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Assessment of the hydric, demographic, and economic sustainability of the coastal cities of Veracruz, Mexico: a look to the future

Evaluación de la sustentabilidad hídrica, demográfica y económica de las ciudades costeras de Veracruz, México: una mirada al futuro

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ABSTRACT

The balance between population growth, the economy, and the efficient use of water resources is essential for the sustainability of the coastal cities of the State of Veracruz, Mexico. In this paper, we analyzed these factors. The population growth analysis showed a significant imbalance in the fourteen coastal towns evaluated; four towns (Tuxpan, Veracruz, Boca del Río, and Coatzacoalcos) showed very high population growth. This growth requests a high demand for public services, sources of employment, and water supply. The other ten cities have a small population. In the economy, the four largest cities have good stability of economic activities with a growing trend, making them attractive for investment. However, the rest of them are unattractive due to the few sources of employment. The fourteen coastal cities have good sources of water supply; however, all these cities present an alarming situation that puts water sustainability at risk, which must be addressed. Pollution of surface waters and aquifers puts their balance and future at risk. Carelessness, lack of attention, and actions made out of time will result in social and economic problems that will be more difficult to solve in the future.

Keywords: sustainability; coastal cities; water resources; population; economic activities.

RESUMEN

El equilibrio entre el crecimiento poblacional, la economía, y el uso eficiente de los recursos hídricos es esencial para la sustentabilidad de las ciudades costeras del Estado de Veracruz, México. En este artículo, analizamos estos factores. El análisis del crecimiento de la población mostró un desequilibrio significativo en catorce ciudades costeras evaluadas; cuatro poblaciones (Tuxpan, Veracruz, Boca del Río, y Coatzacoalcos) mostraron un crecimiento poblacional muy alto. Este crecimiento representa una alta demanda por servicios públicos, fuentes de empleo, y abastecimiento de agua. Las otras diez ciudades tienen una población pequeña. En la economía, las cuatro ciudades más grandes tienen una buena estabilidad de actividades económicas con una tendencia de crecimiento, haciéndolas atractivas para la inversión. Sin embargo, el resto de ellas no son atractivas debido a las pocas fuentes de empleo. Las catorce ciudades costeras tienen buenas fuentes de abastecimiento de agua. Sin embargo, presentan situaciones de alarma que ponen en riesgo la sustentabilidad del agua que debe ser atendida. La contaminación de las aguas superficiales y acuíferos pone en riesgo su equilibrio y su futuro. El descuido, la falta de atención y de acciones realizadas fuera de tiempo resultarán en problemas sociales y económicos que serán más difíciles de resolver en el futuro.

Palabras clave: sustentabilidad; ciudades costeras; recursos hídricos; población; actividades económicas.

1. Introduction

All life is water. Water exists; it moves, it can die, and it transforms. In the ancient worldview of the original peoples of the Gulf of Mexico, such as the Popolucas, Totonacas, Otomíes, Téneks, and Nahuas, water is vital in culture and spirituality (Budar and Ladrón de Guevara, 2020).

Sustainability is a concept that has multiple definitions; however, they all lead to the same idea. In 1983, the World Commission on Environment and Development (WCED) defined sustainability as "Development that meets the needs of the present without compromising the capacity of future generations to meet their own needs" (Calvente, 2007; Estrella-Suárez and González-Vázquez, 2014; Hernández-Paz et al., 2016).

By another hand, the concept of sustainable development is designed from the 1987 Brundtland Report and now the focus is shifted toward economic, environmental, and social development. The development which includes all these factors is termed Managed Sustainable Development. It is a system where climate change and other sustainability practices that influence economic development are turned into business ideas (Santhanalaxmi and Chandramohan, 2020).

The State of Veracruz is strategic in the development of Mexico as it has excellent coastal potential to carry out economic activities, including national and international port traffic and transportation, fishing, shipyards, oil activity, refining, and petrochemicals. Its location in the Gulf of Mexico places it as a lever for economic development for Mexico.

However, this potential does not use to its maximum capacity. Only four coastal cities do most economic activities, causing an overpopulation compared to the others. However, there

are ten other coastal cities with excellent potential. With an economic development plan and a good distribution of economic activities, these cities could grow sustainably.

An integral vision of economic development for the coastal cities of the State of Veracruz must consider the availability and protection of water resources to supply these cities and satisfy their needs, whether for human consumption, industrial use, services, and tourism.

Sánchez-Gil et al. (2004) analyzed some socio-economic indicators in the Mexican states of the Gulf of Mexico, such as environmental aspects, economic indicators, population, fishing, oil and gas production, tourism, and urban expansion.

Considering that 33% of the surface waters in Mexico flow in Veracruz state, these water resources guarantee the sustainability of the coastal cities with surface waters (rivers, lagoons) and groundwater (coastal aquifers) (SEMARNAT, 2015).

Groundwater is the primary source of supply for small communities and a secondary source in more populated cities, despite its limited water production. However, the real problem is the quality of the water. Most rivers present different degrees of pollution caused by industry or waste from cities located on riversides and coastal towns, making it impossible for humans to consume the vital liquid (Ortíz-Lozano et al., 2005; Landeros-Sánchez et al., 2012).

