CHINAMPA AGRICULTURAL SYSTEM OF MEXICO CITY
MEXICO

A PROPOSAL FOR DESIGNATION AS
GLOBALLY IMPORTANT AGRICULTURAL
HERITAGE SYSTEMS
(GIAHS)

GOVERNMENT OF MEXICO CITY
AUTHORITY OF THE WORLD NATURAL AND CULTURAL HERITAGE ZONE
IN XOCHIMILCO, TLÁHUAC AND MILPA ALTA

MEXICO CITY
JULY 7th, 2017

TABLE OF CONTENTS

Annexes

Globally Important Agricultural Heritage Systems (GIAHS)

Information Summary

Name/title of the Globally Important Agricultural Heritage System

Chinampa agricultural system in Mexico City, MEXICO

Requesting Agency/Organization:

Government of Mexico City/Authority on the World Natural and Cultural Zone of Heritage of Xochimilco, Tláhuac and Milpa Alta.

Country/Location/Site[1]

In Mexico (Annex 1), in the capital Mexico City or formerly Federal District (150,000 ha in area composed of 16 delegations or municipalities) within the rural area of the city, classified as Area of soil Conservation (85,000 ha with 7 municipalities in southern Mexico City, with the presence of 36 rural villages that are over 500 years old) and within the Natural and Cultural World Heritage Area Site in Xochimilco, Tláhuac and Milpa Alta (7,534 ha with 3 municipalities and twelve rural villages); currently, there is a chinampa agricultural system that integrates five areas of active chinampas, three in the municipality of Xochimilco (Nahuatl: place of flowers) and two in the municipality of Tláhuac (Nahuatl: place of who takes care of the water), which cover a total of 2,215 ha in five rural villages (Figure 1). These areas correspond to the proposed GIAHS site. The geographical coordinates of the site are: 19º 19’ 13.52” y 19º 12’ 37.75” North, y 98º 56’ 25.76” y 99º 07’ 00.83” West.

[1] See the folowing maps:

a) Map of Mexico (Annex 1).
b) Map of Mexico City and neighboring states (Annex 2)
c) Site Map in the context of Mexico City and its ecological framework (Annex 3)
d) Map of the site (Annex 4).
e) Maps of the five chinampas zones and its active chinampas (Annex 5 to 10).

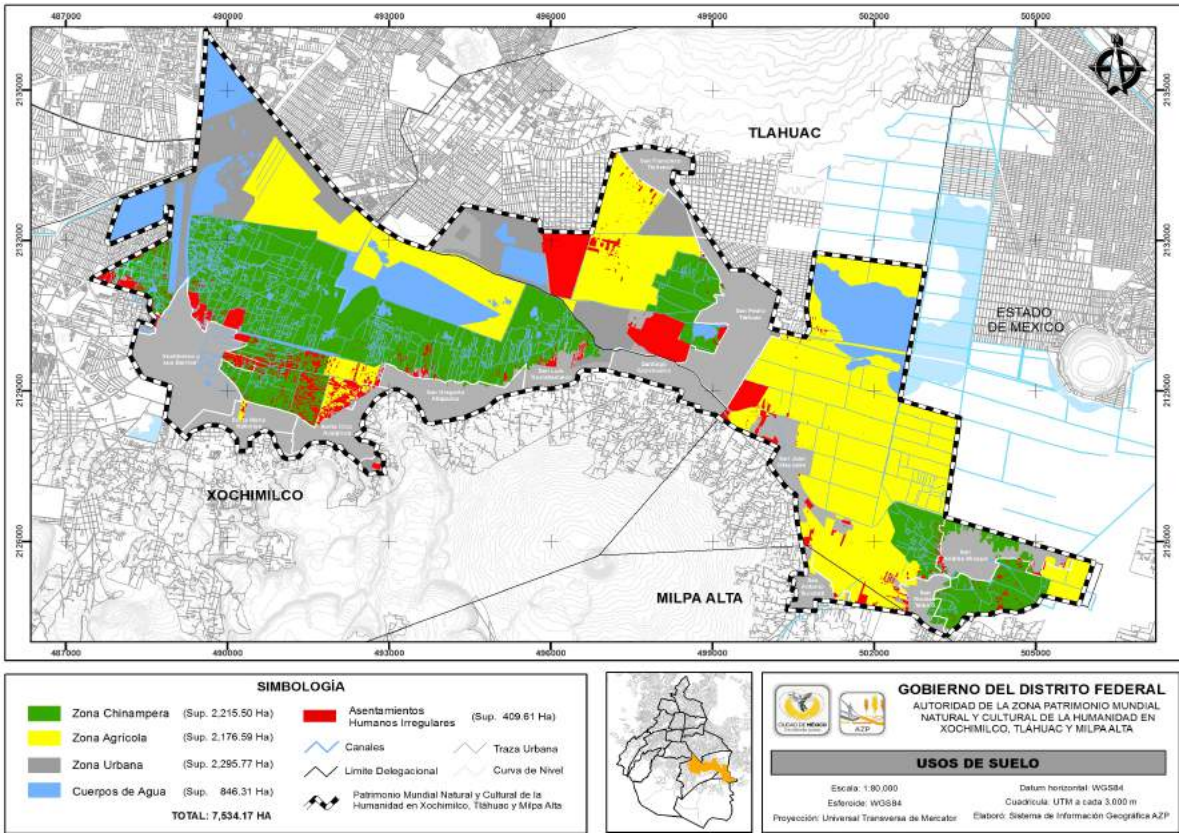


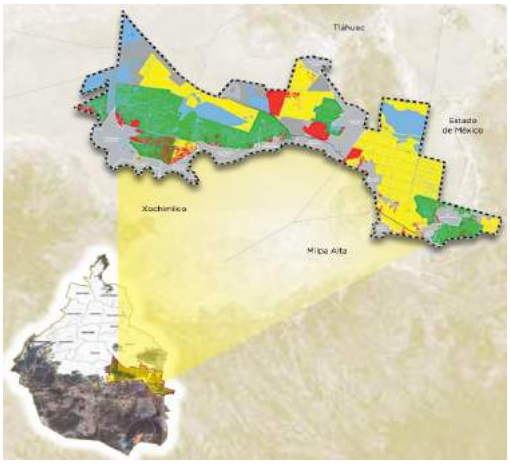
Figure 1. Map of the heritage zone with the location of chinampa agricultural system in Mexico City.

Chinampa agricultural system

Twelve rural towns

Agricultural zone

Wetlands



Attainability of the site to important cities:
The site is located in the center of Mexico City, to 18 km south of his historic center, it can be reached by car (about 45 minutes) or from every place by the most used urban mains of transportation, which are varied and frequent to access the site (Annex 11).

Approximate surface area:
75.34 square kilometers (7,534 ha). It corresponds to the declared by UNESCO as a World Natural and Cultural Heritage Zone in Xochimilco, Tláhuac and Milpa Alta, and it is also part of a Protected Natural Area, including 2,600 has. that has been declared as a Ramsar Site, Wetland of International Importance (Figure 2). According to the chinampas cataloging system in this heritage area, five chinampas zones are located with strictly rural characteristics, preserved around the still prevalent rural villages, covering an area of 2,215 ha: three in the municipality of Xochimilco (Xochimilco, San Gregorio Atlapulco y San Luis Tlaxialtemalco) and two in the municipality of Tláhuac (San Pedro Tláhuac y San Andrés Mixquic). Around this area still remains an extensive canal network covering more than 406 km long that provides water for chinampas agricultural activities (Gonzalez-Pozo, 2014).

Agro-ecological zone:
Tropical high, temperate with vegetables and ornamental.

Topographical features:
The land is predominately flat; due to it is located on an old lakebed into the endorheic Valley of Mexico closed basin. The site is part of the lake area and represents the last stronghold of the 5 lakes that formed this Cuenca. The elevation of this site is between 2,242 and 2,236 meters above sea level.

Climate:
Yearly rainfall is about 700 mm. having a sub humid weather. Average annual temperatures is of 16, 2º.

Approximate population:
The population living into the site is of 255,000 inhabitants (González-Pozo, 2014), distributed in twelve locations, which, since Aztec times, have been linked to the agricultural production on the chinampas[2]

[2] Xochimilco, Santa María Nativitas, Santa Cruz Acalpixca, San Gregorio Atlapulco, San Luis Tlaxialtemanco, Santiago Tulyehualco, San Francisco Tlaltenco, San Pedro Tláhuac, San Juan Ixtayopan, San Antonio Tecomitl, San Nicolás Tetelco y San Andrés Mixquic.

Main source of livelihoods:
Agriculture (vegetables and ornamentals) tourism and urban employment.

Ethnicity/Indigenous Population
A majority, about 60 % of farmers are descendants of the original indigenous inhabitants. Between 5 and 10% of them still understand or speak the language Nahuatl of the Aztec, which is one of the most researched ancient civilizations in the world (Rodríguez-Alegría y Nichols, 2016).

Summary Information of Agricultural Heritage System:
Chinampa is the Aztec name for an ancestral agro-productive system, which consists of plots of land in the middle of the lake. It is an island surrounded by three or four small channels, which work as a water body and drainage. It is a kind of agriculture that allows five crops per year. Also known as floating gardens, the chinampa agricultural system is nowadays used for floriculture and for vegetables planting, agroproductive systems comprising 36% (1,294) and 64% (2,292) of the total chinampas (3,586), respectively (González-Pozo, 2014) (Annex 5). The main features are:
(I) Formed by a diversified agriculture, which includes horticulture, floriculture and the production of basic crops for its regional consumption as well as the consumption by many metropolitan residents.
(II) Biodiversity, because besides of the endemic and introduced agricultural products, they offer ecologic niches for the aquatic fauna and for the endemic or transitory bird populations.
(III) The landscape follows a special pattern of elongated islands with a prevailing direction that shows a slight deflection of 15 ° from North to East. This direction has a coincidence with other prehispanic models, among them, the Teotihuacan's urban pattern. The accumulation of thousands of cultivated chinampas, ahuejote trees and hundreds of kilometers of water channels in a huge territory not only make up an impressive cultural and productive site itself, but it also represents an esthetic landscape articulated by the water, the soil, the trees, the fauna and the natural environment, which can be enjoyed by this great city's people with a population of more than 20 million inhabitants.
(IV) The chinampa agricultural system is officially administrated by local, metropolitan and federal authorities, but its operation and agriculture productivity are still in the original farmers' hands, which are the landowners.

(V) The cultural diversity and the natural environment offer different ecosystem products and services. It is estimated that the chinampas wetland agroecosystem has a monetary value between $ 15.6 million and $ 31.5 million USD / ha / year (Aguilar *et al.,* 2013). As a result of its aesthetic value and its cultural importance, the chinampas were declared as a part of the heritage of humanity by the UNESCO in 1987 (Clauzel 2009), a natural area protected by the Mexican government in 1992 and a Ramsar site in 2004 due to its supply of the ecosystems services (namely, a recharge of underground aquifers, a local and regional water flow regulation and biodiversity keeping) (Merlin-Uribe *et al.,* 2013).
(VI) They provide a history with sustainable paths with economic and viability capacities to face process of changes, such as urbanization.

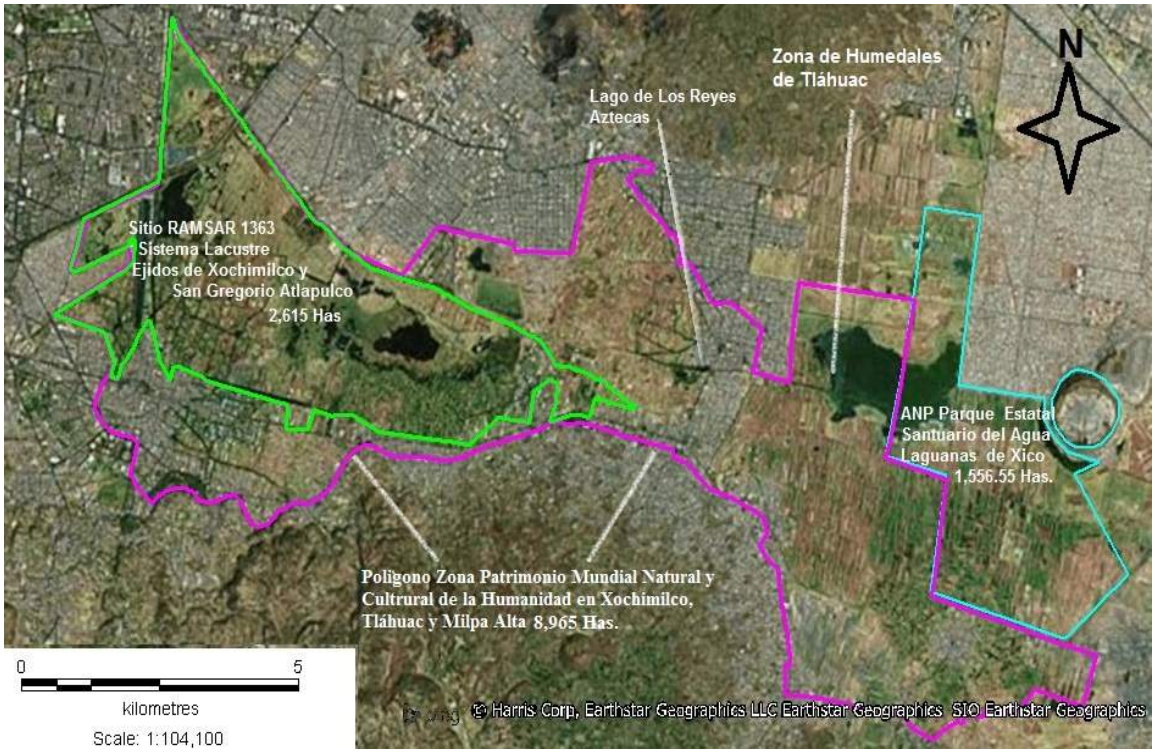


Figure 2. International Declarations Sites in the Chinampa Area.

Figure 3. Chinampas Geographical Landscape.

Figure 4. Chinampas Landscape and making seedbeds

DESCRIPTION OF THE GLOBALLY IMPORTANT AGRICULTURAL HERITAGE SYSTEM

I. Characteristics of the GIAHS proposed

Archaeological evidence of the presence of chinampas in ancient lakes in southern Mexico Valley dates back more than a millennium (González-Pozo, 2014). The chinampas are a kind of wetland raised-field agriculture composed by small islands in strips, built with the sediments from the lake bottom, branches and decaying vegetation, creating a web of channels. The channels form part of the irrigation system and have an average depth of 1.5 meters (Contreras et al., 2009).

