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ECONOMIC VALUATION OF THE AGRI-FOOD CROP NOPAL (OPUNTIA SPP) IN MEXICO CITY

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Abstract: The contextual analysis of the nopal (*Opuntia spp*) provides an overview of its evolution, behavior, and trends, indicating where efforts should be directed to support producers of this cactus and establish links with the different links that form part of this agri-food chain in Mexico City (CDMX). To understand this, information was compiled from the Agricultural and Fisheries Information System (SIAP), which is part of the Ministry of Agriculture and Rural Development (SADER), The following variables were analyzed: harvested areas, average yields per hectare, production, average rural prices, and production value, from which the monetary impact of nopal in CDMX was determined. Records were also reviewed to determine the participation of nopal growers in the municipalities of Milpa Alta, Xochimilco, and Tláhuac.
Keywords: Average rural price, production, average yield per hectare, harvested area, production value.

INTRODUCTION

According to SIAP (2024), nopal cactus is the plant group with the most species and widest distribution in the cactus family. Its distinctive features are its flat stems (pencas) shaped like paddles and covered with spines, also known as glochids (stiff hairs with sharp tips). The product obtained is known as nopalitos, which are the tender, fleshy, green, flattened shoots or pencas that are mainly consumed as a vegetable in many culinary dishes. When fresh, they are high in zinc, phosphorus, calcium, and fiber. They are also used in various medicinal treatments and in the manufacture of cleaning and personal care products, such as soaps, creams, and shampoos.

The Ministry of Agriculture and Rural Development (SADER) considers the nopal chain to be one of Mexico City's priorities, as this product is representative of rural activities in the Mexican capital.

The nopal (*Opuntia ficus-indica* L.) is a cactus with characteristics that allow it to adapt to areas with little water availability and extreme temperatures (SAGARPA, 2015). The nopal is also part of Mexican identity, as it appears on the national coat of arms.

Mexico City has had several names over the centuries. Its original name was Tenochtitlán, which was changed by the Spanish to Nueva España. With independence, it took the name Distrito Federal as the capital of the republic, and since 2016, it has been known as Mexico City. It is located in the south-central part of the country and is the smallest state in terms of territory, covering an area of 1,495 km^2, which is 0.08% of the country's total area. It has a population of 9.18 million inhabitants (INEGI, 2016 and CONAPO, 2025). Similarly, the contribution of agricultural activities (including nopal production) to Mexico City's GDP is not significant, as they only reach marginal levels, with the main contribution to this indicator coming from the tertiary activities of the Mexican capital (INEGI, 2015).

Figure 1 shows the location of the boroughs (formerly delegations) of Mexico City where the greatest amount of agricultural activity in terms of nopal production takes place: Milpa Alta, Xochimilco, and Tláhuac. However, the first of these is where nopal production is concentrated (Moctezuma, 2017 and 2018). Based on data from SIAP (2024), the entity has 2,097 hectares of land planted with nopal, which places it in second place nationally, after the state of Morelos, with the State of Mexico in third place. The neighborhoods most representative of nopal cultivation in the municipality with the highest production (Milpa Alta) are: Santa Ana Tlacotenco, San Lorenzo Tlacoyucan, San Pedro Atopcan, San Pablo Oztotepec, San Juan Tepenahuac, San Jerónimo Miacatlán, San Francisco Tecoxpa, San Francisco Tecomitl, and San Agustín Ohtenco. In addition, this municipality has the