Landeros-Sanchez et al. (2012) assessed water pollution in different aquatic systems in the state. The study was conducted in 5 zones (Pueblo Viejo Lagoon, Cañero irrigation, Jamapa River, Mandinga Lagoon, and Alvarado Lagoon), finding different pollution degrees.

Other problems are the human impact on the coast that affects rivers, lagoons, and aquifers (Martínez et al., 2017) and the coastal aquifers' vulnerability to saltwater intrusion from the sea (Costall et al., 2020). Many works were carried out in coastal aquifers to investigate the boundary line between freshwater and saltwater intrusion. Most of these investigations use Electrical Resistivity Tomography (ERT) (*e.g.*, Abdul-Nassir et al., 2000; Wilson et al., 2005; Gemail et al., 2011; Tajul-Baharuddin et al., 2011; Satriani et al., 2012; El-Waheidi et al., 2021).

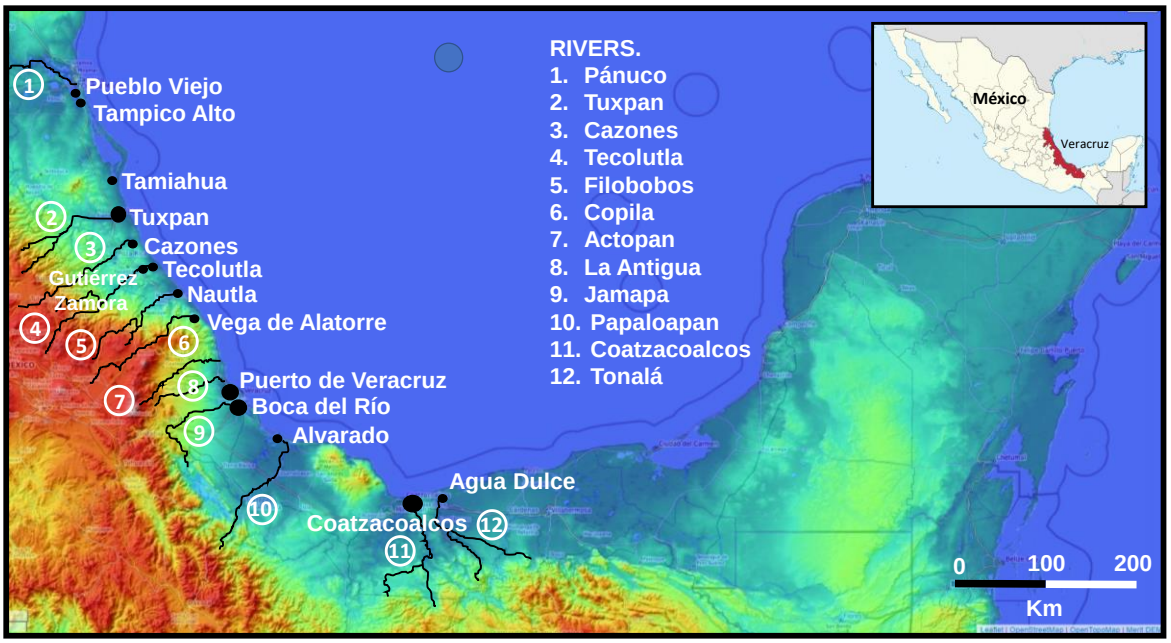
This paper aims to show the current situation on the population growth, the factors that influence the development of the economy, and analyze the different water resources that supply the coastal cities and that guarantee the sustainability of the coastal cities in the State of Veracruz, Mexico. Another goal of this paper is to suggest the implementation of preventive and corrective actions that can be applied to the coastal cities of Veracruz to prevent factors that put their sustainability at risk in the future.

2. Location of the main coastal cities

Veracruz has 745 kilometers of coastline from the Pánuco River in the South limit of the State of Tamaulipas (Cd. Madero and Tampico) to the Tonalá River in the Southeast of the State of Veracruz, bordering the State of Tabasco (Secretaría de Desarrollo Económico y Portuario, 2022). There are four large coastal cities and another ten small ones; to the North is the town of Pueblo Viejo and to the southeast is the city of Agua Dulce. The geographical location of these fourteen coastal cities is strategic for developing various economic activities in the state and the country. For example, Pueblo Viejo and Tampico Alto are close to an essential

economic pole in Tamaulipas (Tampico, Cd. Madero, and Altamira), and the cities of Tamiahua and Tuxpan are near the cities of Cerro Azul and Poza Rica (oil centers). The ports of Veracruz and Boca del Río are in the central part of the state's coast and well connected with the cities of Puebla and Mexico City. Coatzacoalcos and Agua Dulce are in the southeast, with roads that connect to the states of Tabasco, Oaxaca, and Chiapas (Figure 1).

Figure 1. Location of the 14 coastal cities along the Veracruz coast from the North to the Southeast of the State. Source: modified from Topographic-map (https://es-mx.topographic-map.com/maps/6cfh/Veracruz/).