The chinampas agricultural system is an articulated set of floating artificial islands built in a traditional way based on oral transmission chinampera prevailing culture since Aztecs times. They offer high agricultural productivity (grown up to 5 times a year) and great ecological importance, surrounded by canals and ditches and rows of "ahuejotes" (*Salix Bonplandiana*) native willow species that performs several functions, including fences live and windbreaks and insects, habitat for birds, and keep the soil in the plots, whose roots protect the borders or edges chinampa erosion. Its agroforestry elements and the channels, which are between 4 and 6 m average width that are used as means of transport navigated by canoes and trajineras, loaded with goods, farmers and tourists compose the chinampas landscape.

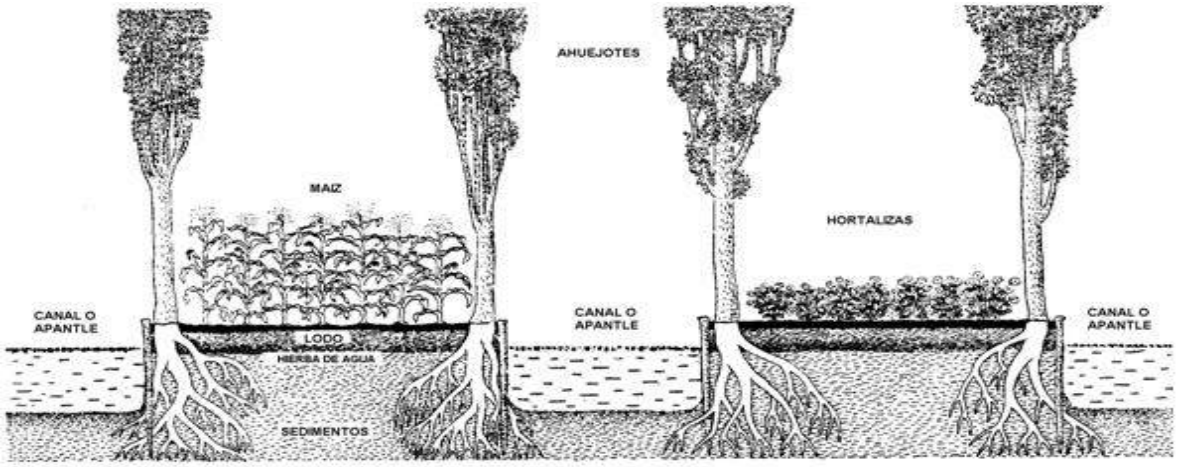


Figure 5. Traditional chinampa scheme, physical structure.

According to Koohafkan (2012), the chinampas developed by the Aztecs in Mexico, as agricultural ecosystems based on corn, may be classified and typified as GIAHS in accordance with the importance of the management systems, the high levels of agricultural biodiversity and the associated biodiversity, and the biophysical, economic and socio-cultural resources which have evolved under the specific ecologic and socio-cultural constraints and opportunities. The chinampas include a highly sophisticated and complex micro-climate, soil and water handling; adaptive use of numerous varieties of crops to deal with climate variability; the integrated agro forestry and a wealth of indigenous knowledge and an associated cultural heritage.

The chinampas depicts an example of traditional agricultural systems adapted to the environmental change conditions through the time (Onofre, 2005). They form part of the agriculture on median strips, which have been also found in other places in the world like China and Thailand, and stand for an agricultural production system based on permanently flooded areas or swamps bordering lakes (Altieri y Nicholls, 2008). The chinampas of Mexico, that are known at present, arise from the agricultural development based on a wide irrigation web with flooding systems and channels, corresponding to a technology level reached in the agriculture rarely equaled in other parts of the world during the late Aztec period 1325-1521 (León-Portilla, 1992) rarely matched elsewhere in the world. The urban centers growing in the lakes of Tenochtitlan (Today Mexico City) was correlated to the chinampas system evolution, which is considered surrounding and inner city agriculture. Along history, the use of the human work, the agricultural hydraulic technological sophistication, the natural resources distribution and use, and the innovations on the farming intensive production have been one of the main regional economic activities and of supply of food

and ornamental plants for Mexico City. The chinampas are an example of ecologic engineering with wide contributions to the contemporary sustainability (Renard *et al.,* 2012).

Based on a contemporary characterization of the chinampa agricultural system based on the analysis of the historical evolution of land use and the identification of the social strategies that have sustained the socio-environmental resilience and adaptability of the system (Jiménez, 2013), it is identified that the worldwide importance and current validity of this site is that, despite the expansion of the urban spot in Mexico City over the lake area of Xochimilco, the general state of the multifunctionality of the chinampas and, therefore, the services ecosystems and agrodiversity, are an example of how agriculture is a social construction that is associated with the maintenance of biodiversity, local economy, territorial configuration, re-appropriation of the heritage of lakes, particularly. Faced with climatic contingencies such as frost or variation in rainfall, chinampera agriculture offers an example of the intensification of current and future agroecological multifunctionality that allows integration into the planning of urban development and the revitalization of the heritage by linking social networks, which develop technological strategies and promote solidarity and a sense of community. In this way, the nature of this type of agriculture implies the conservation of the water resources (ie the channels) and of the biodiversity, and the natural resources that allow a management congruent with the temporal, spatial and jurisdictional scales, which in turn determine their ability to provide food security and satisfiers of rural origin such as ornamental plants. The chinampa agricultural system of the lake area of Xochimilco represents a multifunctional activity complementary to the urban dynamics of Mexico City that fulfills integral objectives of socioenvironmental sustainability, which include the satisfaction of the needs of social and economic welfare the local and regional population (Jiménez, 2013).

It is estimated that if the Xochimilco wetlands did not exist the temperature of Mexico City would be 2ºC higher, at the same time it is reported that the chinampas sequester 110 tons / ha of carbon per year (Natoure, 2016). In summary, the chinampa agriculture makes up a world example of farming systems on raised beds in wetlands brought under temporary flooding (Altieri *et al.,* 2015) at the same time that it is an international referring of urban agriculture with the potential for the agricultural systems development which supplies food and ornamental products to the local rural settlers and urban centers worldwide.

Figure 6. Historical Chinampas Geographical Landscape in the Aztec era.
Source:https://mx.search.yahoo.com/yhs/search?hspart=GenieoYaho&hsimp=yhs-fh_ds&type=a1432806369192751&p=chinampas+aztecas

At present, the urban development patterns, the population growth, the spoilage of natural resources for the productive agricultural systems and the disturbances on the Mexico City's regional hydraulic system constantly threaten the knowledge and accumulated experience inheritance, as well as the sustainability and the chinampas' dynamic evolution. This type of urban agriculture goes through various processes of change, some irreversible and others with the potential to restore the original condition of agricultural production. Thus, it has different land uses: active chinampas surfaces dedicated to the production of ornamental plants and flowers and horticultural production; other and with the use of greenhouses with different levels of inputs and technological capacity; other "potential chinampas" abandoned or used for other purposes that have not significantly disrupted their nature chinampera (i.e. gardens, sports fields, etc.) and, therefore are maintained with great chances of recovering its traditional agricultural use; and finally, areas of ancient chinampas which show various non-agricultural uses, including predominantly the occupation of irregular human settlements.

In this sense, out of 7,534 has that are included in the Natural and Cultural World Heritage Area Site in Xochimilco, Tláhuac and Milpa Alta, 2,215 has are identified as chinampas area (almost 30%), including 20,922 chinampas, which are proposed to be designated as GIAHS. Of this total, 3,586 chinampas are active and 17,336 are considered as potential[3] (González-Pozo, 2014) (Table 1). In particular, each of the five chinampas zones are characterized by the following:

1. In San Gregorio Atalpulco can be found the largest number of active chinampas (1,530) in 230.1 ha, which means 47.5% of its surface, and it may exist therefore by the abundant fine network channel. On the other hand, there are 122.8 has of flooded potential chinampas which, if implemented a plan to recover the hydrological system of the chinampa areas could be recovered.
2. In Xochimilco, the 864 active chinampas occupy a small portion of the area (3.24%/34.3 ha). It is recorded that a 62.34% (15,000 chinampas) corresponds to areas of potential chinampas, which only require restoring its fine canal network to return to their traditional productive state.
3. San Luis Tlaxialtemalco is the chinampa area of lesser extent. However, 38.9% is occupied by 430 active chinampas (40.1 ha) thanks to its abundant fine canal network, while 23.9% (24.6 ha) are potential recoverable chinampas, some inactive and other flooded.
4. The chinampas of San Pedro Tlàhuac area are similar to Xochimilco's, with a small canal network. However, 14.7% (59.5 ha) corresponds to 288 active chinampas, while 50% (202.1 ha) includes 970 potential chinampas.
5. The chinampas area of San Andrés Mixquic includes 59.5 ha (14.7%) of 288 active chinampas and 202.1 ha (50%) of 970 potential chinampas that depend on the restoration of the fine canal network to recover its agricultural profile.

The distribution of the total area of the chinampa agricultural system by zone corresponds to: 1) 47% in Xochimilco; 2) 22% in San Gregorio Atlapulco; 3) 18% in San Andrés Mixquic; 4) 8% in San Pedro Tláhuac; and 5) 5% by San Luis Tlaxialtemalco.

These data confirm the current and relevant need to protect wealth, authenticity and patrimonial integrity not only of agroecological practices of the agricultural chinampa system that are still active but

[3] Active chinampas are considered those who retain their agroproductive integrity and authenticity and are cultivated throughout the year. Meanwhile, potential chinampas are those that are not grown either because apantles deficiency or some level of flooding, among others issues, and that are easily retrievable for agricultural production.

also the socio-environmental and historical value that have the potential chinampas about expanding trajectories of sustainability that occur in this cultural and productive agricultural landscape, closely linked to the provision of ecosystem services and the satisfaction of food, tourism and socio-cultural needs of the population of Mexico City for more than a century.

The chinampas keep their world, domestic and local contemporary significance because they represent not only a historical vestige or an agroecological model in the management, conservation and resource use but also because the chinampas, as a kind of urban agriculture, include a geographical diversification of agricultural production based on continuous technological changes for every kind of farming, which encompass responses to the water needs, the farming nutritional status, phytosanitary needs, and to the weather conditions of these ones. Unlike the Xinghua Duotian agrosystems in China and the agricultural systems in high fields in Bangladesh, which are not urban farming systems since their origins, currently in the agricultural system of chinampas aquaculture is not practiced and crops are temperate, without there being an agroclimatic difference in the seasons of the year as happens in these two referrals.

The main two agroecosystems present in the chinampas are the horticulture and the floriculture. Both farming systems (ornamental plants and flower production and horticultural production) require high abilities and knowledge application in the management of the ecologic cycles and interactions within the components of these agroecosystems. Such ecologic processes (i.e. nutrients cycles) determine the space and temporal intensification in the use of the natural resources available for the farmers to keep the chinampas fertility. Horticulturists and growers consider the technologies for the resource management based on their agronomic effects and the economic and potential benefit that would result from them. By coordinating with the complex technical requirements of the crop, the chinampa farmers try to increase the productivity and to reduce the environmental risks and the economic losses. This kind of wetland handling is considered as one of the most sundry and productive agricultural systems known so far (González-Pozo, 2010).

Figure 7. Chinampas Water Channels Network

Figure 8. Chinampa surrounded by Canals or Channels

Figure 9. Chinampas Wetland Landscape.

Chinampas zones	*Sectors or rural landscapes*	*Surface area (ha)*	*Numbers of Chinampas*		
Zones	**Sectors**	**Ha**	***Active***	***Potential***	***Totals***
Xochimilco	18	1,059	864	15,000	15,864
San Gregorio Atlapulco	23	484	1,530	530	2,060
San Luis Tlaxialtemalco	16	103	430	170	600
San Pedro Tláhuac	9	165	474	666	1,140
San Andrés Mixquic	10	404	288	970	1,258
Total	**76**	**2,215**	**3,586**	**17,336**	**20,922**

Table 1. Chinampas zones, rural sectors, surface area and amount of chinampas[4]

1. Food Security and Livelihood.

The chinampa system has been closely linked to the high population density of the region and to the local urban communities growth. Due to the chinampa system has been an intensive farming method, expanding local food production through technological innovation has brought new land under cultivation and increased labor inputs. This efficient production form enabling intensive cultivation throughout the year has been one of the main activities that have supported the regional economy (Torres Lima *et al.,* 1994). However, instead of depending on state protection or the market, or the strict application of technological innovation and capital investment, human settlements on the chinampas zone with the more resilience have been those which have shown a fair distribution of property and a power balanced distribution among the groups of social regional interests.

Both equitable distribution of social power as well as community respect for private ownership of the chinampas, have been the underlying conditions in developing chinampa livelihoods, which has allowed favorable conditions emerge with high participation rates, within the local social fabric and under the setting of hierarchical relationships between the rural and the urban. In this sense, the specific strategies of livelihood developed in the chinampa system have given people the freedom and space to choose their own fate and evolution - which has

[4] The first 3 chinampas zones located in Xochimilco Municipality and the last 2 in Tláhuac Municipality. (González-Pozo, 2014)

meant that chinampa farmers are not necessarily dependent on one of containment strategies to change processes, such as the urbanization regional process, but they have been able to consolidate strong capabilities of combining different agroecological strategies in search of food systems and achieving optimal conditions for their suburban resilient livelihoods.

The main sources of livelihood of chinampa population are based on a broad division of the region according to their main farming systems. Thus, farmer's income generation differs in each kind of agroecosystem (i.e. horticulture vs. floriculture). These differences may be attributed to diverse factors, such as: (1) a combination of on and off-farm activities, (2) the degree of participation on the farm of both, the family members and the wage workforce; 3) the technological levels to manage the three essential chinampa components: water, soil, and biological resources, and (4) levels of expenditures for farm and housing needs.

Particularly, the chinampa agriculture is a very dynamic activity in terms of the economic flow like gross income. At present, only one chinampa may contain at least three or four crop harvests per year in periods of 90 days suitable for the cultivation, and in the case of ornamental crops 5 to 6.

In the chinampas area of Xochimilco, most of chinampas agricultural farmers engage in cultivation of endive lettuce (*Beta vulgaris* L. var Cicla.), Purslane (*Portulaca oleraceae* L.), coriander (*Coriandrum sativum* L.); and to a lesser extent, the production of cabbage (*Brassica oleracea* sp.), chard (*Beta vulgaris*), rosemary (*Rosmarinus Officinalis*), chamomile (*Chamaemelum nobile*), spinach (*Spinacia oleracea*), radish (*Raphanus sativus*), beets (*beta vulgaris),* epazote (*Chenopodium ambrosioides* L.) and some flowers that are grown in the traditional way, as Mercadela (*Calendula officinalis*) (Merlin-Uribe, 2009; Icaza and Aguilar, 2014).