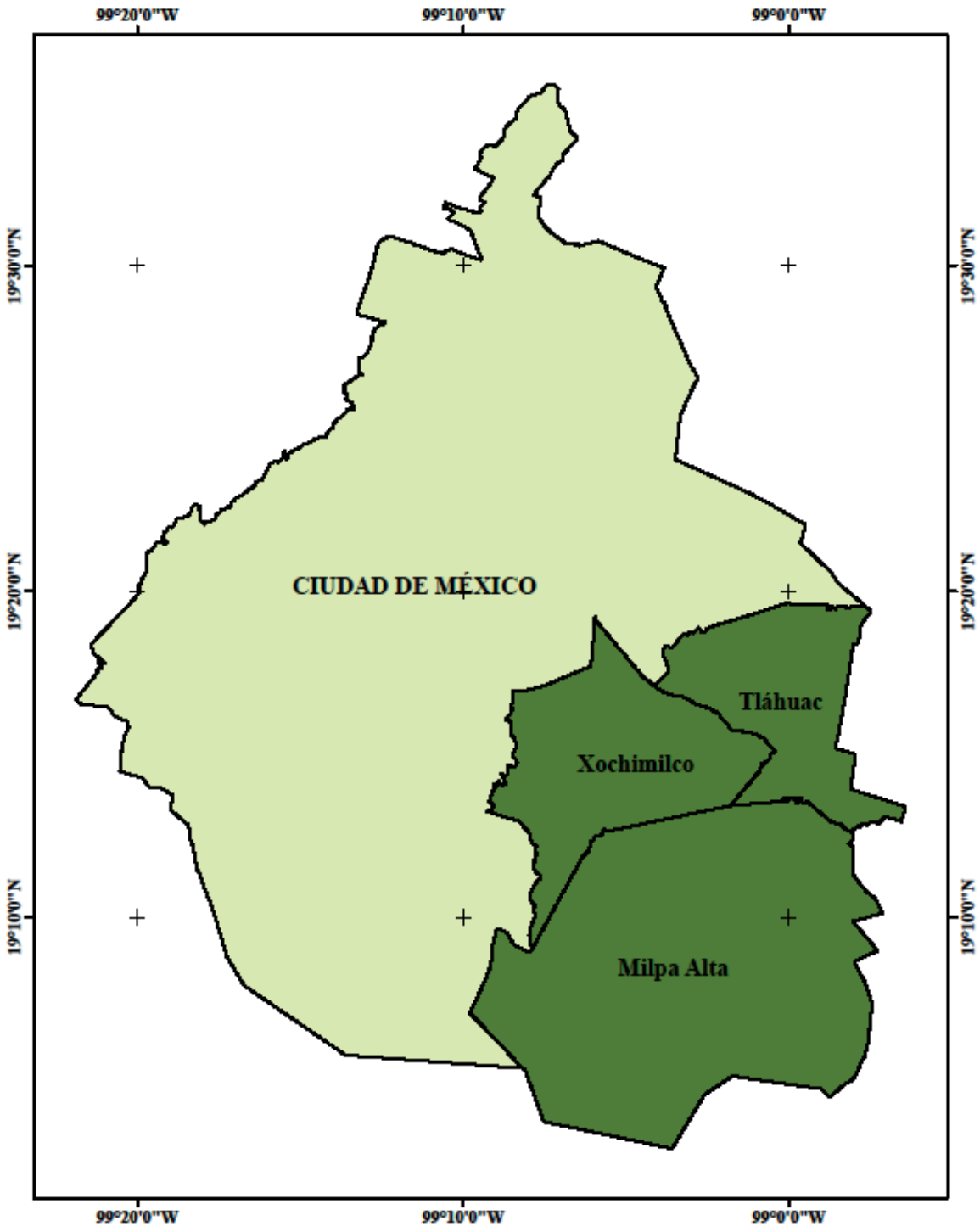

Figure 1. Location of the main nopal-producing municipalities in CDMX

largest land area (288.13 km^2)and the three districts together represent 33.14% of the surface area of Mexico City (CDMX, 2020).

MATERIALS AND METHODS

The methodological process used was divided into two phases:

I. Phase: An analysis of the dynamics of nopal cultivation as the main crop in Mexico City, which is historic and iconic for the inhabitants of the three main boroughs (formerly delegations) located in the south of CDMX.

II. Phase: Documentary research consisting of five stages:

First stage: selection of the topic to be studied. For the socioeconomic research, the topic chosen was the evolution of the area planted with nopal (*Opuntia spp*), its average yield per hectare, production, average rural price paid to the producer, and production value in its two forms: at current or market prices and at constant or deflated prices; in the three municipalities of Mexico City located in the south of the city, namely Milpa Alta, Tláhuac, and Xochimilco.

Second stage: collection of information from secondary documentary sources. The main idea was to compile statistics for the purpose of quantifying, organizing, and classifying them in order to assess and evaluate the importance of the issue. This involved searching for and locating specific documents held by information centers, libraries, reference centers, and databases, as well as articles and summaries of proceedings from national and international seminars and conferences, among others. During this phase, an Excel database was designed and developed, which was fed with information generated by the Agrifood and Fisheries Information System (SIAP) of the Ministry of Agriculture and Rural Development (SADER) in its various documents published periodically, which were used to organize the documentary sequence. The study period was defined in accordance with the national accounts published by the aforementioned source over a period of 36 years (1989–2024). For the production value variable, the base year taken into account was 2018, in order to use constant (deflated) prices, which allows the data to be comparable when analyzing the value of nopal production.

Third stage: development of the research plan, with the aim of organizing and exercising thought and understanding, as well as ensuring that the concepts have a logical and systematic structure for prioritization. the following indicators were chosen: planted area (in hectares), average yield per hectare (in tons/ha), nopal production (in tons), average rural price (in $/ton), and production value (in thousands of pesos).

Fourth stage: organization of the information collected, which was done by indexing the content and secondary sources of information, segmenting it by the indicators mentioned in the previous point and visualizing the contribution of each of them to the local economy, which allowed for a better understanding of the subject. This information was captured and entered into an Excel spreadsheet to facilitate its processing and the creation of graphs to understand its behavior, trends, and selection of the best fit equation.

Fifth stage: selection of the statistical indicator. It was considered that the mathematical formula that best reflects annual growth is the average annual growth rate because it is assumed to be the one that best visualizes the growth of an activity in the medium and long term. Its mathematical expression is:

$$AGCR = ((FV / PI) \wedge (1 / n) - 1)) * 100.$$

Where Vf is the final value for the period; Vi is the initial value for the period; and n is the number of years considered in the analysis.

Similarly, growth in a specific year was taken into account and compared with the previous year to facilitate and identify the sizes of positive and negative increases resulting throughout the period (Addin Technology, 2018). A trend line was also included to provide a better understanding of the evolution of the indicators.

RESULTS

The variables selected to analyze economic performance over the 36-year study period (project horizon) were: i) the area harvested for nopal in hectares in each of the municipalities of Mexico City, ii) nopal production in tons, iii) average yield per hectare of nopal in tons per hectare, iv) average rural price of nopal in pesos per ton, and v) value of nopal production in thousands of pesos; this variable was quantified in two ways, at current pesos and at constant prices.

I. Area harvested for nopal (hectares).

Table 1 shows data on the areas of nopal harvested during the period 2003–2023 in the three boroughs of Mexico City.

Table 1 shows that in 2014 there was a drop of almost a third in the harvested area, and this decline continued for the next 10 consecutive years, while the greatest growth occurred in 1992 in the nopal harvest, reaching its largest harvested area of 4,337 hectares, which remained stable for a period of five years (2006–2010). This area did not recover, but rather declined, reaching its lowest area in 2023 with only 2,947 hectares. The only municipality that reported an area was Milpa Alta, and in 2005, Tláhuac joined in, followed a decade later by Xochimilco. It should be noted that these two municipalities participate in the cultivation of nopal with insignificant areas.

Figure 2 shows the behavior and recovery of the area harvested for nopal in the three boroughs of Mexico City.

Figure 2 shows that, during the first two-thirds of the study period, the harvested area of nopal maintained moderate growth, and from 2013 to the end of the period, there was a drastic decline. The area harvested for nopal in Mexico City's boroughs between the start of the study (1990) and the end of the period (2024) fell significantly, representing a reduction of 39.1% in hectares and a notable decrease from 2013 to 2014. This can be explained by a polynomial equation:

$$y = - 5.8021x^2 + 167.28x + 3129.3$$

$$R^2 = 0.8751$$

The equation shows a high correlation with the downward trend in the area harvested for nopal, which is influenced by the urban expansion of Mexico City.

II. Average yield per hectare (ton/ha).

Table 2 shows the average yields per hectare of nopal obtained during the 36-year analysis period (1989–2024) in the municipalities of Milpa Alta, Tláhuac, and Xochimilco.