3. Methodology

We used information from the population census and the economic census published by Mexico's National Institute of Geography and Informatics (INEGI). The population census is every ten years, and the economic census is every five years.

We analyzed the historical evolution of each coastal city's population growth and economy with data from INEGI. The different graphs helped analyze various coastal towns' factors (*e.g.*, the evolution of the population growth, future population projection, and economic productivity by city).

With the information provided by the National Water Commission (CONAGUA) and the Ministry of the Environment and Natural Resources (SEMARNAT), we analyzed different factors of water sources (rivers, lagoons, and aquifers), like rivers and lagoons' proximity, aquifers' characteristics, and pollution.

Based on these factors, we assessed the possible sustainability of the coastal cities of Veracruz and how to mitigate the high imbalance observed currently. Finally, a series of actions are proposed that promote the sustainable development of coastal towns to balance the distribution of the population, access to goods and services, equity in economic growth, and assurance of good quality water.

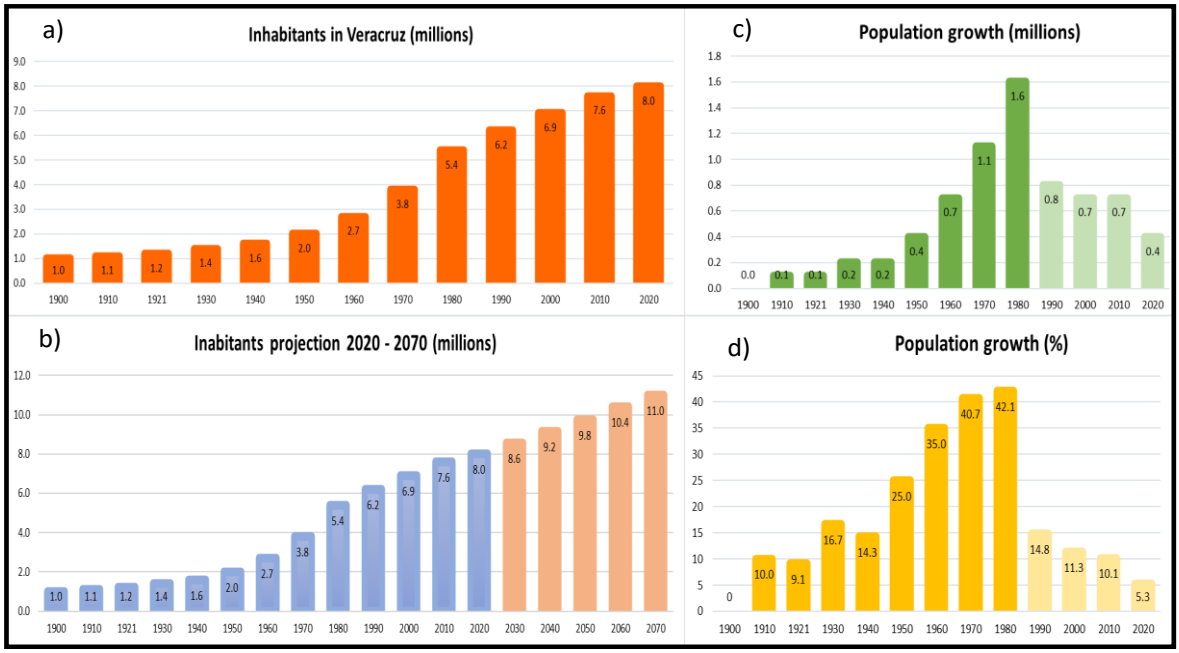
4. Results

4.1. Historical analysis of the population

The geographical location and the number of inhabitants of the smaller coastal cities show that they have an excellent potential to develop sustainably as essential centers in the strategic economy of the State of Veracruz (Figure 1).