Figure 10. Agroproductives Profiles of Chinampas.

In the Mixquic area, on the other hand, can be found maize (*Zea mays* L.), pumpkin and chilacayote (*Cucurbita* sp.); tomato (*Solanum lycopersicum*), beans and green beans (*Phaselus vulgaris* ssp.); pepper (*Capsicum* sp.), chayote (*S. edule*), quelites (common name to define many edible herbs of various kinds), goosefoot (*Chenopodium* spp.), broccoli (*Brassica oleracea italica*), rosemary (*Rosmarinus Officinalis*), purslane (*oleraceae Portulaca* L.), chard (*Beta vulgaris*), celery (*Apium graveolens*) and spinach (*Spinacia oleracea*) (Quinonez., 2005; Pérez-Olvera et al, 2014; Quintos and Quispe, 2004).

As for the chinampas production of corn, Sanders (1957) found that 6.5 t/ha was almost three times higher in corn yield of US at the time, of 2.5 t/ha, and it served to feed 15 to 20 people. Nowadays, a similar

performance, mentioned by Sanders (1957), would greatly exceed the national average yield of 2.78 t/ha and compete for first place with the average yield obtained in the State of Sinaloa, 7.76 t/ha, between the base year 1998 and 2008, irrigated and highly technical systems (Knight, 2010). Also, in the specific case of broccoli grown in the chinampas area of Mixquic with traditional methods, Perez-Olvera *et al.* (2014) reported an average yield of 13.2 t/ha, which is within the range reported by Santoyo and Martinez (2011), between 11 and 21 t/ha in the states of Guanajuato, Michoacan, Puebla and Jalisco, the major producers of Broccoli. Regarding ornamental production there are no statistically recorded production data, but there are 131 species of ornamental plants in the chinampas agricultural system that satisfy 94% of the demand in Mexico City, particularly 65% of the flowers Produced in pot (Torres-Lima et al., 1994).

It is reported the main horticultural products at the proposed site, with Romerito standing out with 69% of the national production and purslane with 27% (SIAP, 2014). Among the crops grown in Xochimilco and Tláhuac that stand out for representing 100% of the total volume of agricultural production in Mexico City are the following: Chard, Celery, Beetroot, Broccoli, Chilacayote, Green Pepper, Cabbage, Cauliflower, Romerito, Green Tomato and Purslane (Table 2)[5].

Municipality	Production (Ton)	Percentage	Contribution to the total production volume of the Mexico City
Chard			
Xochimilco	71.71	14.14	100%
Tláhuac	435.25	83.86	
TOTAL	506.96	100	
Celery			
Xochimilco	21.35	2.3	100%
Tláhuac	902.55	97.7	
TOTAL	923.9	100	

[5] It should be mentioned that the high productivity or yield data of the chinampas crops per plot or area (ha) can not be compared to dry land or irrigation crops at national level due to the technological conditions and the management of natural resources in the chinampa production itself. Thus, the average productivity yields recorded at national level can vary either in increase, equality or less proportion by comparing the chinampas farming system data.

Beetroot			
Tláhuac	3.75	100	100%
TOTAL	3.75	100	
Broccoli			
Xochimilco	73.9	2.2	100%
Tláhuac	3,324.80	97.8	
TOTAL	3,398.70	100	
Squash			
Xochimilco	208.47	49.3	66.40%
Tláhuac	214.25	50.7	
TOTAL	422.72	100	
Chilacayote			
Tláhuac	29.25	100	100%
TOTAL	29.25	100	
Green Pepper			
Xochimilco	2.04	16.2	100.00%
Tláhuac	10.5	83.8	
TOTAL	12.54	100	
Coriander			
Tláhuac	236.3	100	83.50%
TOTAL	236.3	100	
Cabbage			
Xochimilco	5.5	45.8	100.00%
Tláhuac	6.5	54.2	
TOTAL	12	100	
Cauliflower			
Tláhuac	30	100	100.00%
TOTAL	30	100	

Spinach			
Xochimilco	318.35	50.7	88.12%
Tláhuac	308.61	49.3	
TOTAL	626.96	100	
Beans			
Xochimilco	22.72	55.7	44%
Tláhuac	18.05	44.3	
TOTAL	40.77	100	

Other Vegetables			
Xochimilco	90.65	65.7	97.24%
Tláhuac	47.24	34.3	
TOTAL	137.89	100	
Lettuce			
Xochimilco	1,175.85	44.1	93.27%
Tláhuac	1,488.05	54.9	
TOTAL	2,663.90	100	
Romerito			
Xochimilco	236.88	5.2	100%
Tláhuac	4,277.78	94.8	
TOTAL	4,514.66	100	
Green Tomato			
Tláhuac	170.75	100	100%
TOTAL	170.75	100	
Purslane			
Xochimilco	328.75	20.7	100%
Tláhuac	1,253.85	79.3	
TOTAL	1582.6	100	

Table 2. Main horticultural production in chinampas, 2014.
Source: SIAP, 2014, SIACON, 2014 y Diagnostico Seguridad Alimentaria CDMX, 2014

Palerm (1990) compared the slash-and-burn system with the chinampas system. In this comparison shows that while a family grows corn under the slash-and-burn system requires a minimum of 1.5 hectares to meet their needs, the chinampas farmers only need to use 0.4 hectares to achieve the same goal. On the other hand, Merlin (2009) concluded that, even in the production of greenhouses more outputs/yield are obtained, the chinampas farmers are the ones who dominate traditional techniques, who produce by achieving a better cost-benefit ratio, which shows that it is a more profitable than greenhouses, which are largely dependent on external inputs system.

It is clear that the yield per crop varies depending on the species and variety sown. However, in the case of the chinampas, yields are between 10 to 15 tonnes/hectare. An average of 12.5 tons/ha, multiplied by 422 hectares of active chinampas, would result in 5,275 tons per harvest. Such volume would be enough for the annual diet of vegetables for a population of 400,000 thousand inhabitants deeming a quantity of 50 kg per capita per year (Torres-Lima et al., 1994).

Currently, it is estimated that 12,500 economically active population are engaged in agriculture at the proposed site, representing 2,500 families currently engaged in agri-food activity[6]. Independently of farmers' location, agricultural activities are still sources of employment and income. For instance, 79% of the farmers in San Gregorio Atlapulco have agriculture as a main economic activity while the percentage varies as 75% in the municipality, and 46% in San Luis Tlaxialtemalco. Despite the fact that only 35% of the total income is provided by rural activities for farmers that combine agriculture with permanent urban employment, there are powerful socioeconomic forces that are causing a convergence toward farming. Because the frequent instability and low salaries of urban jobs, agricultural technology and resource management are still economically viable in both farming systems (Torres Lima *et al.,* 1994). For instance, it is estimated an income between U.S. $300 and 500 per month in the case of horticulturists and three times as much in the case of floriculturists. Yet an annual agricultural production of 40,000 tons and its marketing at regional scale, both may be equivalent to U.S. $14 million (FAO, 1988).

Likewise, the importance of the chinampa system is still relevant to the extent that the flower local production and marketing that occurs in the region of Xochimilco from other plants brought outside the area satisfy the demand in Mexico City of the 94 percent of the ornamental plants and the 65% of the flowers produced in pots (Torres Lima *et al.,* 1994). In addition to agricultural activities already mentioned, it is known that carp and trout fishing and hunting rabbit used to be practiced (Quiñónez, 2005).

Sixty years ago all farmers cultivated in chinampas, part corresponded to the common public land which had chinampas, however the construction of many deep wells in this area, to carry out that water to Mexico City drastically decreased the water supply of San Andres Mixquic, it was through the rivers coming down from the volcanoes, especially the Amecameca river and had many springs and a lake of clear water where a varied aquatic fauna lived.
It is worth mentioning that this agricultural production system depends not only on the chinampas farmers. Merlin-Uribe (2009) reports that 40% of the chinampas farmers hire laborers originating mostly from the state of Mexico and Puebla, which is an incentive for migration of peasants to Mexico City.

[6] 5% of the economically active population is engaged in agricultural work, considering that the total of the current population of the proposed site is 250,000 (González-Pozo, 2014).

In the chinampas area of Xochimilco tourism is an important activity for the local economy. Each year, the ten jetties this area receive 200 thousand visitors who walk through the main channels on more than 1,000 trajineras (local boats). In addition, while the tour takes place, some local residents and chinampas farmers approach the trajineras in canoes to offer food, drink, crafts, plants and music bands service to the visitors. The tourist center also includes a crafts market where merchants offer various traditional products: textiles, food and ornamentals (Caraballo, 2006; Paez, 2015). While there is no specific data on the economically active population, in 5 chinampas areas, it is known that in Xochimilco 267,541 people work in restaurants and accommodation services (6 hotels accumulate 405 rooms), there are 112 economic units engaged in services, cultural, sports, entertainment and other recreational services (INEGI, 2008). It can be seen that the chinampas and canals, where the trajineras navigate, are the main attraction of the site and the people involved in the provision of the services mentioned depend heavily on conservation of these traditional agricultural landscapes.

In this sense, agricultural growth and productivity in the chinampa site have relied on production systems and horticulture that are resilient against production failures that occur from changes in the landscape at different spatial and temporal scales, such as the heterogeneous reduction quality and quantity of water in the channels that surrounds own chinampas. The long history of the agricultural management has produced different kinds of the use of the land that are scattered and there is not apparently, a consistent pattern across the region (Merlín-Uribe *et al.,* 2013). These imbalances in soil and water resources endanger the resilience objectives strengthening for sustainable growth and development of local livelihood thereby also undermine or jeopardize regional and local objectives achieving food security.

Figure 11. Chinampa surrounded by natives trees.

Figure 12. Ahuejotes, (*Salix bonplandiana), natives trees.*

2. Biodiversity and Ecosystem Functions

The chinampa system has been very productive, not only in terms of rate and amount of production per unit of the land surface and by the supplies used, but it has been sustainable too, with a long-term

continuous agricultural productivity. Facing hydrologic and climatic constraints (i.e. frost and hail) and the pressure by the high city's food demand, the chinampa farmers have been able to handle certain balance between the sustained yield and the environmental and technological management factors. This ecosystem performance has been based on the biological stability improvement, including sophisticated farming methods such as multiple cropping and shift of crops. These farming practices reach up to seven harvests per year through the intensive use of nutrients, water and biological resources.

In spite of the biological resources the chinampa sites are progressively diminishing due to the urban expansion in Mexico City. It is reported that since 1973, at least twenty species of plants have disappeared (Novelo and Gallegos, 1988). One of chinampa producers' main efforts to conserve agricultural biodiversity is intercropped agriculture, both temporarily and spatially, many of which are for local consumption and others for sale in markets that include both domesticated and non-domesticated as well as introduced species. It is possible to affirm that the management of the vegetation in the chinampas by the local producers, which comprises 51 domesticated species, is an example of a process of evolution of the agrodiversity, which also includes 96 non domesticated species, which are used as fodder crops (67%), medicinal (20%) and food (13%) (Jimenez-Osornio and Gomez-Pompa, 1991). The biological diversity is still a main component, which affects the ecologic mechanisms and the interactions in the chinampa agriculture. For instance, about 20 home species and 30 wild plants were recorded in a plot of 2,279 m2 (Jiménez-Osornio *et al.,* 1990). In the chinampas one can still find four of the five main agricultural crops used by the Aztecs, maize, bean, squash and amaranth (Annex 13).

The strategy to preserve the agrodiversity close or within the conurbations may have two basic advantages: 1) the supply of different agricultural products for the domestic consumption; and 2) the immediate benefit from the farming production sales around the urban markets; and 3) the conservation of a wide variety of ecosystem services derived from sub-basin hydrological and biotic and abiotic components; natural and manipulated. Therefore, the maintenance of traditional and modern varieties of crops and their management under traditional techniques is part of the chinampa cropping system; intensive, commercial and highly sustainable, that deserves to be preserved, largely for its biodiverse and ecosystem-leading role.

In particular, there are key native species in chinampas that have contributed global and locally to the demand for human food (ie Zea

Mays, Amaranthus sp. and Phaseolus vulgaris) and in contemporary horticulture (ie Euphorbia pulcherrima [Christmas flower Cuitlaxóchitl in Nahuátl] Tagetes erecta [Cempoalxóchitl in Nahuátl] and Dahlia coccinea [Xicamoxóchitl in Nahuátl]), which have been cultivated since the time of the Aztecs and are mostly examples of the innovative use of plant genetic resources by chinampa producers to obtain improved varieties. In addition to these crops, other plants brought by the Spanish are produced. There is also a great variety of aromatic plants used as condiments, frequently present in the modern Mexican diet. Also, in terms of economic importance, there are several ornamental plants that are grown in the chinampas (Annex 13).

It has been estimated that over the centuries, the production profile of the chinampas was transformed from a milpa production, where the maize was the main crop (Varadero chalqueño) and Mesoamerican vegetables (chile, tomato, squash, chilacayote and tomato) to a diversification and incorporation of species of diverse botanical nature of different social and commercial value that have offered to the chinampa producer greater options, as well as a better adaptation of its means of production to the environmental conditions and the commercial demands of the urban market of the City of Mexico, such as the vegetables-ornamental complex that implies greater use of resources and increase in number of harvests per unit time and surface area (Rojas, 1983). Particularly there are key native species in the chinampas which are in great demand for the religious festivities and grown since prehispanic times. Besides these crops, other plants brought by the Spaniards are produced. There are also a great variety of aromatic plants for seasoning, frequently present in the modern Mexican diet. Likewise in terms of economic importance, there are different ornamental plants grown on the chinampas (Annex 13).

As for its biological richness, the chinampa agricultural system contains 2% of the world and the 11% of the domestic biological diversity. There are 139 species of vertebrates, 21 from these, fish, 6 amphibians, 10 reptiles, 79 birds and 23 mammals; many of them are under a conservation status (Annex 12). Among the aquatic species threatened the most important is the Ajolote (*Ambystoma mexicanum*), (in Nahuatl Axolotl), which still lives in the canals, an indigenous salamander forming part of the old religious beliefs, and whose medicinal and healing properties are currently the subject of national and international scientific research. This specie currently lives in the canals and is not consumed locally for food purposes, but on the contrary local breeding and conservation programs are developed (Mena and Servín, 2014).The place's bird-fauna (193 species) shows a great diversity of local and

migratory species that come mainly from North Canada and the United States and spend the North Winter in the chinampa sites' wetlands (annex 13). Besides the native tree Ahuejote, previously mentioned and other tree species (annex 14), the local flora includes many examples of aquatic, sub aquatic and halophytes native species (annex 15 and annex 16). Among the diversity of native plants present in the area, some species such as the nymph (*Mexican Nympha*), white cedar (*Cupressus lusitanica*) and acezintle (*Acernegundo var. Mexicanum*), which is also endemic, is under some risk category according the standard NOM-059-SEMARNAT-2010.