Table 2 highlights that the municipality of Milpa Alta led the way in terms of average yield per hectare of nopal in 2014, setting a record in Mexico City with almost 103 tons/ha. Of the three municipalities, the largest percentage increases over the previous year were in 1990 and 2014, with average yields per hectare of just under 63½ tons. Conversely, negative growth overall was seen in 2004 and 2016, with yield decreases of around 20 percentage points.

Figure 3 shows the trend in average yields per hectare of nopal in each of the municipalities of Mexico City, as well as the average of these yields.

The figure above shows that the nopal-producing boroughs of Mexico City have a positive trend in their average yields per hectare, indicating that, despite fluctuations, there is a process of innovation and technological deve-

Year	Milpa Alta	Tláhuac	Xochimilco	Total	Increases (%) + or -
1989	3,373.0			3,373.0	0
1990	3,317.0			3,317.0	-1.66
1991	3,319.0			3,319.0	0.06
1992	3,975.0			3,975.0	**19.76**
1993	4,024.0			4,024.0	1.23
1994	4,054.0			4,054.0	0.75
1995	4,057.0			4,057.0	0.07
1996	4,057.3			4,057.3	0.01
1997	4,057.0			4,057.0	-0.01
1998	4,057.0			4,057.0	0.00
1999	4,159.0			4,159.0	2.51
2000	4,159.0			4,159.0	0.00
2001	4,159.0			4,159.0	0.00
2002	4,159.3			4,159.3	0.01
2003	4,176.0			4,176.0	0.04
2004	4,176.0			4,176.0	3.83
2005	4,326.0	10.0		4,336.0	0.00
2006	4,327.0	10.0		4,337.0	0.02
2007	4,327.0	10.0		4,337.0	0.00
2008	4,327.0	10.0		4,337.0	0.00
2009	4,327.0	10.0		4,337.0	0.00
2010	4,327.0	10.0		4,337.0	0.00
2011	4,327.0	4.0		4,331.0	-0.14
2012	4,327.0	4.0		4,331.0	0.00
2013	4,327.0	4.0		4,331.0	0.00
2014	2,852.0	22.0	32.0	2,906.0	**-32.90**
2015	2,850.0	22.0	32.0	2,904.4	-0.07
2016	2,850.0	22.0	31.5	2,903.5	-0.02
2017	2,743.0	22.0	32.0	2,797.0	-3.67
2018	2,634.0	15.0	32.0	2,681.0	-4.15
2019	2,434.0	15.0	32.0	2,481.0	-7.66
2020	2,234.0	15.0	33.0	2,282.0	-8.02
2021	2,2014	15.0	33.0	2,552.0	-1.31
2022	2,184.0	15.0	31.0	2,230.0	-.0.08
2023	2,004.0	14.0	29.0	2,047.0	-8.21
2024	2,054.0	14.0	29.0	2,097.0	2.44

Table 1. Harvested area of nopal in hectares in the boroughs of Milpa Alta, Tláhuac, and Xochimilco from 2003 to 2023.

Source: SIAP: Historical data on planting and harvesting progress 2003–2024

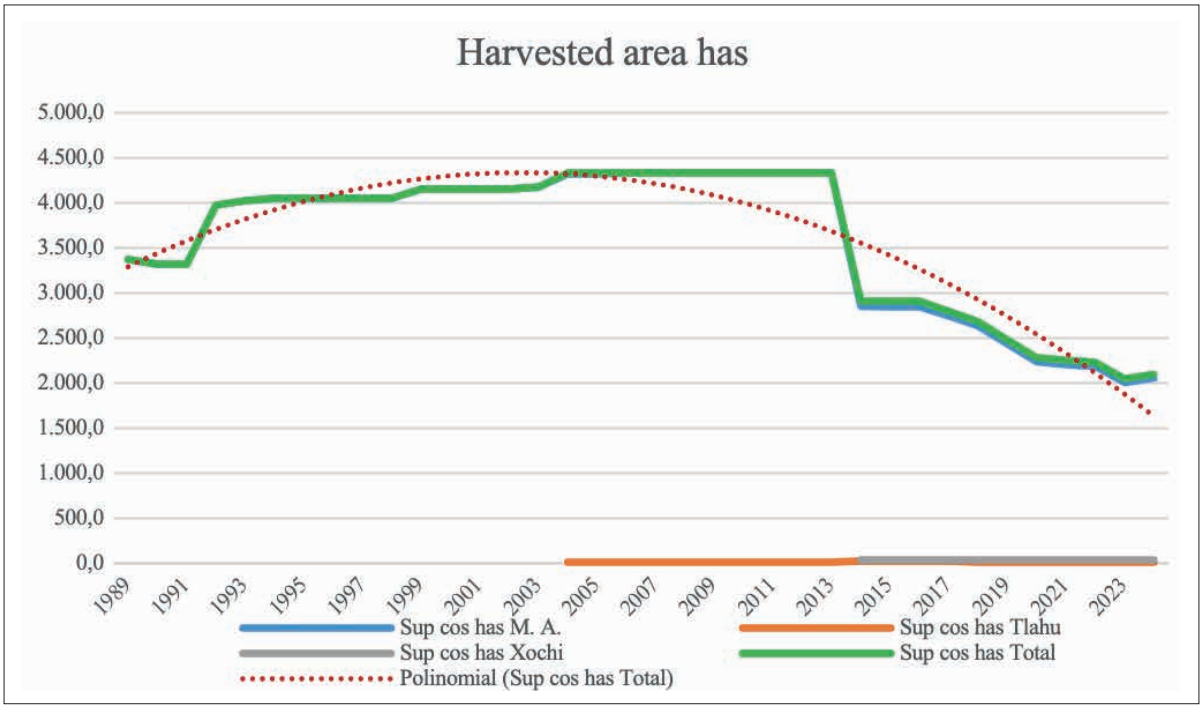

Figure 2. Nopal harvest area in the boroughs of Mexico City during the period 1990–2024.

