between these four elevations: Toluca, Greater Mexico City and Puebla (source: Wikipedia).

Alcocer and Escobar (1990) and Alcocer and Williams (1996) describe that the Mexico Valley originally almost totally existed (80%, approximately 7,868 km^2) of ancient Lake Texcoco. This lake was created by the enclosure of a depression by volcanic mountain building. Later, it split into the smaller freshwater Lake Xochimilco in the South, and the larger saline Lake Texcoco in the North. When the Aztecs arrived in 1245, a complex of four interconnected water-bodies was present in the Valley: Zumpango, Xaltocan, Texcoco and Xochimilco. Through endiking, Xaltocan was separated into Xaltocan and San Cristobal lakes, Texcoco into Texcoco and Mexico lakes, and Xochimilco into Xochimilco and Chalco lakes. (Figure 1). The Aztecs built the city of Tenochtitlan on an island in Lake Texcoco. Climatic change, drainage and the growth of Mexico City has led to the now almost complete demise of this once huge lake complex. There remain just sparse remnants, namely fragments of the Zumpango, Texcoco and Xochimilco lakes.

It is further described that control of the water levels dates from the Aztec times. An example was the building of the 16 km long and 20 m wide Albarradón de Nezahualcóyotl dike in the 15th century. It divided Lake Texcoco from Lake Mexico, and avoided flooding in Tenochtitlán from overflows of Lake Texcoco. With the arrival of the Spanish in 1519, many dikes were destroyed. The lakes became more a problem, mainly due to floods lasting several years, the worst being in 1555, 1579-1580, 1604, 1607, 1629-1635 and later. After the Spanish conquest of the Aztec Empire, efforts to control flooding by the Spanish led to most of the lake being drained by the canals and a tunnel to the Pánuco River, but even that could not stop the floods, since then most of the city was flooded. Although several hydraulic works were constructed in the 17th century it was decided to eliminate the lake complex altogether. Alcocer-Durand and Escobar-Briones (1992) describe that it took four centuries and a considerable amount of hydraulic work to complete the drainage of the lakes through north-western canals. The first of five

drainage canals was the Nochistongo Cut (Tajo de Nochistongo), constructed from 1609 till 1634. After another catastrophic flood in 1878 the construction of the Great Channel, with the Tequixquiac Tunnel (Tunel de Tequixquiac) - completed in 1884 - was constructed. The Great Channel project was completed in 1900. It consisted of an open channel, 50 km in length, which, among others, also directed 27 m^3/s of wastewater into the Tula and Panuco rivers for removal to the sea. This drainage system was considered the most important infrastructure built in Mexico during the 19th century. In 1976 that drainage system was further expanded with the construction of a second Tequixquiac Tunnel (Tunel de Tequixquiac), and, finally, with the Deep Drainage System (Sistema de Drenaje Profundo), a network of several hundred kilometres of tunnels at a depth between 30 and 250 m. The central tunnel has a diameter of 6.5 m and carries excess water out of the basin (Alcocer and Williams, 1996).

Also Sosa-Rodriquez (2010) describes the four artificial drainage systems of Mexico Valley, and that it was expected that another artificial drainage system would be completed in 2010 with the construction of the East Drainage System. The Eastern Discharge Tunnel was inaugurated in 2019.

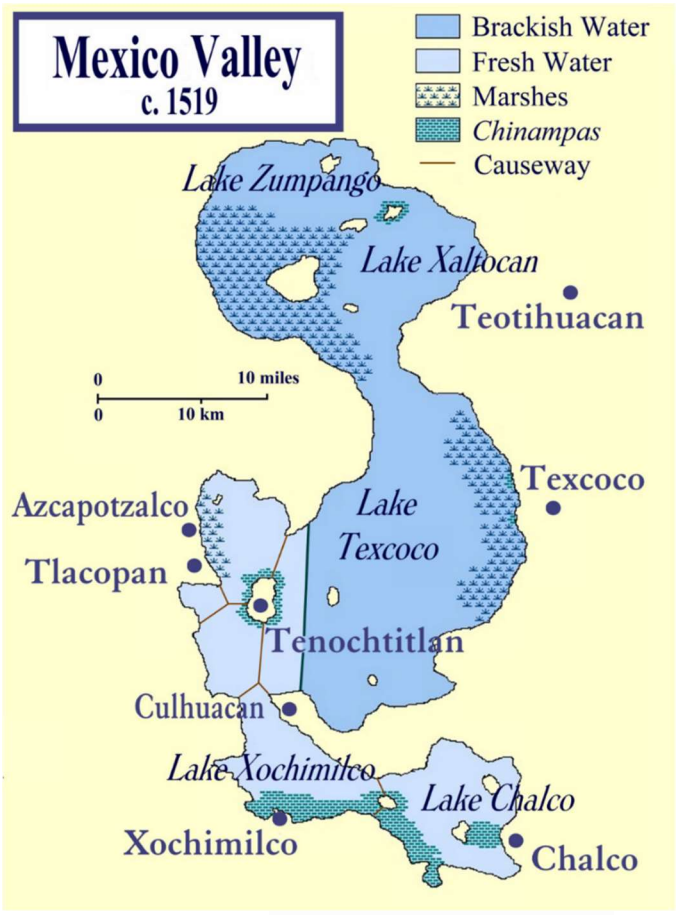


Figure 1. Former Lake Texcoco (Alcocer and Williams, 1996; Madman, 2001)

Sosa-Rodriquez (2010) further describes that water from the lakes was extracted at the beginning of the 20th century. Most rivers were channelled, and the few that were not became highly polluted because they carry wastewater from Mexico City to the sea. In addition, the drainage of the lake complex has also left much derelict land. During the dry season, this erodes, creating dust storms. The problem seems insoluble given that city growth is still high and groundwater extraction increasing.