The surfaces of the channels and small ponds are often covered with aquatic communities giving hideouts for birds and little animals. The local artisans, to manufacture a great variety of handcrafts, appreciate the aquatic and sub aquatic flora for their long, strong and flexible leaves. Moreover, since even today the soil handling technology is a key factor for the chinampa agricultural production, the keeping of the soil fertility, is secured by constant organic matter inputs through the incorporation of aquatic vegetation, which subtracts the rhythm of the eutrophication processes of water bodies (channels and lagoons) that have no impact on the trophic levels of the chinampas agricultural system; in the shape of unusable crops, channel dredging, the fertilizer that includes weeds waste and animal manure, as well as the crop rotation (Government of Mexico City, 2006).

In addition to its extensive biological wealth, the chinampa agro-ecosystems of the five zones, which are located on permanent wetlands within a closed sub-basin, provide important ecosystem services to urban and peri-urban area (Merlin-Uribe, 2009; Salazar *et al.,* 2014). First, they serve to control flooding when excess water in the rainy season is diverted from Mexico City, working as vessels of regulation. Also, the humidity generated by the water deposited in the canals and wetlands, and evapotranspiration of vegetation, promotes the climate to be more humid, the most compact soil and less aggressive wind erosion in the microclimate of the southern zone city (Merlin-Uribe, 2009). On the other hand, the delegations of Milpa Alta, Tláhuac, Xochimilco, Tlalpan, Coyoacán and Iztapalapa benefit from water runoff from hydrological sub-basin (Salazar *et al.,* 2014). In this regard, another important service it is associated with infiltration and groundwater recharge mantle (Figueroa *et al.,* 2014). Finally, in particular, the Ahuejotes, which are a fundamental part of the chinampas ecosystem by the existing density and coverage achieved, they play an important role in the production of oxygen, carbon fixation and suspended particles dioxide, among others (Gonzalez-Pozo, 2014). So, it is

observed that nowadays agroproduction in chinampas continues to represent a system combining agrobiodiversity and habitat conservation.

It is a natural discharge area of groundwater flow; its importance in terms of biodiversity, is determined by the presence of characteristic plant communities. This is the case of tulares, floating islands made up of cattail (*Typha latifolia* and *Schoenoplectus americanus*), home to many species of flora and aquatic and terrestrial fauna, some of them vulnerable and very restricted distribution, as the nymph (*Mexican Nymphaea*), the neotenic axolotl (*Ambystoma mexicanum*), Xochimilco frog (*Rana tlaloci*) and Moctezuma frog (*Rana montezumae*); they provide a significant genetic heritage, in addition to functioning as a feeding and reproduction zone of fish and birds (SMA, 2012).
In this area there is a great biological diversity of aquatic, underwater, halophilic and terrestrial vegetation. Eleven species of wildlife have been identified and classified in special protection categories according to the Official Mexican Standard NOM-059-SEMARNAT-2001, "Environmental Protection-Native Species of Mexico of Wild Flora and Fauna, Risk categories and specifications for inclusion, Exclusion or change-List Species at Risk ".

This standard aims at the protection and conservation of the lake system of Xochimilco, which provides environmental services relevant to Mexico City. These include improving air quality, continuity of the hydrological cycle, regulating local climate, food supply and habitat and species of wild flora and fauna. The chinampas area adjoins with the Ramsar site (wetland of international importance) also in registration process Tláhuac's wetlands area (SMA, 2012).

Figure 13. Ajolote (Ambystoma mexicanum).

Figure 14. Wetland Landscape.
Refuge of local and migratory birds of Canada and United States.

Figure 15. Birdlife identified on the site.

3. Knowledge systems and adapted technologies

Mexico City's urbanization in the rural zones it is not only affecting the ecosystems services such as water supply or the local climate modification but also its cultural heritage and the ecologic traditional knowledge. Particularly, in the chinampa sites the environment's gradual deterioration has forced the farmers to combine the traditional ecologic knowledge and conventional agricultural practices in accordance with the ecosystem's biophysics' changes. The spotlight on the chinampas sustainability is defined itself by the traditional or conventional practices integrated or not to increase the productivity and profitability. To explain the apparent convergence or divergence between both technologies on the chinampa agriculture drawing upon to an alternative setting based on the following variables is required: 1) the chinampa farming systems; 2) the strategies on the biodiversity handling; 3) the technologic efficiency on the agricultural production systems; 4) the available financial systems; and 5) the chinampa farmers' education and employment profile.

As already mentioned, the chinampas farmers still adapt prehispanic crop practices, with a strong emphasis on measures and specific agricultural and agro-ecological technologies for risk reduction and for sustainable use and management of vital resources such as land, water, soil nutrients and genetic resources. Some of these practices have been driven by individual decisions from the chinampas farmers and not necessarily by the zonning and land use planning from the governmental territorial planning levels. Currently, the traditional knowledge and practice of traditional agriculture experience, in the five areas of chinampa agricultural system, varies considerably, however in general traditional practices are used, such as:

- The incorporation of nutrients of organic sludge from the bottom of the aplantes, extending on the surface of chinampas to enrich soil and build traditional seedbeds called: chapines (small seed). According to (Ochoa, 1972; cited by Olivares, 2007): The so-called leather mud "or zoquimaitl", is a cloth bag tied to a ring that is fixed to a pole, used to remove silt from the lake to form a new layer of chinampa. The so-called wooden rake serves to spread the manure and pull the canoe's muck and onto the chinampa. The "tlacuiquialon" is a kind of small mud leather get the mudo out of the canoe and onto the chinampa. The measure are two sticks about 80 centimeters (or a rod) which are connected by a thread and serve to trace the grooves of the chinampa correctly. Currently, it is very common to use metal blade.
- Chapines, at the same time, are small squares drawn on the base sludge from the apantles. To build them, it is required to excavate

between 20 and 25 centimeters deep, in this space the mud is deposited, the grid (ranging from 3 to 10 cubic cm) is delimited and seeds (Martinez, 2004) are seeded. The tools used for this procedure are: The dredge, which is nothing more than a hoe with a table where they lay 15 to 20 nails for pictures or slippers. The "huacal or Cuauhcalli", is a basket to carry the seedbed chapines to the chinampa, it is also known as "zaranda" when it's a woven basket. The "cuitlaxmalli" is a litter that has the same use of huacal or Cuauhcalli, except that this one is managed by two chinamperos. The "huitzoctli" is a wooden punch to make holes where the chapines will be placed, this can be a simple stick the branch of a tree "(Ochoa, 1972; cited by Olivares, 2007).

- For the preparation of the surface of the chinampa the hoe is used. It replaces the wooden stick, called "coa", which was used in ancient times. Some chinamperos are beginning to use a manual engine called rototiller. Also, (Ochoa 1972; cited by Olivares, 2007) mentions that currently in Míxquic the coa is used with hardened metal tip with fire for planting, is called the "huictli". *(in Nahúatl)".*
- As for the irrigation of each chinampa, it is carried out using a small plastic-bag (before leather) attached to a long pole, to irrigate with water taken from the surrounding channels and spread on cultivated areas, too, according to (Ochoa, 1972; cited by Olivares, 2007). In the area of Mixquic they use the "texpetlatatl" is a trough to water by hand, it is almost a wooden spoon. With this same use the "cuetlapala" is managed, kind of small hoop lined blanket to irrigate from the canoe to chinampa materially throwing water. This practice is giving a slowly rise to the use of portable water gasoline pumps connected to hoses. Water pumps are mainly used in larger chinampas, those that have only one or two wet apantles (aqueducts) with them or where distances between water and cultivated areas are extensive.
- It is noteworthy that planting Ahuejote trees (*Salix bonplandiana*) along the edges of each chinampa. This willow tree, tall and thin, provides support for elevated platforms to the extent that its roots extend along the edges, which is related to the prevention of erosion. Also, these trees block the strong winds and also provide shelter for many aquatic species and small birds (González-Pozo, 2014; Martínez, 2004).

Figure 16. Sowing seeds in seedbeds "chapines".

Other traditional practices currently being carried out include:

- Protection of cultivated areas with dry wild grass that grows along the borders of the chinampas. This type of protection is used when the crop is still young and has two intentions: to preserve soil moisture and prevent the growth and competition of weeds.
- Protect the crops from occasional hail storms and certain wading birds, with fine nets held by poles at a distance of 2 or 3 meters above the crops.
- The removal of aquatic vegetation, especially lily (considered as a pest), to process it as compost (thus avoiding the use of agrochemicals) or as feed for livestock.
- Also, According to (Ochoa, 1972; cited by Olivares, 2007): Another vital tools for chinampa agriculture is the canoe, which the Aztecs called "ascalli". The rower was called the acanello. The boat is powered with long poles or small paddles, according to their size. Currently in Míxquic, there are only several pieces of canoes without bow or stern, built of wood fir and small parts of oak and pitch pine. Canoes used today in Míxquic Chinampas of the locally built or are ordered from Xochimilco ".
- Finally, the maintenance of the network of channels making tasks such as building small provisional dams built with sandbags, in order to curb the flow of water between the highest and lowest areas; and cleaning or reopening of small apantles (fine canal network).

These examples reflect the best practices that have been replicated and updated on a wider scale in the areas of chinampas, where the declining quality and quantity of water, as well as the availability of organic matter causes the damage and agricultural losses.

Figure 17. Traditional practices in chinampas.

By means of the combination of different agricultural production systems in the same chinampa plots, farmers improve the own agroecosystem's yields. For instance, today, the high degree of the plants diversity that is still present in the chinampa site includes at least 40 different kinds of vegetables, from which 60% are sown with multiple farming systems. Likewise, 131 species of ornamental plants and flowers are produced as trade farming (Torres Lima *et al.,* 1994). Most of the chinampa farmers cultivate more than five different ornamental plants at the same time, on a field or on several plots. Having an average of 1,200 m2, this land extension allows the space and temporal management of the different farming for every farming system. Within this agroecological management, the farmers consider the control of their phyto-genetic resources either locally gendered or newly introduced, as an important topic to keep the crops diversity. It is reported that the 80% of corn, 69% of ornamental plants, and 55% of vegetables from the previous season are propagated and reproduced by the chinampa farmers in their own plots (Torres Lima *et al.,* 1994).

Thus, the preservation of the vegetable diversity in the chinampa agroecosystem is associated with an economic strategy that has the intention to use and handle the genetic vegetable material. For example, according to the market demand, a farmer can increase or decrease the population density of "flor de nochebuena" (poinsettia/*Euphorbia heterophylla* L.), having kept the vegetative structures from the previous season.
Due to the farmers have high educational levels, for example, 20% of them have finished, at least the junior high school, (Torres Lima *et al.,* 1994), and agriculture continues representing a potential source of employment and incomes, where the academic background or the formal studies may be applied.

In particular, women participate mainly in the harvesting practices, marketing of plants and agricultural products, making and selling food to the tourist who visit the site and by oral trasnmission of food recipes and culinary culture, while children do agricultural work only on weekends when they do not attend school. They also participate in community festivals and carnivals.

Figure 18 . Women participating in chinampas activities

Farmers' skills, either for the urban or agricultural employment, are related to this financial enhancement of regional development. For instance, through the use of the expertise, and the inclusion of technological improvements on the chinampa agriculture, some flower growers have gotten financial aid from the regional banks. They have also organized cooperatives or farmers associations to get technical assistance from the public institutions. Furthermore, due to floriculture are economically viable, most of the farmers producing ornamental

flowers and plants are in the 20-30 year old aged. Thus, agriculture still represents a better economical option for this high proportion of young farmers than the cost of the opportunity of an urban job may imply.

Nowadays, the farmers use their knowledge, perceptions and beliefs during the traditional and modern practices for the management of the regional natural resources and external supplies. Each farmer can use a set of experiences, past and present as well as personal and collective. This traditional chinampa agriculture synchronizes specific forms of social organization, ways of life, land production organizing, traditional ways of communities, technical abilities and formal training, which constitute a certain kind of "chinampa stewardship".

Figure 19. Lettuce crop.

Figure 20. Cabbage crop with net used for shading and protectioning

In summary, the dynamic development of the chinampa agriculture has been based on both the experience of farmers and their technical field abilities. The components explaining the evolutional and dynamic conservation of the agricultural chinampa system in Mexico City are the following: 1) Through the renewable resources conservation and reduction of environmental impacts the farmers have efficiently handled the lake habitat for agricultural purposes; 2) By recycling practices, having kept flow cycles of nutrients and wastes; 3) The conservation of a high degree of biodiversity in the time and in the space the resources have been efficiently used, the biological interdependence between the farming and pests has increased, and the loss of harvest has been reduced; 4) to intensify the production and to increase the sustainable levels of productivity, the farmers have based on regional resources, the efficient use of the labor hand and high complexity technology; and 5) through the use of social and economical factors in decision making, the farming diversification and by maximizing yields the development of self-sufficiency and the economic viability of the chinampa system has been obtained. In a long term, this kind of chinampa agriculture stabilization has been done to keep the base of resources and energy, to a high quality level of the environment, the development of the proper local technology, steady land tenure, the economic profitability and the community's cultural and social cohesion.