Year	Milpa Alta	Tláhuac	Xochimilco	Total	Increases (%) + or -
1989	30.16			30.16	0
1990	49.30			49.30	**63.46**
1991	52.29			52.29	6.06
1992	60.00			60.00	14.74
1993	52.66			52.66	-12.23
1994	59.58			59.58	13.14
1995	66.40			66.40	11.45
1996	68.48			68.48	3.13
1997	76.98			76.98	12.41
1998	66.66			66.66	-13.41
1999	62.27			62.27	-6.59
2000	68.52			68.52	10.04
2001	73.04			73.04	6.60
2002	67.38			67.38	-7.75
2003	80.52			80.52	19.50
2004	63.85	27.60		63.76	**-20.81**
2005	72.55	19.60		72.43	13.60
2006	65.52	38.80		65.46	-9.62
2007	68.12	35.00		68.04	3.94
2008	$62.95	45.50		62.91	-7.54
2009	74.36	36.00		74.27	18.06
2010	67.98	34.00		67.90	-8.58
2011	78.89	22.20		78.84	16.11
2012	77.80	58.50		77.78	-1.34

2013	62.36	54.00		62.36	-19.83
2014	102.80	47.14	60.00	101.91	63.42
2015	87.82	74.82	83.50	87.68	-13.96
2016	70.38	63.00	66.13	70.28	-19.84
2017	72.85	73.58	74.63	72.88	3.70
2018	76.10	73.00	73.60	76.05	4.35
2019	91.87	86.00	91.91	91.84	20.76
2020	91.92	85.00	88.00	91.82	0.02
2021	86.50	86.67	84.94	86.48	-5.82
2022	89.00	87.00	86.77	88.95	2.86
2023	90.48	86.43	87.00	87.00	1.63
2024	81.95	72.50	81.03	81.87	-9.44

Table 2. Average yield per hectare of nopal (ton/ha) in the boroughs of Milpa Alta, Tláhuac, and Xochimilco for the analysis period 1989–2024.

Source: SIAP: Historical data on planting and harvesting progress 2003–2024

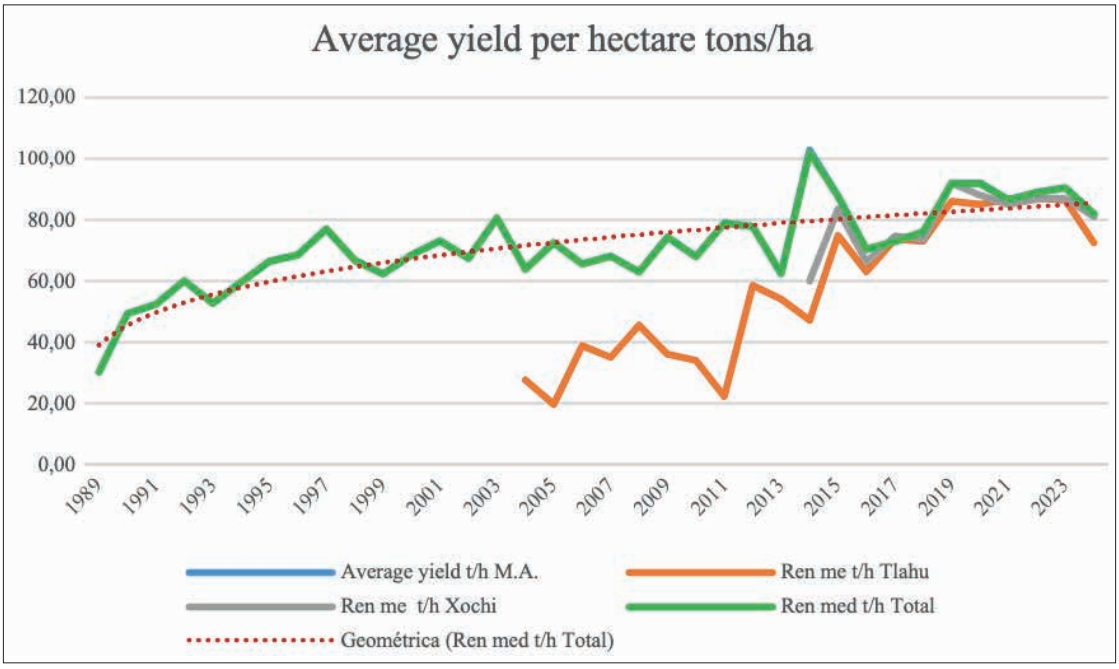

Figure 3. Average yields per hectare of nopal in the boroughs of Mexico City 1980–2024.

lopment in nopal plantations, as well as adoption by producers engaged in the production of this cactus.

The best equation describing the behavior of average yields per hectare of nopal cultivation in Mexico City is a potential type with the formula:

$$y = 39.071x^{0.2183}$$

$$R^2 = 0.731$$

The correlation of R^2 is considered adequate and acceptable in terms of average yield per hectare.

The municipality that stands out in terms of average yield per hectare is Milpa Alta, which has the highest nopal productivity. However, despite only starting nopal production in 2014, Xochimilco is very close to Milpa Alta's productivity.

III. Production

Table 3 shows the nopal production generated during the 36 years of analysis in the three boroughs of Mexico City.

Table 3 shows that, during the period analyzed, the municipality that contributed the largest amount of nopal was Milpa Alta. It is noteworthy that the municipality of Xochimilco, despite having only recently incorporated nopal into its production, surpassed the municipality of Tláhuac. In the study area, record production occurred in 2012 with 336,852.5 tons, a figure that has not been repeated throughout the period. The lowest cactus pear tonnage coincided with the beginning of the period for which data was available, and the largest percentage decreases in cactus pear production were in 2016 and 2013, reaching 19.86% and 19.83%, respectively, compared to the previous year.

Figure 4 shows the behavior of nopal production in each of the municipalities and the sum of the three.

The trend resembles a parabola, which from the beginning of the period (1989) until 2011 is upward (with peaks and valleys), at which point Mexico City reached its highest nopal production, and from that point onward, a decline began, also with ups and downs, a situation caused by the growth of the urban sprawl that demands space for housing and real estate developments.

The equation that best explains the trend in total nopal production in the three boroughs of Mexico City is a polynomial equation with the following formula:

$$y = -511.19x^2 + 1852x + 137328$$

$$R^2 = 0.7729$$

This is slightly acceptable in its correlation, due to strong variations in production during the analysis period. The tonnage of nopal from the three municipalities represented the second highest national production of nopal in 2023, after the state of Morelos.

IV. Average rural price ($/ton).

Market prices in rural areas are a major factor in decision-making by nopal producers, as they encourage or discourage the production of this cactus. Table 4 shows the prices per municipality, as well as the average for Mexico City, for the 36 years of the study.