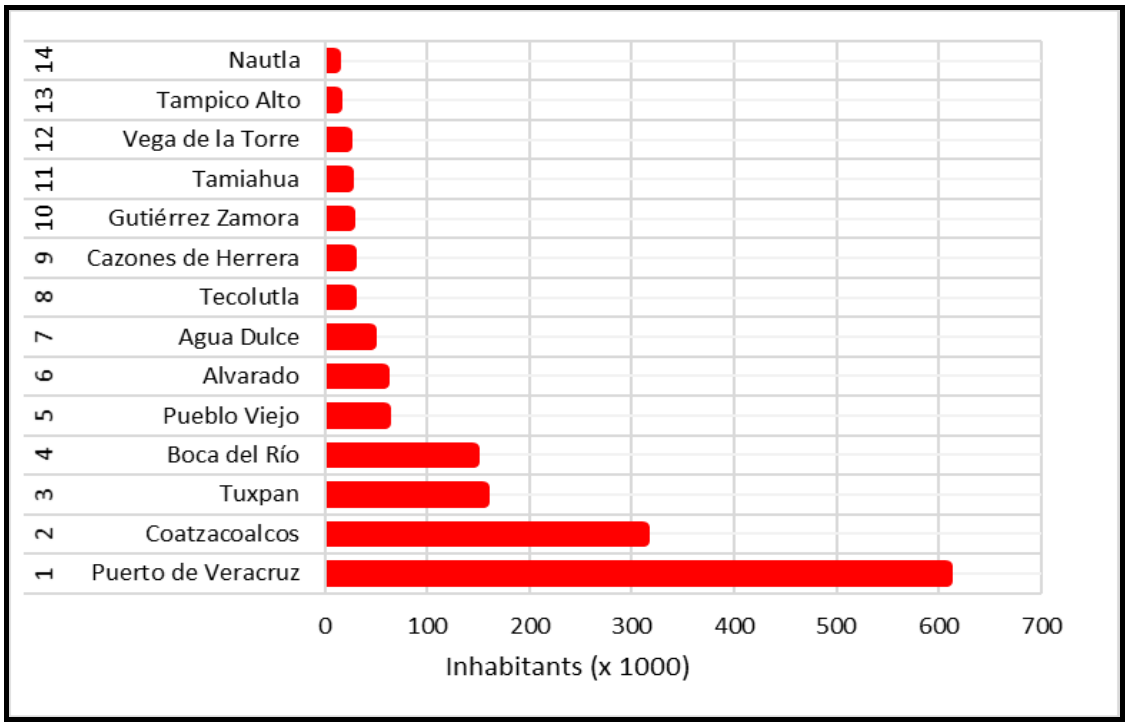
The population in the State of Veracruz has been ascending since the year 1900. However, the growth rate has not been constant, which shows the evolution of the population considering some multifactorial aspects (birth rate, deaths, and migration), which allows for making a future estimate of population growth (Figure 2).

Figure 2. Demographic evolution of the State of Veracruz, from 1900 – 2020. (a) Population in the state, (b) Population projection 2020–2070, (c) Population growth, (d) Population growth (%). Source: INEGI (https://www.inegi.org.mx/app/indicadores/?ag=30189#divFV53000000115300000092).



According to the last population census in 2020, there are four major coastal cities. The Port of Veracruz depicts more than 600,000 inhabitants, Coatzacoalcos has more than 300,000 inhabitants, Tuxpan has 154,000 inhabitants, and Boca del Río has 144,000 inhabitants. Also, there are ten coastal cities whose populations are less than 60,000 inhabitants (Figure 3).

Figure 3. The number of inhabitants of the coastal cities of Veracruz according to the census of 2020. Four cities with more than 100,000 inhabitants and ten towns with less than 60,000 inhabitants. Source: INEGI (https://www.inegi.org.mx/app/indicadores/?ag=30189#divFV53000000115300 000092).



A balanced distribution of the population in the state can avoid overpopulation and its associated problems in the four biggest coastal cities. Table1 shows the population imbalance recorded in 2020.

Table 1. The number of inhabitants of the coastal cities of the State of Veracruz. In blue color are the four bigger coastal cities, in orange color are the rest of them. Census 2020. Source: INEGI (https://www.inegi.org.mx/app/indicadores/?ag=30189#divFV53000000115300000092).

No.	City	Inabitants	No.	City	Inhabitants
1	Puerto de Veracruz	607,209	8	Tecolutla	24,551
2	Coatzacoalcos	310,698	9	Cazones de Herrera	24,421
3	Tuxpan	154,600	10	Gutiérrez Zamora	24,085
4	Boca del Río	144,550	11	Tamiahua	21,902
5	Pueblo Viejo	57,909	12	Vega de la Torre	20,204
6	Alvarado	57,035	13	Tampico Alto	11,561
7	Agua Dulce	44,104	14	Nautla	10,130

The knowledge of the population growth evolution (*e.g.*, 1995–2020) in coastal towns is essential because this factor links to the economy and demand for goods and services. Table 2 shows the evolution of the population growth of 6 of the 14 coastal cities. The first four biggest cities had enormous population growth. In contrast, the two smaller towns had little change. The population's concentration is interrelated to the job offer, the variety of productive activities, and the supply of goods and services.