Figure 21. Chinampa Landscape

Figure 22. Lettuce crop using a protective net

Building a chinampa

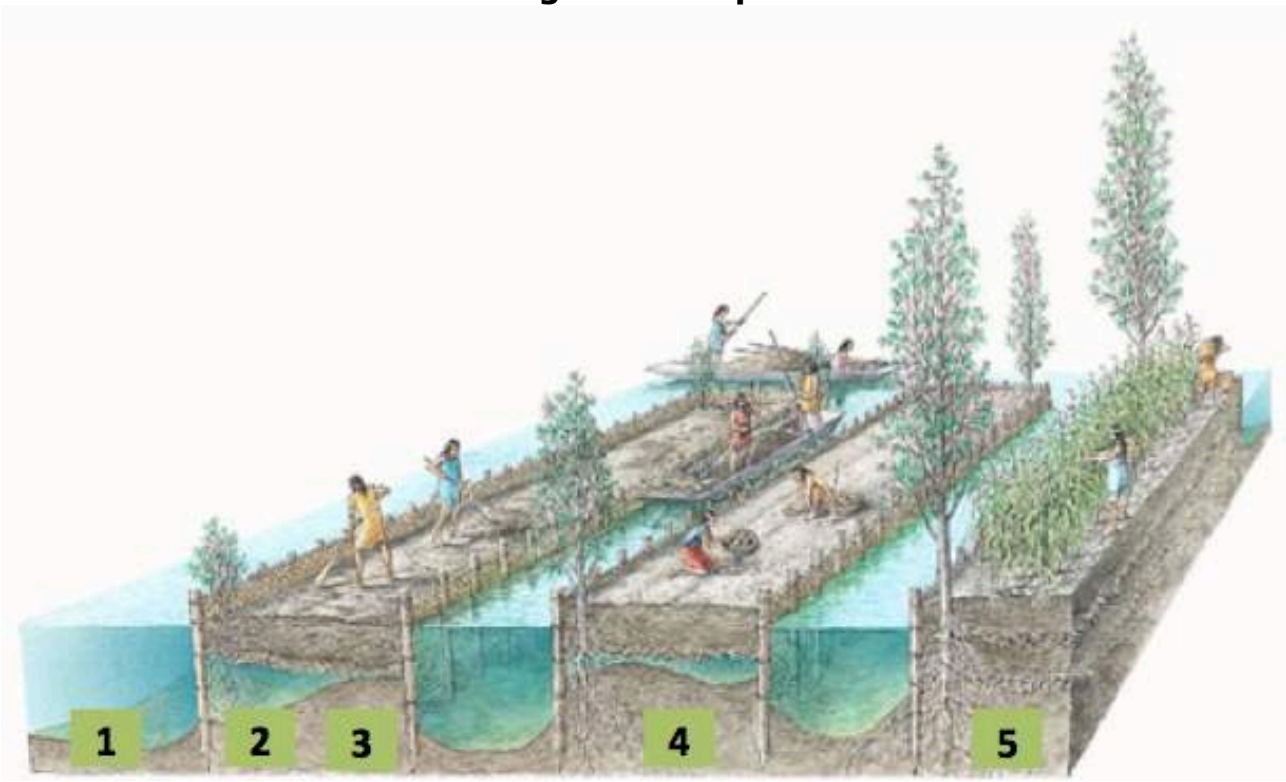


Figure 23. Five basic steps to build a chinampa.

Building a chinampa implies applying a pre-Columbian agro-hydrologic technology that is still in use and which constitutes a legacy of the water culture that should be preserved and communicated. In the chinampa system the cultural expression of ancient techniques that brought about an artificial agricultural system is materialized. The system relies on the superposition of multiple layers of organic soil in the middle of a lake and is characterized by an intensive agricultural production that respects the ecosystem that sustains it.
Using the empirical knowledge that has been preserved for centuries in the region of Xochimilco and Tlahuac, and aided by a group of *chinamperos* from San Gregorio Atlapulco, the Mexican Institute for Water Technology (known as IMTA), recorded the chinampa building process.

As a result of this study where a chinampa was built with the aforementioned producers to document the traditional construction process, the IMTA added the chinampa to a special category known as *Group of technologies suitable for the use of water in rural sustainable development* (IMTA, 2004).

In order to illustrate the technological knowledge that has been preserved over two thousand years of continued effort on behalf of the cultures that have used the system and as a product of this study, the IMTA developed a handbook –published in 2004- for chinampa construction that describes and explains how to build a chinampa using traditional knowledge. The construction process is described in what follows.

1. Selecting a plot to build the chinampa

The first step is locating a firm floor in a shallow area of the lake (30-60 cm). This will provide a foundation to raise the ground. Having identified the site where the plot will be built, its dimensions are defined. Ahuejote stakes are used to mark the perimeter, planting them with a separation of 1 or 1.5 m between them.

Figure 24. The area of a chinampa is rectangular and delimited by ahuejotes.

The chinampa has a rectangular shape, its long side is 20 m long and its width does not exceed 12 m in order to efficiently absorb moisture provided by the surrounding canals.

These proportions will make water absorption easier and allow for the irrigation of the plot from a canoe, using a paddle or *cuero* with which water is collected from the canals and dropped over the chinampa.

Elongated islets allows transporting water a very short distance between the canal and the crops. In the same fashion, this shape makes reaching every spot on the surface of the plot easier without having to leave the craft and makes harvesting easier too because produce may be collected from edges of the chinampa.

This shape makes moving produce from the chinampa to the trajinera possible, since with this shape concentrating the produce on one edge to move them to the canoe may be avoided; produce may be loaded into the trajinera as it is collected from the plot while the vessel moves around it (Toledo y Barrera-Bassols, 2008).

2. Outlining the limits of the chinampa

In order to outline the perimeter of the chinampa, large ahuejote branches and stalks are cut. These should be made into stakes and anchored to the ground, along the borders of the chinampa, outlining a fence which will serve as a first structural container for the chinampa.

Figure 25. Ahuejote stakes that will become an adult tree.

The stakes should remain in a vertical position and be about one meter high. Using ahuejote takes is useful because they can be easily fixed and will soon become trees.
When ahuejotes are planted, water canals become permanently defined. The tree's extensive secondary roots create a compact mesh that contains the chinampa's perimeter, avoiding erosion and stabilizing its edges. Its primary roots fix the chinampa to the bottom of the lake. Its roots may be in direct contact with the water without causing damage because they are water resistant.

Figure 26. Ahuejotes outlining the limits of the chinampa

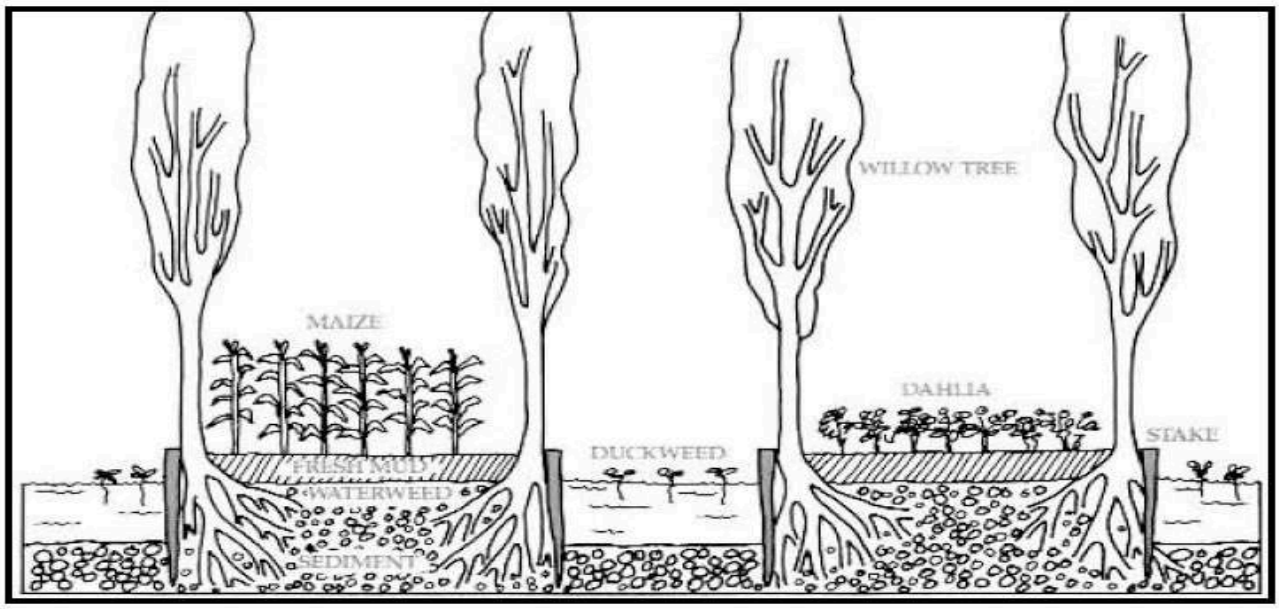


Figure 27. The roots of the ahuejote trees delimit the chinampa and define the canals.

3. Building the chinampa's structure

Chinampa (Nahuatl) means *cane-woven fence*, because in order to form it a *chinamil* must be woven around the surface of the plot. To achieve this, a reed mesh is woven around the chinampa, creating a robust net-like structure that is fixed around the stakes, known as chinamil.

Figure 28. Formation of the chinamil by weaving reed around the perimeter of the chinampa, delimited by stakes (Martínez).

The final result of this stage is a structure resembling a box that stops the mud and organic matter from crumbling into the lake.

4. Forming the chinampa soil

Once the chinamil is ready, the chinampa is filled with two layers of soil, one with organic matter and one made out of sludge. To achieve this, organic mater is collected from the canals; water lilies are often mixed with other weeds that are abundant in the lacustrine area. The material is deposited inside the chinamil to create the first layer of organic matter.

Figure 29. Constructing the organic soil into a flattened layer (Rangel).

First layer
When there is enough organic matter to cover the surface of the plot, the material is evenly spread and flattened until a spongy cushion of around 50 cm above water-level has been created. This first layer is let to dry for two weeks.

Second layer
In order to produce a fertile soil, sludge and mud from the floor of the lake is extracted with a long shovel. The muddy soil is distributed above the organic layer until a homogenous layer is created.

As the sludge and the organic matter that has been previously decompose, they crate a nutrient-rich soil
The process is repeated as many times as needed; the desired height depends on different factors. Subsequently, an additional layer of compost or other organic mater may be added to provide more soil.

5. Cultivation. The chinampa is now ready for agricultural activities.

4. Cultures, systems of values and social organizations (agro-culture)

The most important heritage for the five villages is the cultural knowledge transmitted for many generations from the chinampas culture. Chinampa agricultural systems and the chinampa culture represent the basis of the Declaration of the World Cultural Heritage of Humanity granted by UNESCO to the Patrimony Zone, in which both area mixed, the tangible or material values and the intangible values represented by their intangible cultural values. The second heritage is the Nahuatl language still spoken by chinampas farmers, although needless to say, its use has declined in recent generations. This heritage is made up of inherited ancestral knowledge system and customs and habits learned in the family and the community. Their cosmovision allows the local inhabitants to generate community conceptions around the origin, existence and functioning of the universe, nature, society and the human being itself, which are expressed in different forms of everyday life lacustrine, traditions, beliefs and ancestral knowledge.

Historically, the farmers have built the social capital to relief the urbanization negative impacts through the design and use of a wide range of strategies and adaptation agriculture forms. These include a trend to continue producing both the traditional farming and the introduction of strictly commercial farming and in this way overcome the limited opportunities to get consolidated in wider markets through the food processing and the incorporation of an added value to their products. The farmers of these rural suburban zones have also been adapted to take advantage of the local emerging markets to commercialize their products, as well as the urban infrastructure, transport, health, education and communications that, as a whole, let them to create new employment opportunities and extend the typical urban demand of goods and services they produce. In front of the hydrological, agronomic and climatic current limitations, (namely, the frosts, the hail, land uses changes and the habitat alteration) and the pressure of a high demand of food from the city, the chinampa farmers have been able to certain value system looking for the balance among the sustained yield, environmental factors and agroecosystems management factors. This value system, and on a large scale, the social and family organization revolves around the chinampa itself and its associated traditions (Quinonez, 2004).

Despite being part of the territorial processes of urbanization and the professionalization or increased educational levels of the chinampas farmers, popular religion remains an instrument of social cohesion through the temporary daily nature, spacial, personal and community in the chinampas areas.

There are parties that allow the recovery of historical memory, values, traditions and ways of life of the community same ones that constantly find themselves violated by those promoted and sometimes imposed by the physical expansion of the city and which are adopted by the modernizing project of Mexico City (Landazuri and Lopez, 2012). Popular religion has meant the continuation of pre-Hispanic traditions and forms of community organization. The cultural practices that are derived from the party, as a form of reproduction of cultural identity, reflect the community in many ways, it comes to be more important than the individual.

The cultural practices, as in civic and religious parties and the cultural products same ones associated with chinampas activities, manifest beliefs and worldviews that nourish popular piety and feed off of it at the same time. The rituals and the popular and regional parties on the site, over the centuries, have come to established forms and systems of identity and unity within neighborhoods, chinampas, towns, and extended families.
This way of practicing the religion helps to build or maintain social networks that strengthen the unity, solidarity and cohesion through which people claim a lifestyle and an identity and build resistance to external impositions that arise at other times (Narchi and Canabal, 2015).

It is identified that the charges and popular organizations of believers, as the brotherhoods and other systems involving public and religious rituals, would create neighborhood or village institutions, to become what we know today as stewardships, boards, committees or associations (Landazuri and Lopez, 2004). Like in many other towns, social life in five chinampas áreas revolve to some extent, in this kind of festive rituals (Quinonez, 2004). Thereby, the festivities are to ways to give thanks for they have done well in the field or because there hasn't been bad timing. For example, the party to San Gregorio, in early March, has been linked with celebrations and rituals of pre-Hispanic times that concur to the parties to fertility or celebrations to the goddess Xiloen (goddess of tender corn) or Chicomecoatl (goddess of the harvest and all kinds of seeds and legumes) (Landazuri and Lopez, 2012). In the case of stewardships, it is a system in which families or individuals

acquire the commitment to provide financial resources or in kind for the celebrations of the patron saint; besides being an "honorable" act, it is a ritual laden with a deep community respect. In occasions, the feast of the patron saint, particularly for each village or neighborhood, includes the circulation of his images through other areas, in what is known as "correspondence" (Quinonez, 2004).
For example, religious activities, festivals and food culture, in Xochimilco since 434 years ago, in the homes of the stewards and the innkeepers, are carried out in honor of the Niñopa, the Child of the district of Belén and the Child of the neighborhood of Xaltocan. The Niñopan does not have a temple but is under the rotating custody of the families of the districts of Xochimilco that function like stewadrship[7].
The name of the image is Niñopan, a hybrid Spanish-Nahuatl word that translates as Child of the People (of the Spanish Child and the Nahuatl - pan, place). In Tláhuac, there is the fiesta in the lagoon of the Kings where on a canoe that looks like a chinampa covered with flowers and vegetables the image of San Pedro is navigated, which is associated like opener of the doors of the sky so that it rains, besides being a fisherman. At this party, water is asked for and watered by canoers and chinamperos for sowing, protecting plants to promote soil fertility, appeasing drought and providing abundant crops (Rodríguez, 2016). Thus, the party becomes an indicator of rains, the well-being of crops and the conservation of the wealth of local natural resources. Elsewhere, the fiesta of the Tlacualeras is celebrated in honor of San Isidro Labrador, a saint who favors agriculture, on which farmers base their agricultural economy.