Table 4 shows that the average rural price of nopal during the period analyzed was highest in the municipality of Milpa Alta in most years, and the most significant increase in percentage terms compared to the previous year was observed in 1991, with an increase of just over 170%; This situation was repeated in 2016 with a little over 100%, and the most significant decrease in the price of nopal cactus was in 2011 with almost 50%. The same situation was repeated in 2017 with a very similar proportion, which coincided with a sharp decline in nopal cactus production in Mexico City.

Figure 5 shows the variations in average rural prices for nopal in the municipalities of Mexico City.

The above graph shows a positive slope and intertwining of prices in the three boroughs. The greatest price difference occurred in 2019 between the average price and that of the Xochimilco borough, and the highest price (record) for nopal was in 2016 in the municipality of Tláhuac, and in 2024, the best price was generated in the municipality of Xochimilco.

The best curve to explain this trend is an exponential curve with the following formula:

$$y = 272.09_x^{0.7084}$$

$$R^2 = 0.8332$$

The above equation has a high correlation.

During 2024, the average rural price of nopal nationwide reached $3,459.46, which meant that in Mexico City, this cactus was sold at 7.92% less.

Year	Milpa Alta	Tláhuac	Xochimilco	Total	Increases (%) + or -
1989	101,734.00			101,734.00	0
1990	163,515.00			163,515.00	**60.73**
1991	173,550.00			173,550.00	6.14
1992	238,500.00			238,500.00	**37.42**
1993	211,916.00			211,916.00	-11.15
1994	241,529.00			241,529.00	13.97
1995	269,375.00			269,375.00	11.53
1996	277,854.50			277,854.50	3.15
1997	312,324.00			312,324.00	12.41
1998	270,422.00			270,422.00	-13.42
1999	258,985.00			258,985.00	-4.23
2000	284,961.50			284,961.50	10.03
2001	303,755.00			303,755.00	6.60
2002	280,269.50			280,269.50	-7.73
2003	336,255.42			336,255.42	19.98
2004	276,194.00	276.00		276,470.00	-17.78
2005	313,857.10	196.00		314,053.10	13.59
2006	283,493.50	388.00		283,881.50	-9.61
2007	294,757.80	350.00		295,107.80	3.95
2008	272,367.80	455.00		272,822.80	-7.65
2009	321,742.30	360.00		322,102.30	18.06
2010	294,145.90	340.00		294,485.90	-8.57
2011	341,365.50	88.80		341,454.30	15.95
2012	336,648.50	234.00		336,882.50	-1.34
2013	269,848.00	216.00		270,064.00	**-19.83**
2014	292,983.60	1,037.00	1,920.00	295,940.60	9.58
2015	250,292.80	1,646.00	2,672.00	254,610.80	-13.97
2016	$200,578.79	1,386.00	2,083.00	204,047.79	**-19.86**
2017	199,836.50	1,618.82	2,388.00	203,843.32	-0.10
2018	200,437.80	1,095.00	2,355.20	203,888.00	0.02
2019	223,613.90	1,290.00	2,941.00	227,844.90	11.75
2020	205,360.00	1,275.00	2,904.00	209,539.00	-8.03
2021	190,648.00	1,300.05	2,803.02	194,751.07	-7.06
2022	194,368.00	1,305.00	2,690.00	198,363.00	1.85
2023	181,312.00	1,210.02	2,523.00	185,045.02	-6.71
2024	168,321.50	1,015.00	2,349.87	171,686.37	-7.22

Table 3. Nopal production in tons in the boroughs of Milpa Alta, Tláhuac, and Xochimilco during the analysis period 1989–2024.

Source: SIAP: Historical data on planting and harvesting progress 2003–2024

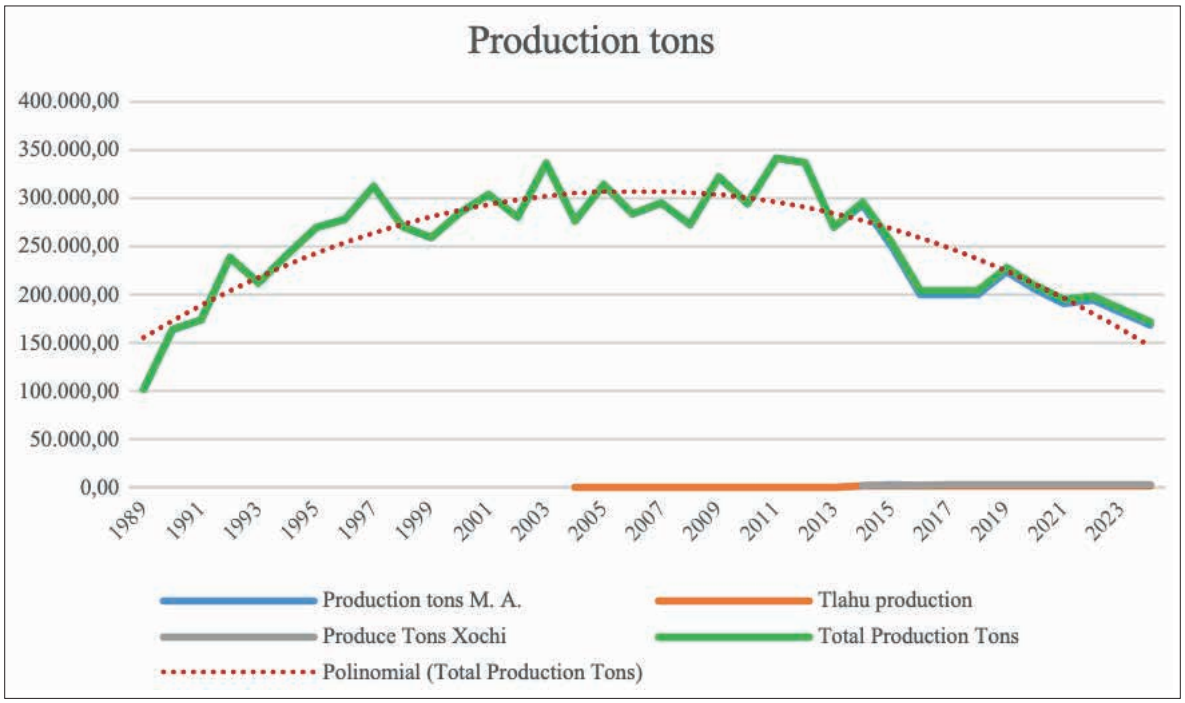

Figure 4. Production of nopal in tons in the three municipalities and the total for Mexico City.