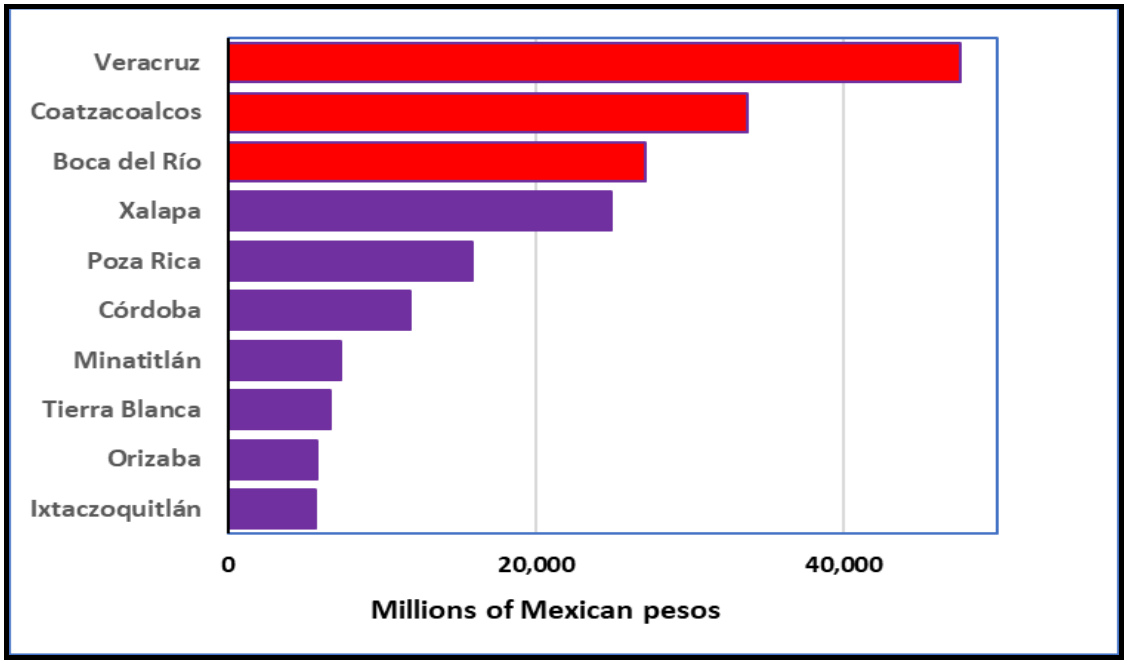
Table 2. Evolution of the population of some coastal cities 1995 – 2020. In blue color are the four bigger coastal cities and green color the smaller cities. Source: INEGI (https://www.inegi.org.mx/app/indicadores/?ag=30189#divFV53000000115300000092).

City	Inhabitants (1995)	Inhabitants (2000)	Inhabitants (2005)	Inhabitants (2010)	Inhabitants (2020)
Veracruz	425,140	457,377	512,310	552,156	707,209
Coatzacoalcos	259,096	267,212	280,363	305,260	310,698
Tuxpan	127,622	126,616	134,394	143,362	154,600
Boca del Río	135,060	135,804	141,906	138,058	144,550
Alvarado	48,480	49,499	48,178	51,955	57,035
Nautla	9,599	9,798	10,023	9,974	10,130

4.2. Analysis of the evolution of the economy

An index of a city's economy is its income from commercial activity; this reflects the population's purchasing power at all socio-economic levels (https://www.economicsdiscussion.net/national-income/net-national-income-and-per-capita-income-as-growth-indicators/11764). The three cities with the largest economy in the State of Veracruz are coastal (Cd. de Veracruz, Coatzacoalcos, and Boca del Río), each with more than 25 billion revenues pesos (1.25 billion dollars) from commercial activity in the year 2020. As a non-coastal city, the fourth is Xalapa (state capital), and the fifth is Poza Rica (Oil center) (Figure 4).

Figure 4. The ten cities with the largest economy in the State of Veracruz (2020). The first three economies of the state are coastal cities (Red color). Source: INEGI (https://www.inegi.org.mx/app/indicadores/?ag=30189#divFV53000000115300000092).



We made a table with the commercial activity (income) and the number of personnel employed in some coastal cities of the State of Veracruz with data from the economic censuses of INEGI for 1998, 2003, and 2008. From 1998 to 2003, coastal cities such as Veracruz, Coatzacoalcos, Boca del Río, and Tuxpan showed notable growth in their economies. Alvarado and Nautla showed low growth (Table 3).

The indicative of employed personnel (employees) presented a similar behavior to the incomes from the commercial activity, reflecting an interdependent relationship. Also, we saw a significant imbalance in the economy between big and small coastal cities (Table 3).

Table 3. Relationship of the economy of six coastal cities. Commercial activity (income) and employed inhabitants. In blue color are the four bigger coastal cities, and in green color are two of the smaller cities. Source: INEGI (https://www.inegi.org.mx/app/indicadores/?ag=30189#divFV53000000115300000092).

City	**Commercial activity, millions of pesos**			**Personal employed (total)**		
	1998	2003	2008	1998	2003	2008
Veracruz	13,021	22,285	47,622	99,750	116,740	128,912
Coatzacoalcos	9,496	12,714	33,795	61,588	67,304	85,596
Boca del Río	3,466	7,598	27,163	22,419	27,831	36,868
Tuxpan	1,463	2,551	4,038	12,097	14,404	19,016
Alvarado	287	465	613	6,330	6,453	6,566
Nautla	56	77	31	383	500	500

4.3. Analysis of water supply sources

Water resources are essential for every society; water supports life, and life supports development, supporting the continuity and permanence of society.

CONAGUA is the public body in Mexico managing the country's water resources. The area of action is vast, including technical studies, legislation, hydraulic infrastructure works, management of water use, environmental protection, and remediation (Cámara de Diputados del H. Congreso de la Unión, 2022).