Another very popular celebration in Xochimilco is the religious devotion of the Little Holy Cross (Santa Crucito in Spanish) and the Holy Cross, which is celebrated every May 3 and is transferred to the works under construction: Holy Cross Day. On that date the chapel is adorned with a floral arrangement called Tularco, which is worked and offered by the Barrio de Caltongo, through the butler for the neighbors of the Barrio de Santa Crucita, with the desire for good and abundant crops. Collectively, they will gather fresh tulle to the lagoon, in the wetland area, to weave a carpet on oars of trajineras, known as Tularco. The rug represents a chinampa that is decorated with flowers. Only the men carry it to the Church of Santa Crucito (female and male), representing a ritual of fertility propitiatory of good harvests.[8]

---

[7] This celebration, which reflects a syncretism between Aztec practices and Christian religious practices, which is directly linked to the farming system of chinampa as it begins in the Barrio de Xaltocan in Xochimilco and honors the landscape and local agricultural products.

[8] Praxedis, J. 2004. The Tularco, xochimilca offering, Enjoy Xochimilco yesterday and today, Mexico, (4)

Figure 30. Celebration of the Tularco, pre-Hispanic cultural practice. This rite is associated with what was done to the corn god Centeotl during the pre-Hispanic period (Cordero, 2001).

Figure 31. Dance of concheros in Xochimilco

People in these feasts produce and consume various foods and materials that come from domesticated species and local resources, such as *Gramineae* (corn), vegetables (tomatoes), ornamental (cempoaxóchitl), and wild plants (amaranth, Huautli in Nahuatl), weeds (quintoniles) and aquatic vegetation (reeds). People produce tamales, various stews, floral arrangements and clothing accessories, many of which are consumed by the urban population of Mexico City. The main festivals on the site are based on the products of local agriculture and their transformation (Gutiérrez and Cordero, 2015). The main festivals are shown in the following table:

Festival	Place	Date
Olive and amaranth	Tulyehualco	January
Community most beautiful flower	Xochimilco	March-April
Ice cream	Tulyehualco	March-April
Corn and Tortilla	Santiago Tepalcatlalpan	May
Candies	Santa Cruz Acalpixca	July
Honey	Xochimilco downtown	November
Poinsettia	Xochimilco downtown	Decemeber

Table 3. Festivals in the proposed site.
Fuente: http://www.xochimilco.df.gob.mx

In the case of Tlahuac, the best known cultural practices are[9]:
1. Amarguras de Ixtayopan: *tapetes de aserrín* (an ornamental carpet created with colored sawdust)
2. San Francisco Tlaltenco's carnival
3. San Pedro Tláhuac's carnival
4. Santa Catarina Yecahuiízotl's carnival
5. Zapotitlán's carnival
6. San Juan Ixtayopan's *chiles zolotes* (a special type of chilli pepper)
7. The celebration of the *danza del guajolote* (the turkey dance)
8. Tlaltenco's carnival
9. *Chacualole* (a type of pumpkin candy)
10. San Andrés Mixquic's celebration of the Holy Cross Day

[9] Conaculta, General Directorate of Popular Cultures, Intangible Cultural Heritage Program of Mexico, Integration of the PCI, Registration Form.

11. San Andrés Mixquic's celebration of the Day of the Dead
12. Giblet *mextlapique* (a kind of *tamal)*
13. San Andrés Mixquic's *mixmole* (a special kind of soup)
14. The pilgrimage to Chalma
15. Pilgrimages to Santiago Zapotitlán's Villa de Guadalupe
16. Mixquic's Holy Jubilee

Many of these cultural practices are internationally renowned, as is the case with San Andrés Mixquic's Day of the Dead celebrations. In this town filled with colorful traditions, the festivity includes plays, dance and musical acts, exhibitions, and the preparation of different types of traditional food, some of which is later offered to the dead. These offerings are placed and displayed on altars specially created to honor a family's dead relatives and friends. The altars traditionally include the departed's favorite food and drinks, some lit candles to light the way and *cempazúchitl* (Mexican marigold), a flower that is synonymous with these celebrations. The offering may also include fruit, a form of dessert and some of the deceased's former belongings.
When honoring children, it is not uncommon to see *xoloitzcuintli* (Mexican hairless dog) figurines that are said to guide their souls through the underworld. When the festivity ends, it is customary for the town's neighbors to go from house to house exchanging food and sharing memories of their loved ones.

Likewise, the existence of the association between festivities and agriculture can be evidenced in the Archaeological Museum of Xochimilco that includes pieces like the stone of Tetitla, that represents the dance of the spring; The Dahlia or Cocoxóchitl, known as the signature of the stone carvers or natural sculptors of Xochimilco; also the Xoloxóchitl or magnolia, symbolic flower of beauty, the flower of the heart. In addition to pedestals, the first includes animals like fish, océlotl, rabbit, dog, snake and a pelican, and the second pedestal form monoliths of personages and female goddesses, like the goddess of the corn and the hill of Xilotepec, who remembers the goddess Xonen, or goddess of tender maize. Also, according to the investigations that have been carried out by archaeologists regarding the petroglyphs of the site of Cuahilama, it is suggested that the reliefs were made by the Xochimilcas to foster the fecundity of the land (Benavides and Severiano, 2012), which is currently under an archaeological rescue project (INAH, 2016).

The festivals and the celebration is a way to affirm their identity and promote the frequent encounter between the inhabitants of Xochimilco and Tláhuac; the older people as well as the young actively participate

without there being a feeling that they are about customs or traditions that have gone out of style. The population is convinced to keep alive these celebrations that give identity to their people, so that they pass from generation to generation.

In addition to the existence of festivities, food culture and the supply of natural resources, the site also provides tourist services for national visitors and international tourists. Most tourists to the site (65%) prefer to visit the canals and chinampas and 14% visit the site to buy different plants (Guerrero, 2006). Touring the canals in the chinampas areas was created in 1789, and by 1850 steamboats operated as well as tourism, connecting Xochimilco's vegetable production with the urban inhabitants of Mexico City (Herrera, 2016). At present, there are 2,500 trajineras that can transport approximately 50,000 people leaving 10 piers that were mainly built since 1950 (Guerrero, 2006). In particular, navigation on the canals in the chinampas areas of Xochimilco and Tláhuac have a positive impact on the economy of their respective communities as visitors enjoy food, religious celebrations; small musical bands that sail along with tourists. In addition there are dancers, known as concheros, who perform representations of pre-Hispanic dances; as well as pyrotechnic shows, are some examples of activities that attract people outside the locality and who contribute to the local economy. Other economic activities such as the production of traditional handicrafts, in the form of baskets and pottery, are now less important but still exist.

Figure 32. Tour in trajineras in Xochimilco.

On the other hand, in Xochimilco-Tláhuac, there is a great variety of participation in the "local governance" with different levels of impact and visibility as well as different action fields. The "participation system and regional actions", is present in almost all the intervention sectors. In a social level, there are local committees for the guaranteed minimum income control, such as the committee's environmental conditions protection, the education local councils, and social networks. In economic terms, there are different business associations, agricultural associations, trade associations, farmers' associations and tourism. An example of these manifestations is the indigenous peasant association "Axochiatl Threshold" which since 1996 carries out activities such as preservation of axolotl and the rescue of chinampas through traditional practices characteristic of this system (Torres and Gonzalez, 2014), this association works by convincing the chinamperos that they have their unproductive chinampas or at rest as they call it, so that they become productive. They offer advice and sometimes they work on them themselves.

The starting point of the chinampa agriculture development is based on the acknowledgment of their differences; the heterogeneity of their projects, the existence of contradictory interests; the building forms of collective action; and, particularly, in the roles of the different actors. In other words, the "social meaning" of the regional life in the site of the

chinampa agriculture is only recognizable through the analysis of the specific agricultural processes meanwhile new routes of participation in Mexico City potentially arise as forms to extend the participating democracy, such as the concrete processes of participatory planning on the site, managed from the Heritage Zone Authority, as a coordinating organ in the area.

5. Remarkable landscapes, land and water, resources management features.

The current chinampas landscape, resilient and heir of prehispanic agricultural system still retains immersed in congested Mexico City, a great aesthetic appeal. Among others chronic describing in awe at the chinampas, De Acosta (1590) wrote:
"Those who have not seen the crops that are made in the lagoon of Mexico, in the middle of the same water, will by canard what is told here, or at most, they will believe it was an enchantment of the demon who these people praised. But in truth it is a very feasible thing and it has been done many times, do quicksand seed in the water, because of sedges and cattail earth is cast and there is planted and growd, grows and matures, and takes from one part to another ".

Hundreds of years later, in 1937, the artist Miguel Covarrubias reflected in the famous Ritz Hotel in Mexico City a mural that popularized the chinampas even more to foreigners. Also, in 1943, in the film "Maria Candelaria" the remarkable chinampas landscapes of Xochimilco were included (Caraballo, 2006). Both examples, among many others, are a significant sample of the powerful aesthetic impact that this traditional system has, over time, on the minds of those who observe it.
However, the main contribution of indigenous knowledge it's found in the self-building technique of the chinampas. To build a chinampa the indigenous cut tule (*Thypha* spp), lawn and tape or "atlapalácatl". This grass was cut into strips of 5 to 10 meters wide and about 100 meters long, and a layer of wet tule was piled up and another layer of dry one, so that the surface would emerge slightly from the water. The surface was then covered with mud from the bottom of the channel that was extracted with a long wooden stick (Zoquimaitl) where on the end leather pouch or tray (Texpetlatl) was placed. Then the ground was leveled with a kind of rake, which consists of a table of 15 to 20 centimeters wide and 80 long. Finally, the chinampa was reinforced with ahuejotes (*Salix bonplandiana*) meeting the function of fixing the chinampa and retaining agricultural land. The soil was renewed before each planting with layers of mud. Over time, about four years after the chinampa was formed, the decomposition of organic matter is almost

complete, and has a porous soil rich in nutrients, which it incorporates bat guano, permeable to water, and humidity regulator. Once "land has already been made" and have ahuejotes on, the chinampa is ready to be cultivated (West and Armillas, 1950).

The lacustrine zone constitutes a remnant ecosystem of the Basin of Mexico formed by natural inundated plains and induced water bodies, is a natural area of discharge of the underground flow. The lake system is located physiographically in the province of the Neovolcanic Axis, Subprovince of Lakes and Volcanoes of Anáhuac, in the extreme south of the Basin of Mexico. It originated at the end of the upper tertiary and early Quaternary periods; during this phase the southern part of the valley was obstructed by the formation of the Chichinautzin Sierra, emerging the endorheic basin of Mexico, and from there, the deposit of materials of volcanic origin, alluvial and organic, the latter predominant in the area. As for its geomorphology, it is divided into three units: lacustrine plain, lacustrine-saline plain and alluvial plain, while its area of influence towards the southern part is classified as foot of mount or zone of "transition". Xochimilco and Tláhuac belong to the Pánuco region, within the hydrological basin of the Moctezuma River and the Lake Texcoco-Zumpango sub-basin. It is estimated a length of 406 km of channels connected to each other (González - Pozo, 2014); Among the most important are: Cuemanco, Nacional, Chalco, Del Bordo, Apatlaco, San Sebastián, Ampampilco, Texhuilo, Zacapa, Caltongo, Santa Cruz and Japan. The main lagoons are Caltongo, Del Toro and the lake of San Gregorio Atlapulco (Annex 11).

In this sense, at current the lacustrine zone constitutes yet a remnant ecosystem of the Basin of Mexico and its geomorphology continues working in the same way. Only that the natural flow of water has declined considerably because it was used to meet the demands of human consumption.

Following a global trend, specifically favoring water availability for human consumption, the Mexico City Government, through its water operator, named Mexico City Water System, (SACMEX, for its initials in Spanish), has taken advantage of and been reusing treated water for agriculture and industry. This organism is in charge of processing urban generated wastewater and providing such services as drinking water supplies, drainage, sewage disposal, and water recycling.

So, since the middle of last century, the lacustrine zone and its channel network has been fed with treated wastewater from 8 treatment plants, which together contribute the volume of water required, of which 87%

comes from the Cerro de la Estrella and the remaining volume (13%) of the 7 plants local plants, which have gradually been incorporated.

In this way, in the year 1971, the wastewater treatment plants, WWTP, "Cerro de la Estrella" came into operation. And the local WWTP began operating in 1989, in Xochimilco. During the years of 1993, 1994, 1997 y 2000 in Tláhuac. This information is described in detail in the chapter Complementary data (page 137)

Thus, for six decades, the lacustrine area of Xochimilco and Tláhuac has been supplied continuously with treated wastewater, provided by the Government of the City of Mexico through SACMEX, like an entity set up specifically to safeguard water resources. It is the responsible operative agency and operates too the lead instrument on water policy for the City of Mexico, denominated Program on Sustainability and Integrated Water Services Management (PSGISH, for its initials in Spanish), commonly referred to as the "Water Plan for the Future CDMX", that works under the Water Law of the Federal District or Mexico City. (Complementary data, page 139).

In relation to the quality of the treated water used for growing vegetables, it does not represent any risk to the food production, and complies with the Official Mexican Standard NOM-003, a federal norm, which establishes maximum permissible levels of contaminants in treated wastewater for reuse by the public, which is periodically monitored by SACMEX through his Central Laboratory for Quality Control of Water, built since 1982.

The laboratory monitoring results establish that treated wastewater delivered by the WWTPs administered by SACMEX has an excellent quality for the maintenance and conservation of the lacustrine area of Xochimilco and Tláhuac, complying with parameters established by the Official Mexican Standard. This information is described in detail in the chapter Complementary data, Quality of Treated Wastewater (page 144)

Currently, the canals and lagoons are artificially fed with treated water from the Cerro de la Estrella Treatment Plant, which supplies the required volumes to the chinampero system, with which it has covered its demand, supplying 2,150 lps, (2,350-200 = 2150 lps), of which the 47% is contributed to the municipality of Tláhuac and 44% to that of Xochimilco. And the 7 local treatment plants that contribute a volume of 338 lps additional to the area according to the demand, and that currently have an operating expense of half of its real installed capacity of 745 lps (Hydric Balance for treated wastewater in the lacustrine zone

of Xochimilco and Tláhuac, page 141). In this sense, the total sum of the volume of treated water available is 2,488 lps, by which the sustainability of the chinampa agricultural system is guaranteed. (Hydric Balance for treated wastewater in the lacustrine zone of Xochimilco and Tláhuac, pages 142-143).