Year	Milpa Alta	Tláhuac	Xochimilco	Total	Increases (%) + or -
1989	290.03			290.03	0
1990	350.00			350.00	20.68
1991	950.00			950.00	**171.43**
1992	600.00			600.00	-36.84
1993	580.00			580.00	-3.33
1994	575.00			575.00	-0.86
1995	1,000.00			1,000.00	73.91
1996	932.52			932.52	-6.75
1997	1,416.00			1,416.00	51.85
1998	2,047.26			2,047.26	44.58
1999	2,074.26			2,074.26	1.32
2000	1,647.72			1,647.72	-20.56
2001	2,544.09			2,544.09	54.40
2002	2,729.73			2,729.73	7.30
2003	2,302.21			2,302.21	-15.66
2004	1,708.49	2,133.77		1,708.89	-25.77
2005	1,441.21	1,388.27		1,441.18	-15.67
2006	2,903.60	2,559.28		2,903.13	1.44
2007	2,596.45	2,981.43		2,596.91	-10.55
2008	2,964.39	2,887.91		2,964.26	14.15
2009	2,407.09	2,198.81		2,406.86	-18.80
2010	2,995.53	3,251.47		2,995.53	24.46
2011	1,743.21	1,298.42		1,743.09	**-49.81**
2012	1,901.20	2,163.23		1,901.39	9.08

2013	3,198.96	2,243.51		3,198.20	68.20
2014	2,080.66	2,198.00		2,080.55	-34.95
2015	1,851.68	1,703.27	1,797.31	1,850.15	-11.07
2016	3,822.45	3,097.98	2,850.00	3,823.40	**106.65**
2017	1,995.19	1,675.06	1,779.33	1,990.12	**-47.95**
2018	2,850.25	2,800.00	2,875.00	2,850.27	41.22
2019	3,345.69	2,783.16	2,204.48	3,327.78	16.75
2020	2,893.14	2,921.27	2,610.09	2,889.39	-13.17
2021	3,402.21	3,006.39	3,200.00	3,396.65	17.56
2022	3,394.16	3,402.10	3,202.15	3,391.61	-0.15
2023	3,429.82	3,452.85	3,430.24	3,430.24	1.14
2024	3,278.85	3,474.73	3,691.12	3,286.63	-4.19

Table 4. Average rural price of nopal ($/ton) in the municipalities of Milpa Alta, Tláhuac, and Xochimilco, and average rural price for the period (1989–2024).

Source: SIAP: Historical data on planting and harvesting progress 2003–2023

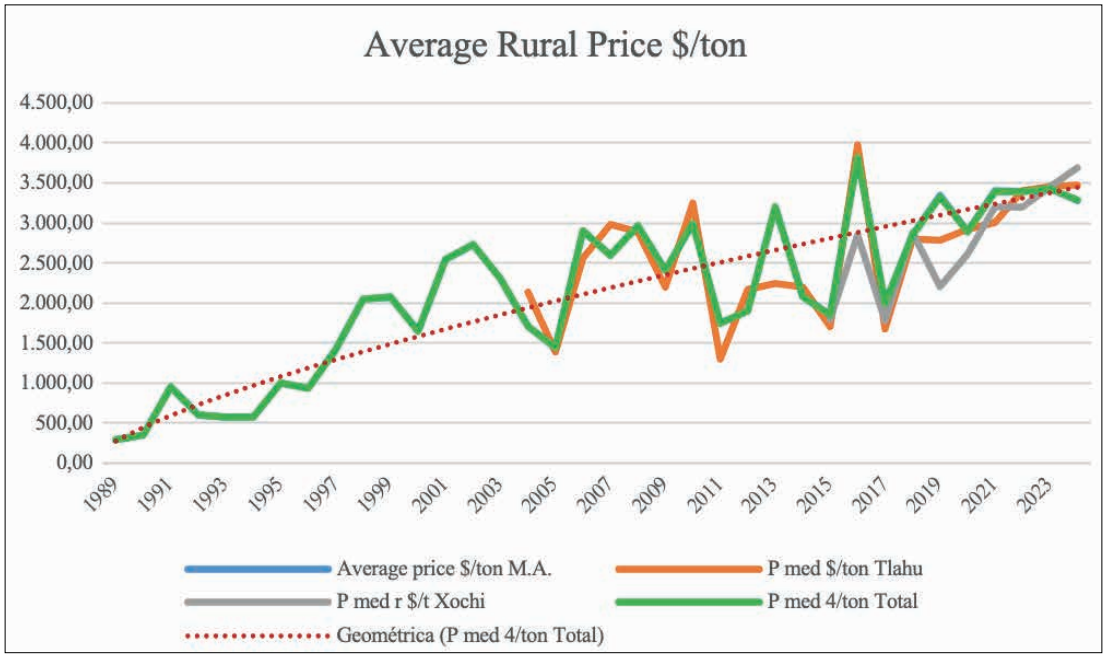

Figure 5. Average rural price ($/ton) of nopal and weighted average price in the three boroughs of Mexico City.

Year	Production Value Current Prices	Increases (%) + or -	Production Value Constant Prices	Increases (%) + or -
1989	29,505.71	0	*2,404.72	0
1990	57,230.25	**93.96**	4,373.54	81.87
1991	164,872.99	**188.09**	15,588.74	**255.75**
1992	143,100.00	-13.21	15,533.51	-0.16
1993	122,911.28	-14.11	14,609.23	-5.95
1994	138,879.18	12.99	17,886.25	22.43
1995	269,375.00	**93.96**	48,158.86	**169.25**
1996	259,104.88	-3.81	58,689.85	17.71
1997	442,250.78	70.68	117,939.44	108.04