The Basin Councils are part of CONAGUA, where the government, users, and society take part. The State of Veracruz has 4 River Basin Councils; the Pánuco River Basin Council, the Tuxpan–Jamapa River Basin Council, the Papaloapan River Basin Council, and the Coatzacoalcos River Basin Council (Cervantes-Pérez et al., 2014; CONAGUA, 2015a).

The State of Veracruz has 745 kilometers of coast with rivers, lagoons, and coastal aquifers where the coastal cities are, so those towns have good sources of water.

With respect to surface waters and aquifers, the State of Veracruz has four hydrological regions (Figure 5), which are: RH 26 Pánuco, RH 27 North of Veracruz (Tuxpan-Nautla), RH 28 Papaloapan, and RH 29 Coatzacoalcos. The four hydrological regions contribute significant quantities of water that flow into the Gulf of Mexico and constitute the primary supply source for coastal cities (CONAGUA, 2015a; SEMARNAT, 2015).

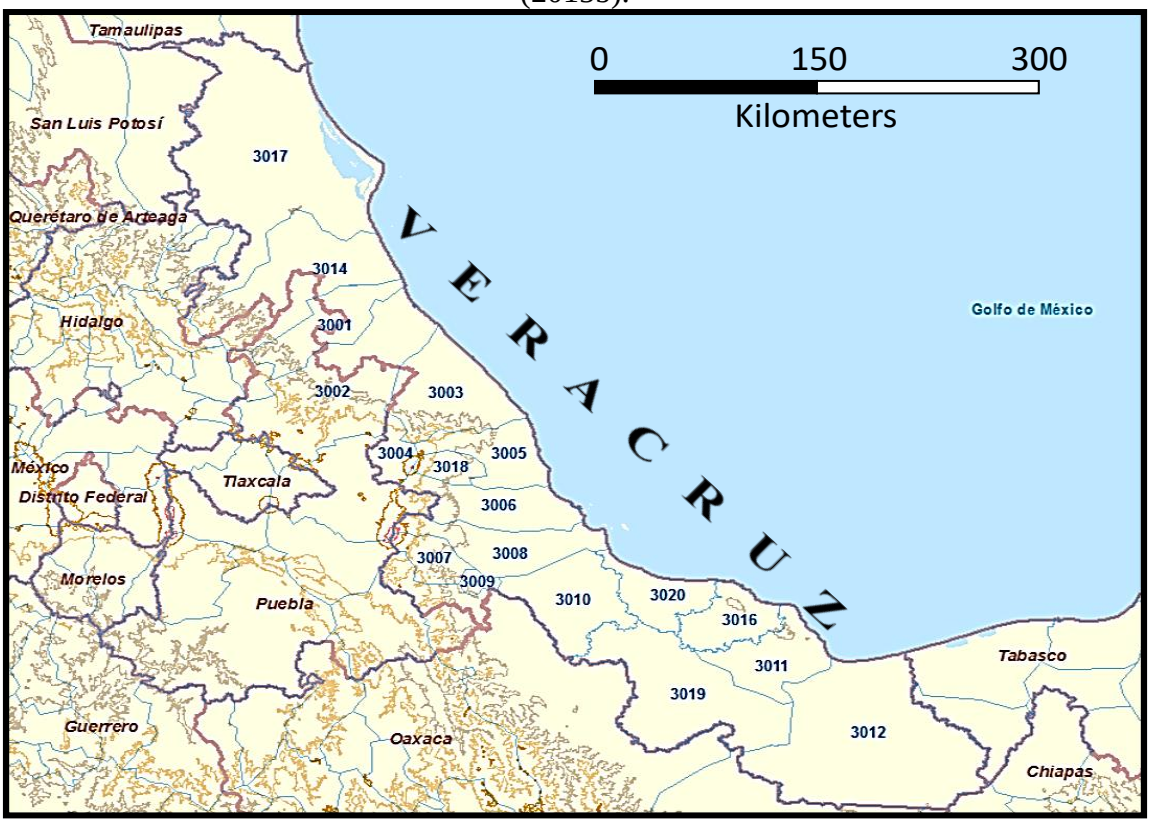
Figure 5. Hydrological Regions 26, 27, 28, and 29 (surface waters) of the State of Veracruz
Source: modified from SEMARNAT (2015).

The coastal region of the State of Veracruz has 10 Coastal Aquifers systems which are the most important coastal cities of the state (Figure 6). These aquifers are a very important complementary water supply source, which names are Poza Rica (3001), Tecolutla (3002), Martínez de la Torre–Nautla (3003), Coastal of Veracruz (3006), Cotaxtla (3008), Soteapan–Hueyapan (3011), Coastal of Coatzacoalcos (3012), Álamo–Tuxpan (3014), Tampico–Misantla (3017), Coastal of Papaloapan (3020) (CONAGUA, 2015b, 2020).

The coastal cities of Pueblo Viejo and Tampico Alto are in the Hydrological Region (RH 26) of the Pánuco River in the Tampico–Misantla Aquifer (3017). Pueblo Viejo is a short distance from the Pánuco River and Laguna de Pueblo, and Tampico Alto is a short distance from Laguna de Pueblo Viejo; Both the river and the lagoon are important for supplying these cities (CONAGUA, 2015b, 2020).