In order to level the circulation of the bodies of water in the Xochimilco area, the 4 floodgates that make up the Yucatan locks, which functions as a water level control system, are used (Annex 26).

In Annexes 24-26, a scheme is added, accompanied by photographs explaining how the channel flooding system is currently operating.

1. Distribution of expenditure for different flows of the Treatment Plant Cerro de la Estrella.
2. Local treatment plants that contribute to the area of Xochimilco and Tláhuac.
3. Diagram of the distribution of treated wastewater from the Cerro de la Estrella plant.
4. Yucatán Lock, Delegation or Municipality of Xochimilco.

Figure 33. Treated wastewater infrastructure in the chinampera area of Xochimilco and Tláhuac. Fuente: SACMEX, 2014.

The soils are predominantly lacustrine and marshy, with diverse geological composition. They vary according to the area in which they are, they have a high content of organic matter, they are of dark colors; Influenced by the presence of a nearby water table; are deep and discontinuous soils, because they originated as small islets surrounded by water; some authors classify these soils as antrosols by the process of formation of chinampas and human influence. In areas adjacent to the Tláhuac chinampas, soils are constituted by alternating layers of clastic, volcanoclastic and biogenetic sediments, deep, with high organic matter content, loose on the surface and with chemical and physical properties to be considered very fertile called histosols) (Tavarez, 2015). In the lacustrine zone, clayey sediments predominate with fine-grained sands, with about 50% volcanic ash, with textures ranging from sandy to silty-loamy, and retain a high amount of moisture. The high fertility and productivity of soils over time has been provided by the incorporation of large quantities of aquatic vegetation, mainly aquatic lily (*Eichornia crassipes*), mud from the bottom of the canals and organic fertilization of animals during the permanent use of plots for crop production. Particularly, the sludge is a substrate of nutrients that will continue to form the soil of the chinampas. The physical (pH) and biological factors (high microbial activity promoted by calcium, potassium and other mineral nutrients) of chinampas soils are associated as responsible for the suppression of short- and long-term diseases (Lumsden *et al.*, 1990).
The conservation of the chinampas agricultural system is fundamental for several reasons, to maintain the quality and dynamics of the aquifer, the conservation soil of the Mexican Basin, to preserve the endemism and the singularity of its natural communities and the associated habitats; preserving the regional ecological balance, and, for the cultural value that it represents as a living natural museum, for the permanence of traditional agrosystems such as chinampería (Aranda, 2004).

In summary, Xochimilco's importance (where the production of flowers, ornamental plants and vegetables occurs) and Tláhuac (that grows vegetables, corn and amaranth), and of its natural resources is based on the following considerations: both agroecological landscapes represent a territorial generator of ecosystem services that besides supply agricultural products for the population inhabiting the Federal District and the Mexico City's metropolitan area; including basic elements to keep the water cycles and nutrients, that serve for stabilizing soil, allowing the CO2 catchment, as well as the dust retention resulting from the pollution; it is also one of the richest and most important reserves of species of endemic plants in the country; it constitutes a base for the development of the original lakeside towns; and it represents a

historically significant space for the local, national and international tourism.
Also, the products supplied by the chinampa system, are mainly vegetable, such as the flowers and plants production for the local and metropolitan markets. The chinampa areas of San Gregorio Atlapulco, Tláhuac and Mixquic are mainly specialized in growing products like lettuce, cabbage, cauliflower, radishes, spinach and broccoli. Meanwhile in the Xochimilco and San Luis Tlaxialtemalco areas are more specialized in the growing of flowers and plants for pots, these products tend to be grown in greenhouses with plastic covers.

Figure 34. Flowers and plants for pots production

Additional to the commercial farming, there are other products produced in the chinampas that benefit the local livelihood. For example, the abundant ahuejote tree (*Salix bonplandiana* Kunth) supplies the rods that serve to build the chinampas and to reinforce their physic limits or borders. The wood is also used in the construction of the town's houses and their medium and smaller sections can be easily transformed into building material for traditional cabins used to keep crops and tools. A more sophisticated but similar solution was used one century ago to build permanent and light housing on the chinampas.
At last, a basic comprehension of any zoning modification in the chinampa site is fundamental to predict the change of the ecosystem services that may affect the whole Mexico City (Merlín-Uribe *et al.,* 2013a). Most of these changes, which result from the kind of the anthropic management of the regional natural resources, are related to

the services of the ecosystems that this wetland gives to the city, such as the food supplying; the air quality; the favorable climatic conditions; the soil productivity; the prevention of floods in times of extreme rains; the provision of water to a city with high hydraulic pressure over its phreatic layer; the local population cultural links; and the esthetics and the recreation.

Figure 35. Producers recolecting mud from the canals

II. Historical Significance

It is reported that in the middle of 20th century, was carried out the first ethnographic study that was formally used of the origin, development and socio-political importance of chinampas (González Pozo, 2014). During the 60's and subsequent, a wide team of archeologists carried out studies about the dynamic of the sedentary prehispanic societies that occupied the Mexico's basin until the 16th century. This provided a range of approaches to their true origin, evolution and agronomic technical variability, building system, relative to household/productive area, structure of the productive system and relevance in the Postclassic political system. From 1980 to conducting rescue works and archaeological rescue, including stratigraphic wells in various chinamperos sites, research relating households with productive areas, archaeological surveys, registration and cataloging of chinampas, and presence of pre ceramic settlements the area are added. During the last three decades, the archeological studies have persisted with the surface records detailing the previous works carried out in the area, in so far as the diggings have privileged the study of the relation among domestic units and productive areas, constructive techniques, the establishment of the chinampas evolutional sequence, dating of these ones, as well as approaches to the inventory of cultivated and tolerated plants for its use in that environment.

Altogether, various authors have noted that the historical significance of the chinampa agroecosystem has to do with its role in the nuclear communities development around the lakes of Chalco and Xochimilco, as well as in the islands of Xico, Tláhuac, Culhuacán, perhaps Mixquic and Xochimilco around 1200 b.C. However, the data show that chinampas expansion peak occurred between 1400 and 1600 b.C. It is referred that the changes that stimulated the rise and expansion of the chinampa agroecosystem occurred in the socio-political order. One of them would have been the geopolitical reordering that happen in the Basin of Mexico Teotihuacán polity falling; and other, the progressive demographic and urban pressure that Aztecs exerted on the same space (Jiménez *et al.,* 1995:24, quoted by González-Pozo, 2014).

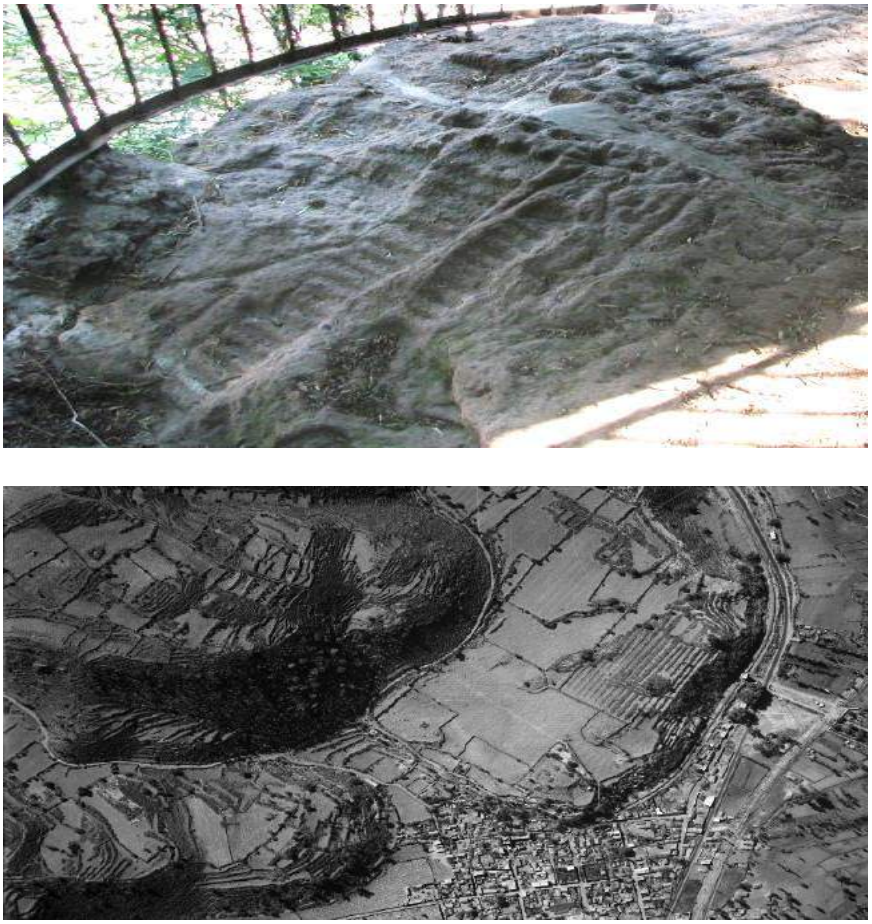


Figure 36. Terrace petroglyph and photograph of terrace landscape near chinampas in Santa Cruz Acalpixca, 1938.

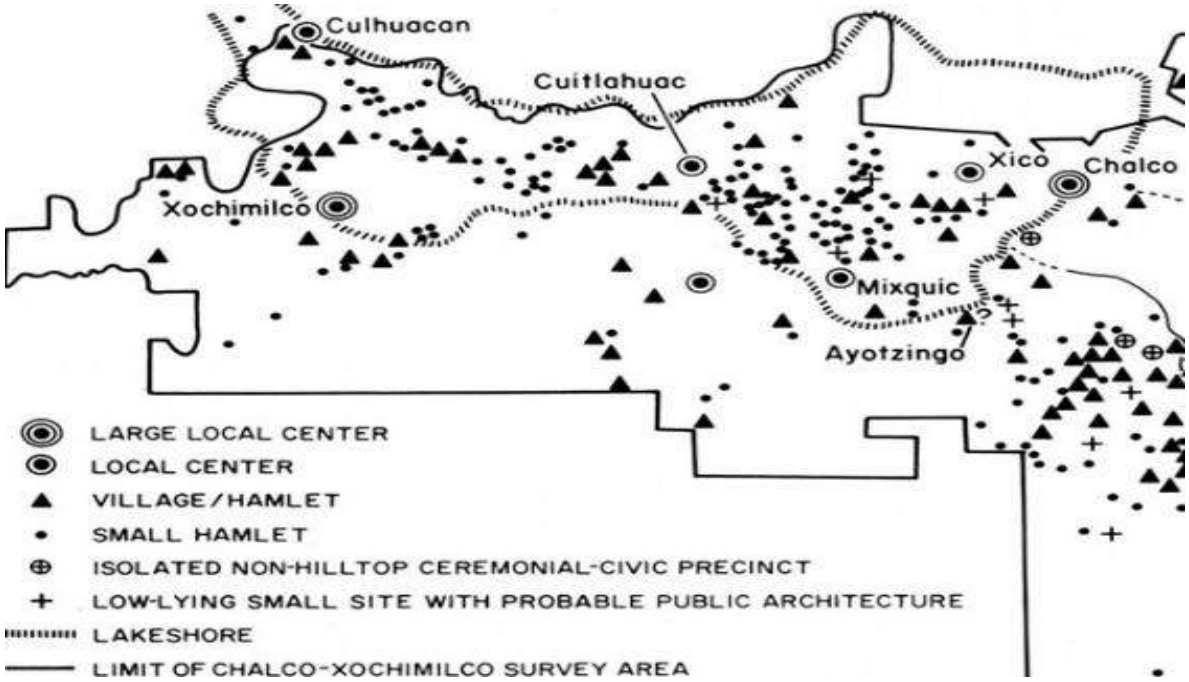


Figure 37. Towns and local settlements in lake shore of Xochimilco IV Aztec stage
Source: Parsons, 1982.

In this sense, it is identified that the extension of the agricultural surface rescued the swamps and got into the productive chinampa agroecosystem in the region of Xochimilco-Chalco consisted of more than 9,000 hectares. It is also estimated around 10,000 has. of highly productive chinampas would have likely been enough to supply basic food at least to half million people (Sanders *et al.,* 1979). About the corn production, Sanders (quoted by Rojas, 1991) estimates that the chinampa system may have at least from 171,000 to 200,000 people with an annual consumption of 160 kg *per capita.* Redcliff (1987) pointed out that the mixed population of both main cities in the Valley of Mexico, Tenochtitlan and Tlatelolco, was between 200,000 and 300,000, five times the size of London in times of Henry VIII. Even with the high population levels of the Aztecs period, about one million, all of the Valley of Mexico potential was not used. The estimated regional carrying capacity in that moment, with a base on the agricultural development, has been estimated in 1,250,000 people. It is concluded that the pressure of the human population on the agricultural resources was never a determinant factor in the cultural evolution in the prehispanic Valley of Mexico. In this sense, the chinampa agriculture, at the same time of the water arrangement as well as the socio-ecologic history of how to keep the agricultural practices thorough the time, have

contributed in a long term to the alimentary security to be constituted as an agricultural system that has not been kept by a regime of the use of fossil energy (Barthel y Isendahl, 2013), but that has been integrated to the urban activities promoting the Mexico City's resilience.