Tortjada (2006) describes that in Mexico Valley the annual rate of withdrawal from the aquifers is 45–54 m^3/s and the natural recharge rate is about 20 m^3/s. This mismatch has resulted in a lowering of the groundwater table by about 1 m/year. The lowering of the groundwater table increased the land subsidence rate, initially to 10 cm/year, and later up to 30 to 40 cm/year. The average annual subsidence rate in the area of the International Airport of Mexico City is 20–25 cm, and in the City Centre it is around 10 cm. It is estimated that the central area of the metropolitan area has subsided by 10 m during the past 100 years. The clay soil keeps compressing and the city continues to sink.

Existing polders

The process as described above basically implies that Mexico City is to a large extend located in the highest polder in the World.

The Group Polder Development (1982) mentions that along the entire coastal region of the States of Veracruz, Tabasco, Campeche and Yucatan inundated zones can be found. These areas are permanently or periodically inundated or swamp areas. In some parts land has been reclaimed in a form of raised fields or floating island agriculture.

General characteristics of the polders in Mexico are shown in Table I.

Proposed polders

No proposed polder could be identified.

Location of the polders in Mexico as shown on the World polder map

The locations of the polders in Mexico are shown in Figure 2.

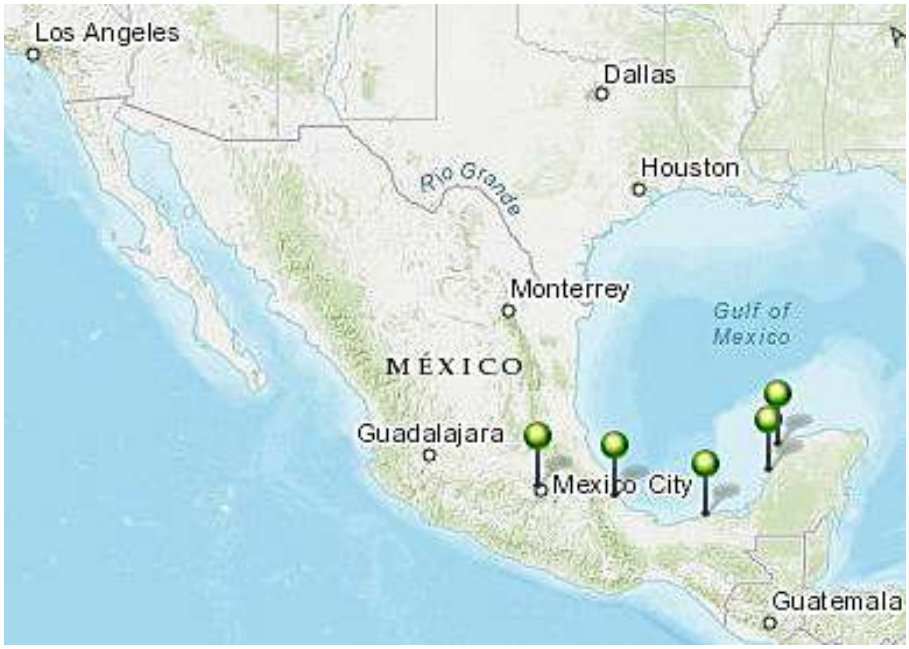


Figure 2. Location of the polder in Mexico (source: esri – Batavialand)

The pictures by Prof. Adriaan Volker are shown in Table II.

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Bart Schultz

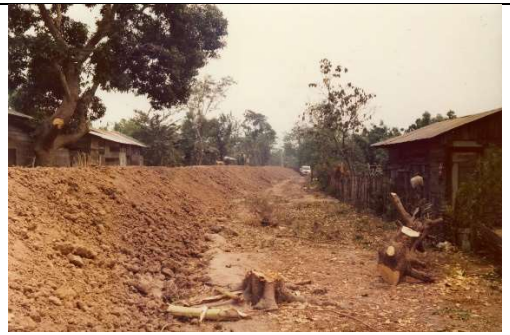
Lelystad, May 2023

Table I. General characteristics of existing polders in Mexico

Name	Reclamation	Area in ha	Type *)	Latitudes	Longitudes	Elevation in m+MSL	Land use
Lake Texcoco, Mexico City	17th century		RLL	19º 25' N	99º 08' W	2236	Urban and agriculture
Polders in the coastal region of Veracruz			RLL	19º 08' N	96º 10' W	1	Urban and agriculture
Polders in the coastal region of Tabasco			RLL	18º 21' N	92º 54' W	2	Urban and agriculture
Polders in the coastal region of Campeche			RLL	19º 59' N	90º 25' W	2	Urban and agriculture
Polders in the coastal region of Yucatan			RLL	20º 54' N	90º 13' W	4	Urban and agriculture
Total							

*) RLL = reclaimed low-lying land; LGS = land gained on the sea; DL = drained lake

Table II. Pictures by Prof. Adriaan Volker on polders in Mexico

		
A2 001/V.2.1 Vertidor lowland area	A2 002/V.2.2 Vertidor lowland area	A2 003/V.2.3 Vertidor lowland area
		
A2 004/V.2.4 Vertidor lowland area	A2 005/V.2.5 Vertidor lowland area	