This region is the Tampico–Misantla Aquifer (3017), a free, heterogeneous, and anisotropic aquifer. In its upper part, there are alluvial sediments and Quaternary conglomerates. There are sandstones, shales, and basalts with secondary permeability due to fracturing in their lower part. The aquifer's water production is medium to low, and its static level is 1 to 20 m deep (CONAGUA, 2020).

Figure 6. Coastal Aquifers of the State of Veracruz. Source: modified from CONAGUA (2015b).



To the south of Tampico Alto is the coastal city of Tamiahua which is south of the Tamiahua lagoon in the Hydrological Region (RH 27), North of Veracruz in the Tampico–Misantla Aquifer (3017). The primary surface water source is the Tamiahua Lagoon, and the Tampico–Misantla Aquifer is its primary groundwater source (CONAGUA, 2015b, 2020).

The coastal city of Tuxpan is on the banks of the Tuxpan River in the Hydrological Region (RH 27) North of Veracruz (Tuxpan–Nautla), and in the Álamo–Tuxpan aquifer (3014). The Tuxpan River and the Álamo–Tuxpan Aquifer are important sources of water supply for the city (CONAGUA, 2015b, 2020).

The aquifer is free, heterogeneous, and anisotropic, consisting of alluvial, fluvial, and aeolian sediments. Its upper part has alluvial deposits and Quaternary conglomerates, with variable permeability. Its lower part has volcanic rocks, sandstones, and shale with secondary permeability and poor production. The static groundwater level is 1 to 6 m deep near the coast and is for domestic use (CONAGUA, 2020).

On the central coast of the State of Veracruz, the five coastal cities have water sources that guarantee their development and sustainability. The city of Cazones is on the banks of the Río Cazones, Gutiérrez Zamora and Tecolutla are on the banks of the Río Tecolutla. Nautla is at the mouth of the Filobobos River. The town of Vega de Alatorre is on the banks of the Copila River, a short distance from the Laguna Grande. All of them are in the Hydrological Region (RH 27) North of Veracruz (Tuxpan - Nautla) (CONAGUA, 2015b).

The city of Cazones is in the Poza Rica Aquifer (3001). There is little information on the type of aquifer and the geology that makes it up. In the City of Poza Rica area, the aquifer is on the

free type with static water levels from 2 to 8 m deep. The little information shows the lack of interest in taking advantage of this resource (CONAGUA, 2020).

Gutiérrez Zamora and Tecolutla are in the Tecolutla Aquifer (3002). The aquifer is a heterogeneous and anisotropic free type, formed by alluvial, fluvial, and aeolian sediments. The upper part has alluvial deposits, sandstones, and conglomerates with thicknesses of several hundred meters in the valley's center. In the lower part, there is a sequence of marine sedimentary rocks such as limestone, shale, and sandstone; volcanic rocks (tuffs and volcanic breccias) with secondary permeability due to fracturing. The static level is 2 to 8 m deep (CONAGUA 2020).

Nautla and Vega de Alatorre are in the Martínez de la Torre–Nautla aquifer (3003). This aquifer counts with very little studied. The static level is 4 to 11 m deep, and it makes up of gravel and sand, with primary porosity and medium to high permeability with a variable thickness of 30 and 50 m. It is of the free type; its static level close to the shoreline is 1 m deep. 80% of the wells produce 1 to 5 liters per second (LPS), 18% have 5 to 30 LPS, and only 2% produce >30 LPS (CONAGUA 2020).

The port of Veracruz, Boca del Río, and Alvarado are in the Hydrological Region (RH 28) Papaloapan. The port of Veracruz is in the Coastal Veracruz Aquifer (3006), where its main sources of surface water supply are the Actopan, The Antigua, and the Jamapa rivers (CONAGUA, 2015, 2020).

The Coastal of Veracruz Aquifer (3006) is a free, heterogeneous, and anisotropic aquifer; its upper part has alluvial, fluvial, aeolian, sandstone, and conglomerate sediments. The lower part has volcanic rocks and limestone with secondary permeability due to fracturing and dissolution in the limestone. The static water level is 3 m on the coast (CONAGUA, 2020).

Boca del Río is in the Coastal Veracruz Aquifer (3006) and the Cotaxtla Aquifer (3008). The primary surface water sources in the Cotaxtla Aquifer are the Cotaxtla River, the Jamapa River, and the Mandinga Grande Lagoon. The Cotaxtla Aquifer (3008) is free, heterogeneous, and anisotropic. In the upper part, it has alluvial, fluvial, aeolian, sandstone, and conglomerate sediments. The lower part has volcanic rocks and limestone, with secondary permeability due to the fracturing and dissolution of the limestone. The static level is a few meters on the coast, up to 180 m deep in the western part of the aquifer (CONAGUA, 2020).