1998	553,678.23	25.20	170,859.56	44.87
1999	537,202.23	-2.98	191,168.79	11.89
2000	469,536.76	-12.60	184,964.62	-3.25
2001	772,780.06	64.58	324,121.73	75.23
2002	765,060.06	-1.00	338,546.73	4.45
2003	774,130.59	1.19	357,217.93	5.52
2004	472,458.09	**-38.97**	235,710.04	**-34.09**
2005	452,606.09	-4.20	239,094.48	1.54
2006	824,144.73	82.09	461,952.49	93.21
2007	766,367.39	-7.01	455,889.90	1.31
2008	808,718.38	5.53	511,441.47	12.19
2009	775,254.17	-4.14	515,986.04	0.89
2010	882,140.12	13.79	612,800.95	18.78
2011	595,187.05	-32.53	436,903.51	-28.70
2012	640,543.73	7.62	491,555.48	12.51
2013	863,717.56	34.84	674,113.52	37.14
2014	615,718.59	-28.71	501,547.94	-25.60
2015	471,068.16	-23.49	$389,096.16	-21.03
2016	780,156.37	65.61	695,860.49	75.68
2017	405,673.34	**-48.00**	385,604.55	**-44.59**
2018	581,135.60	43.25	581,135.60	50.71
2019	758,216.94	30.47	790,964.41	36.11
2020	605,440.37	-20.15	660,767.51	-14.46
2021	661,502.02	9.26	754,353.28	14.16
2022	672,770.56	1.70	817,050.20	8.31
2023	634,749.72	-5.65	805,255.95	-1.44
2024	564,269.47	-11.10	*757,023.92	-5.99

Table 5. Value of nopal production (thousands of $) at market prices and deflated with base year 2018 in Mexico City in the period 1989 to 2024.

Source: SIAP: Historical data on planting and harvesting progress 2003–2023 and World Bank https://datos.bancomundial.org/indicator/NY.GDP.DEFL.ZS?locations=MX * Deflation index values for 1989 and 2024 were estimated based on a polynomial function.

V. Production value (thousands of $).

For this variable, market prices and deflated prices were used in order to compare them over time, taking into account the INEGI's determination of 2018 as the base year for this analysis (Table 5).

The table above shows that both at current (or market) values and at constant (or deflated) values, the period from 1989 to 2024 was characterized by price turbulence, with falls and rises reaching maximum and minimum values, with percentage increases over the previous year showing negative figures for both current and constant values; in the first case, with values of -48% and -39% in 2017 and 2004, up to positive values of 188% and 94% in 1991, 1992, and 1995. for constant values, the strongest percentage decreases were in 2017 and 2004 with figures of -46% and -34%, reductions that coincide with those of current values, although to a lesser extent, and the increases occurred in 1991 and 1995 with values of 256% and 159%.

Figure 6 shows the parallelism between the value of nopal production at current and constant prices. At the beginning, current values are higher than constant values, but over time

the gap closes until the base year 2018, when they equalize, and constant values begin to exceed current values.

The gap in the base year of the analysis (1989) between current and constant values is 12.27 times, favorable to constant values, while at the end of the study period (2024), the gap shifts favorably to constant values by 0.75 times. The maximum value of nopal production at current prices was reached in 2010 with 882.1 million pesos, and at constant values it was in 2022 with 817 million pesos.

In 2024, Mexico City ranked second after the state of Morelos in terms of the value of nopal production at current or market prices. The value of nopal production nationwide reached 3.0135 billion pesos in that year. When comparing the value of nopal production in Mexico City ($564.3 million) to the national total, it represented 18.72%.

VI. Average annual growth rates (%).

Table 6 shows the average annual growth rates of the variables selected over the 36-year project horizon (1989–2024).

Table 6 shows that, of the six variables, only the area harvested for nopal cactus decreased, representing a reduction of more than one-third (37.83%) of the area dedicated to the production of this cactus. This did not affect production, which grew by more than two-thirds (68.76%), driven by an increase in average yield per hectare, which rose 2.67 times from the beginning to the end of the period, mainly due to technological innovations applied to this crop.

INEGI 2022 mentions that, in the reference year, Mexico City had an agricultural area of 19,233 hectares, which meant that the area of nopal cactus in the same year in the three municipalities totaled 2,230 hectares, meaning that this edible product occupied 11.59% of the agricultural area.

Table 7 shows the behavior of the average annual growth rates of each of the variables under study during the six six-year periods.

The table above shows that the first two six-year terms saw growth in all the variables considered in the study, with the first term showing greater increases during its administration. From the third six-year term onwards, lower rates were observed, with several decreases, and during the last six-year term, all variables showed negative results. The variables with average annual growth rates occurred in the first six-year term in the variables of production value at both current and constant prices; conversely, the lowest rates of performance were in the 2007/12 six-year term in the variables of harvested area and production value at current prices.

CONCLUSIONS

The harvested area of nopal in Mexico City remained more or less constant for five five-year periods, with slight growth, but in 2014, there was a drop in the area planted by one-third compared to the previous year, a situation that continues to decline until 2024, mainly due to the strong interference of real estate developers who are constantly looking for space for housing and commercial areas.

The opposite situation occurred with the average yield per hectare of nopal, which increased considerably by just over half, with a positive trend. This was achieved in part by the Mexico City agricultural extension program, which implemented technological innovations among extension technicians and nopal producers.

The average rural price paid to producers continues to grow in line with national standards, with a peak in 2017 that has not been repeated since. There are slight variations in the three municipalities studied, with a slight predominance in Milpa Alta.