Alvarado is on the shores of the Alvarado lagoon, at the mouth of the Papaloapan River, in the Coastal Papaloapan Aquifer (3020). The aquifer is a free type, formed by clay, silt, sand, gravel, and conglomerate; the coarsest materials occur in the upper parts; in the intermediate and lower portions, it has sandy and silt-clay sediments. The thickness of the Quaternary deposits is less than 100 m. Sandstone and shale with intercalations of oyster beds form the basement. The static level varies from a few meters near the coast and 50 m in the highlands (CONAGUA, 2020).

Coatzacoalcos and Agua Dulce cities are in the Coatzacoalcos Hydrological Region (RH 29), in the Coastal of Coatzacoalcos Aquifer (3012). Coatzacoalcos is on the banks of the Coatzacoalcos River, which is the primary source of water supply for the city, but its waters are not used due to pollution. The primary water source that supplies the city is the Yuribia Dam, 38 km northwest of the town. The town of Agua Dulce is on the banks of the Tonalá

River. Both cities are in the Coatzacoalcos Coastal Aquifer (Cervantes et al., 2014; CONAGUA, 2015, 2020).

The shallow aquifers are of the free type with alluvial deposits with thicknesses of 40 to 50 m. In the western part of the left bank of the Coatzacoalcos River, to deeper levels, sandy sediments covered by clayed alluvial formations form confined and semi-confined aquifers.
The aquifer is formed by an unconsolidated material with high and medium possibilities for Coatzacoalcos. For Agua Dulce town, there is a similar material with high chances (CONAGUA, 2020).

As can be seen with analysis, the coastal cities of Veracruz have good sources of water, with surface water as the primary supply and aquifers as a secondary supply.

5. Discussion

Many factors affect the development and growth of a city. However, three of them are the most important, the evolution of population growth, economic activity, and the availability of good quality water resources.

As the population of a city increases, the need for services increases, and service companies will need more workers, as result, job offers increase, and will be the bigger purchasing power of people, and, increases of the supply of services and commerce, by attracting more people from other places. With the growth of the population and economic activities, the demand for water increases

Analyzing the evolution of population growth in the State of Veracruz, in general terms, it is ascending (Figures 2a and 2b). Since 1900 growth was high, but from 1980 began to decry from 42.1 % to 11.3 % in 2020. This percentage drop shows population migration to other places that offer a better quality of life (Figures 2c and 2d).

The unequal growth of the population of the coastal cities shows that only four of them increased their inhabitants at an accelerated rate (Veracruz, Coatzacoalcos, Tuxpan, and Boca del Río); the rest had a small growth (Figure 3). In the activities of trade and services, the trend was similar. The four cities developed a robust and sustainable economy. However, the economy of the other ten cities is limited and fragile, making them unattractive for foreign investment, which is a risk for sustainability and balance.

The petrophysical properties (porosity and permeability) of materials in the coastal aquifers make them very heterogeneous, with a very varied range of water production. In most of the coastal aquifers of Veracruz, wells produce a small quantity of water, and the sites with high and medium amounts are very punctual. Wells are to meet the needs of a family with little consumption. Also, the little research on the coastal aquifers of Veracruz using geophysical methods limits the use and sustainability of this water resource.

The city of Coatzacoalcos is an example of a river's pollution (Coatzacoalcos River) and its consequences of not addressing the problem in time and adequate manner.

The Yuribia dam is 38 km away from the city; this dam supplies the town with water. Not only the distance is a problem, but also the city depends on water from that dam, which on

several occasions was subject to manipulation due to different disputes and claims where the water supply to the city has been cut off (Formato Siete, 2021).

The lack of an efficient implementation of a sustainability plan for coastal cities caused a significant imbalance in the economy, demographic growth, and water supply risk. It is crucial to guarantee the supply of quality water in the present with a vision of the future, considering population growth trends and economic and industrial activities, ensuring that each city has its water treatment plant.

The planning and practical execution of a sustainability program that contemplates the balance of the economy, demographic growth, and water supply is the best alternative that offers enormous benefits for the State of Veracruz.

Every strategic social program must be a great project that is completed 100%, with positive results, not half projects, which do not generate results and much less social and economic gains.

6. Conclusions and recommendations

According to the analysis made, fourteen coastal cities in Veracruz have great potential for economic development. However, only four coastal cities depict good results in their economy. To date, there is no sustainable development plan working that seeks balanced growth among the coastal cities of Veracruz. The unbalanced growth and the concentration of the economic activities of the biggest coastal cities will cause in the future many crucial problems and sustainability risks.

Conversely, despite the coastal cities of Veracruz have good water supply sources that guarantee water sustainability, the pollution of those water sources threatens and limits the sustainability and the future of the coastal cities of the State of Veracruz. This is because the relationship between the factors of population, economy, and water sustainability are highly delicate, so it is necessary to check and attending these factors continuously.

Therefore, we recommend implementing and executing a sustainability program that promotes economic balance and diversifying industrial activities to avoid the concentration of inhabitants in coastal cities in Veracruz. Also, we recommend developing new research projects on surface water sources and aquifers to update the water pollution information, and we suggest that each coastal city has its water treatment plant. At least, we are convinced that a water management plan must be conceived to resolve cities' present and future needs, and it should not be subject to factors of political interests.

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