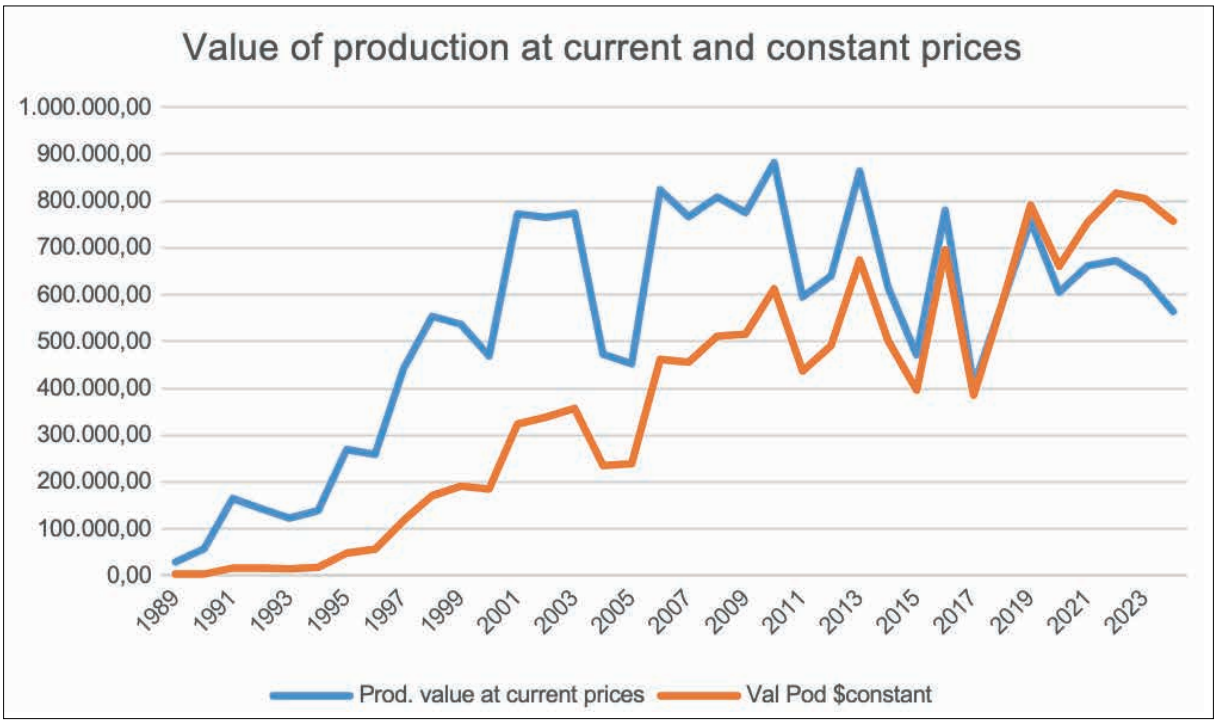

Figure 6. Total nopal production values in thousands of pesos at current and constant values in Mexico City.

Variables	Average annual growth rate (%)
Harvested area (ha)	-1.31
Average yield per hectare (tons/ha)	2.81
Production (tons)	1.46
Average rural price ($/ton)	6.98
Production value at current prices (thousands $)	8.54
Production value at constant prices (thousands $)	17.32

Table 6. Average annual growth rates for the period 1989–2024 for the selected variables for nopal in Mexico City.

Variables *	1989/94	1995/00	2001/06	2007/12	2013/18	2019/24
Harvest area	3.11	0.41	0.70	-7.68	-0.02	-2.76
Average yield per hectare	12.02	0.53	-1.81	3.36	-0.15	-1.90
Production	15.50	0.94	-1.12	-4.58	-0.17	-4-61
Average Rural Price	12.08	8.68	2.22	-1.90	1.27	-0.21
Current market value	29.46	9.70	1.08	-6.39	1.10	-4.80
Val Prod $constant	39.71	25.14	6.08	-2.44	4.71	-0.73

Table 7. Average annual growth rates by six-year periods for each of the variables studied in nopal cactus in Mexico City.

*Note: 1989–94 Carlos Salinas de Gortari. 1995–00 Ernesto Zedillo Ponce de León. 2001–06 Vicente Fox Quezada. 2007–12 Felipe de Jesús Calderón Hinojosa. 2013–18 Enrique Peña Nieto. 2019–24 Andrés Manuel López Obrador

The value of production, like prices, maintains a positive trend, with three sharp declines during the period under review in 2004, 2011, and 2017.

When considering the growth of the nopal sector by six-year period, the highest growth was achieved between 1989 and 2004, and the largest decline was between 2007 and 2012.

REFERENCES

Addin Technology Incorporated. (2018). How to calculate average/compound annual growth rate in Excel? ExtendOffice. https://www.extendoffice.com/es/documents/excel/2596-excel-average-compound-growth-rate.html

Ciudad de México (2020). Un diagnóstico de la desigualdad territorial. http://data.sedema.cdmx.gob.mx/biodiversidadcdmx/suelos.html

Comisión Nacional de Población. 2025. Indicadores Demográficos de la Ciudad de México 2025. http://www.conapo.gob.mx/work/models/CONAPO/Mapa_Ind_Dem18/index.html consultado julio de 2025.

Instituto Nacional de Estadística y Geografía. (2025). PIB- Entidad Federativa, anual. http://www.inegi.org.mx/est/contenidos/proyectos/cn/pibe/tabulados.aspx consultado en julio de 2025.

Instituto Nacional de Estadística y Geografía. (2016). https://www.inegi.org.mx/app/areasgeograficas/?ag=09 consultado en febrero de 2019.

Instituto Nacional de Estadística, Geografía e Informática. (2022). Censo Agropecuario 2022. Comunicado de Prensa 674/23. Consultado en julio de 2024.

Moctezuma L.G., Romero S. M.E., Galicia L.C.A. y Castillo C. A. L. 2017. Extensionismo Agrícola en la Ciudad de México (CD**MX**). Memoria XXX Congreso Internacional de Administración en Empresas Agropecuarias. San José del Cabo, Baja California Sur. México.

Moctezuma, L. G., Ramírez, S. E. U., Velázquez, F. L., Vélez, I. A. y Romero, S. M. E. 2018. Extensionismo rural en la Ciudad de México: aportes del INIFAP al desarrollo de capacidades en el campo. Memorias 60 Años de Investigación Forestal en Coyoacán. INIFAP. CENID – COMEF. Ciudad de México. México. 255 – 267 pp.

Secretaría de Agricultura, Ganadería, Desarrollo Rural, Pesca y Alimentación (SAGARPA). 2015. Estudios de factibilidad para el establecimiento del cultivo de nopal (*Opuntia*) en tierras ociosas en los estados de Aguascalientes, San Luis Potosí, Guanajuato y Zacatecas con fines alimenticios, energéticos y ambientales. Informe detallado. México. 94 pp.

Secretaría de Agricultura, Ganadería Desarrollo Rural, Pesca y Alimentación. (2017). Transformación y aprovechamiento de nopal. Desarrollo, promoción y difusión de modelos de innovación y desarrollo tecnológico para el campo mexicano. Cuaderno No. 6 de casos sobresalientes con nopal. México, D. F. 11 p.