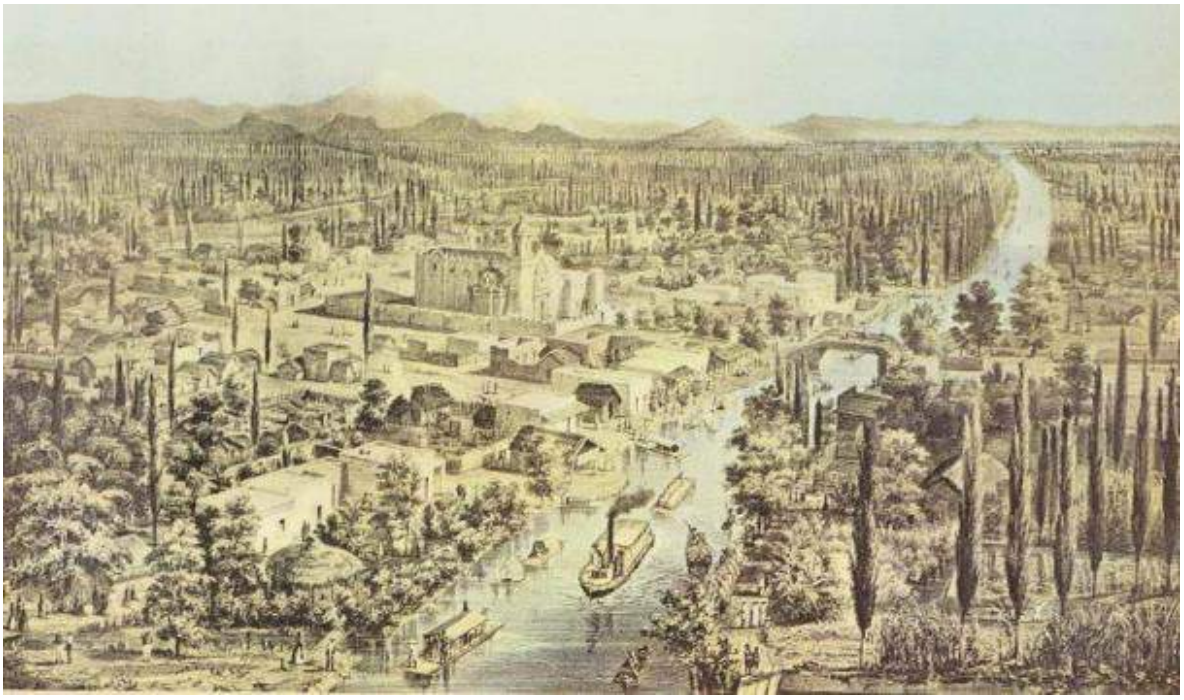


Figure 38. De la Viga canal view from Xochimilco to Mexico City, by 1876.
Source: (Memoria de las Obras del Sistema de Drenaje Profundo, Tomo IV. Atlas de Planos Técnicos e Históricos, DDF, México, 1968).

III. Contemporary relevance

There are only few descriptions in the world literature describing the processes for feeding and for growing ornamental plants in the big cities that contain historic antecedents and in a wide range in terms of intra and periurban development as the one in Mexico City. Likewise, there is a lack of information about the systematic tasks required for the design and application of the political operative policies including the analysis of future scenarios that are derived from ongoing activities in the intra-urban rural areas (Steinberg, 2005). There are also a limited number of case studies focused on the implementation of strategic planning processes for the development of urban agriculture in terms of territorial organization, where the initiatives of local actors, public and private sectors are synergistically articulated to benefit the city. On the other hand, the chinampa agricultural system is not the only example of agriculture in wetlands, these spaces have been claimed historically for

such purposes in many parts of the world (Verhoeven and Setters, 2009), not always with positive results for the conservation of natural preexisting and adapted ecosystems (Bennett and Balvanera, 2007; Hassan et al., 2005).

In light of this background of low public information and insecurity under the global food supply, and under consideration of processes of economic inequality in different regions and cities, the contribution of chinampa agriculture system for global and national policies is relevant in terms of strategic planning for sustainable development of cities and promotion of appropriate types of urban agriculture, especially from an international comparative perspective of the importance of urban agriculture for poverty relief and food insecurity.
Currently the agricultural production in chinampas is vital for the construction of a food security system for the benefit of the population of Mexico City, articulating the varied offer that offers this agricultural productive practices, with the wide demand generated by the current tendencies oriented to the consumption of local, authentic, healthy and seasonal food products. In addition to its productive value, it has an important cultural value, since they support community traditions and a wide range of knowledge about agriculture, the natural environment and the history of the original peoples who have given life to the area for more than five hundred years.[10]
Chinampas are still representing the agriculturally most productive and important in the cultivation of vegetables and ornamental plants in Mexico City, with a production of 17,600 tons of flowers and 3.635,000 plants in pots. This city, as one of the largest urban centers in the world that, despite suffering many problems related to environmental sustainability, has a high cultural and environmental importance closely linked to traditional value systems and social representations conceptualized by farmers with reference to land and water in the chinampa system (Torres-Lima y Rodríguez-Sánchez, 2008).

This particular experience of chinampa agriculture can be applied elsewhere in relation to the design of policies and strategic actions to facilitate local development of urban agriculture, guaranteeing a certain quality of life of the population and the maintenance of natural resources and rural landscapes. In this sense, chinampa agriculture involves different issues in the development agenda of cities around the world, from the perspective of strategic planning and practical application. Although it is well known from the literature that each city is

[10] In this regard, Mexico City has signed an "Urban Food Policy Pact" in Milan, Italy, FAO, in October 2015, which adheres to four basic principles: Guarantee basic food for all; Promote sustainability in the food system; Educate the public about healthy diets; And reduce food waste.

a different case study on the characteristics of urban agriculture, and even the different neighborhoods of the same city may require different approaches (FAO, 2014), urban agriculture is worthy of institutional recognition and direct support of public policies and objectives (Drechsel and Dongus, 2010). Chinampas offer a case to consider restoring the criteria of public policies that provide for joining agricultural activities for ecotourism, the marketing of rural products; restoration and conservation of the environment of farming systems; payment for ecosystem services; and monitoring and active social participation by the local population, through the formation of organizations that include and secure the citizen participation.

As part of the current debate in the Urban Food Forum about sustainable practices and innovation in the field of urban and periurban food systems, a key point of discussion is urban agriculture as a potential contributor to poverty alleviation and the inclusion of marginalized groups in the cities of the global South. In this sense, urban food policies and support programs can foster a real transformational change through the promotion of existing livelihoods and empowerment of surrounding and intra-urban rural vulnerable populations, such as chinampa agriculture. However, a strong political will is needed to reverse the perception that the food economy is a problem rather than a solution for the creation of sustainable and resilient urban spaces (ICLEI, 2015). In terms of achieving inclusive, safe, resilient and sustainable cities and human settlements, what is needed is to support economic, social and environmental links in urban and periurban and rural areas by strengthening the planning of national and regional development (UN, 2014), a spacial historical reference consists in the chinampas agricultural system, which certainly has much to contribute.

Figure 39. Nurseries in the chinampas.

IV. Threats and challenges

According to the latest urban trends in the metropolitan area of Mexico City, the chinampas agroproductive system is being threatened by the expansion of the urban spot on areas that currently have primary vegetation, flower and vegetable crops, which are importants to catch rainwater and to keep the existing biodiversity.

The diversity of species on the site is threatened by changes in land use towards more profitable activities than agriculture. It is because of productive agricultural activities are experiencing greater economic losses in traditional crops, mainly due to lack of local marketing networks or circuits. And so the reduction in their income limits the producers in the care of the environment as part of the management of agroecosystems.

Undoubtedly a challenge for the area is constituted by subsidence, fractures and cracks in the ground existing throughout the Valley Mexico Basin, caused by the continuous groundwater extraction.

However, in this chinampas area is guaranteed water for irrigation of crops, in quantity and quality, considering that the hydrological conditions of the lake system will continue to be artificially fed, through the filling of channels by treated wastewater from Cerro de la Estrella Treatment Plant.

In this way, that residual treated water contains low concentrations of nutrients, so there are no risks for the anthropogenic processes of eutrophication. It is reported that primary production and chlorophyll-a concentration are good indicators of the degree of eutrophication in this body of water and that the channels of the Chinampas zone of Xochimilco are in a homogeneous mesotrophic state (Nuñez-Jimenéz et al., 2015).

A new factor for analyzing like challenge, are locals climatic conditions, which have been changing in the last decade, for wich productors is considering the adaptative process of chinampa system technology, wich has been adapted to regional climatic conditions, like frost and hail (normally almost zero in the area) only affect 15% of agricultural production and cause economic losses of 10% or even less. (protection net, for example)

Another recent agroecological disturbance in the chinampa system has been associated with increased agricultural pests and diseases. Most farmers identify this problem as a result of environmental degradation on soil and water resources used in the production cycles of crops. Both ecological deterioration and increased pests and diseases have caused

several eco-physiological crop responses (i.e., reduction in size of leaf crops, fewer buds, flowers and fruits, and lower dry matter production and yield).
Consequently, agronomic practices have also changed, depending on the crop cycles, which have also been shortened. For example, agrochemicals (ie. Fertilizers applied to ornamental plants in order to increase crop yield)[11] and irrigation are more frequently applied.
In this sense, the main scenarios and problems of chinampas agriculture in Xochimilco-Tláhuac, are associated with processes related to rural production itself and the flow of supplies and agricultural products within the region due to:
1) The alteration of the agroecological balance of production systems linked to chinampas; 2) The alteration of exchange networks and economic cooperation, due to the difference between urban and rural incomes;
3) Low level of social and human capital for the development of marketing activities in agricultural products outside the Federal District, which has better pricing conditions; 4) The high cost of supplies and lack of local technological development for the production of these. 5) Little or no development capabilities for the agro-industrial waste recycling;
6) Insufficient coordination of educational activities in agricultural production and a weak approach in cultural, ecological and tourism conservation; and 7) The lack of a system of technological and scientific support with a wide coverage that allows promoting ecologic production models compatible with the environment and with the surrounding wetlands.

V. Practical considerations

1) Ongoing efforts to promote GIAHS

Based on the GIAHS framework, major efforts underway to agricultural development in the chinampas of Xochimilco-Tláhuac in Mexico City are: 1) Natural resources recovery and preservation, the sustainable use of agricultural soil profile and ecological functions of natural resources is promoted; 2) Recovery of ecological conservation area it is aimed to eliminate the physical-space expansion and growth of human settlement; 3) Control the process of land occupation, protection and increase of aquatic areas of recharge, a reorganization of the areas of human occupation is sought; 4) Recovery of the regional biodiversity, the implementation of a permanent and systematic monitoring , and the replacement of non-native species by local species must be carried out; 5) Establish integrated programs for the management of watersheds to

[11] Fertilizers such as ammonium sulfate, triple 17 and foliar fertilizers.

protect natural areas and contribute to the maintenance of soil and water; 6) To restore the natural system of lakes, the rehabilitation of all channels and areas of chinampas (in order to increase infiltration), capturing rainwater to recharge aquifers and increase the capacity treatment of wastewater, which increases the contribution of treated water system.
It is expected that the benefits and impacts to be registered to GIAHS correspond to three areas of institutional intervention: a) To promote chinampa agroecosystems and revitalize agriculture; b) Recover and restore areas with greater environmental value; and c) to establish payment for ecosystem goods and services as a means to offset the costs of chinampas conservation.

2) Potentialities and opportunities for sustainability and management of GIAHS

The potential and opportunities structured under GIAHS criteria should be designed as planning strategies for chinampa agriculture, able to coordinate institutional intervention, such as: 1) Activities to reverse the hydrogeological spoilage in the wetlands and the chinampas; 2) Consider the Xochimilco-Tláhuac system as a landscape of cultural heritage through projects designed for the rescue, preservation and promotion of ecotourism in the area of chinampas and wetlands; 3) The chinampas rescue by promoting and supporting agricultural production with limited environmental impact and increasing economic benefits; 4) Improving the urban structure to allow greater mobility of chinampa farmers through connections with the rest of Mexico City; 5) Reverse the impacts caused by irregular human settlements, through the creation of appropriate conditions for mass housing and urban upgrading; and 6) The establishment of a geographic information system on the chinampa site, allowing a greater efficiency in the public administration of the Federal District regarding the handling of this geographical area and in terms of planning methods for making decisions concerning the implementation of regional public policies for urban agriculture in Xochimilco-Tláhuac.

3) Expected impacts of GIAHS on society and ecology

The promotion y revitalization of agroecosystems and sustainable management of natural resources in the chinampa site should be considered as a priority measure, involving owners and users of agricultural production areas in the integrated and democratic management of periurban rural zone in Mexico City. This should be a priority area for sustainable management of water, soil and agrobiodiversity. As for the recovery of the areas of greater environmental value, sustainable management of water and lake system of Xochimilco-Tláhuac should be based on the preservation of the hydrological cycle. Water management

involves reversing the trend towards a hydrogeological deficit, so that the lake system hydraulically must be sustainably stabilized. Therefore, it is necessary to support projects that take advantage of rainwater, providing containers for storage in order to channel water in the irrigation system before it reaches the urban area and disappear into the drainage networks. Finally, regarding the payment of ecosystem services and products intended to offset the costs of conservation, restoration of agricultural ecosystems chinampas of Xochimilco-Tláhuac should ensure a continuous environmental services for the inhabitants in Mexico City.

4) Motivation of the local communities, the national/local authorities and other relevant stakeholders

A project for dynamic conservation and sustainable management of agricultural heritage systems and landscapes, biodiversity, along with traditional knowledge and associated cultures in Xochimilco-Tláhuac, with importance for the management and operation of the agricultural system of chinampas, within the framework established by GIAHS it is foreseen the promotion of new forms of citizen participation and organization for agricultural production based on regional social and human capital within a strong legal framework; with the aim of responding to both the need for local urban planning for agricultural development, and for conservation of the environment and promotion of economic activities. The main criterion of sustainability that can be included to meet the demands of both the local population and their participation in processes of decision making and to address the needs of planning and site management in Xochimilco-Tláhuac should be based on: 1) The whole development of chinampa agriculture; 2) environmental conservation and restoration of ecosystem services; 3) the promotion and strengthening of regional economic activities; 4) containment, stabilization and reversal of trends in urbanization from irregular settlements on agricultural land; 5) provision and maintenance of urban services and for the development of agricultural activities; and 6) the security of land tenure.

The benefit of this type of management plans (institutional and social based on collective agreements) and policy frameworks for the protection and promotion of heritage chinampa agricultural system is to promote the approach in terms of planning. The chinampa agriculture should not result in geographical space that is subject to the urban regional real estate market and for the benefit of their own urban watersheds but it must meet the requirements of infrastructure investment for environmental projects and agricultural production as well as for long-term research, technological development, technical training and environmental education. It is also important to reorient the sense of socio- territorial organization on the site,

in order to achieve an integrated city that is livable and sustainable, by promoting agricultural activities of the chinampas in Mexico City. This approach aims to promote priorities: controlling urban settlements; ensure the rational and sustainable use of resources; protect chinampa agriculture, and to give priority and containment to urban growth; along with the maintenance of environmental services that the site provides to the rest of the city enriching rural landscapes and adjusting the urban microclimate.

To consolidate the position of the concept and structure of the GIAHS in all the participants, particularly local communities and authorities, Authority of the Natural and Cultural World Heritage Zone in Xochimilco, Tláhuac and Milpa Alta, in the Federal District, it has been begun in the five areas of chinampas within the site, a monthly program of awareness and dissemination of the advantages of having the GIAHS proposed for registration as GIAHS (Xochimilco, San Gregorio Atlapulco, San Luis Tlaxialtemalco, Tláhuac and Mixquic) to achieve the implementation of agreements and commitments to participate and share the tasks that are planned in the GIAHS action plan.

5) REFERENCES

Aguilar, A., Zambrano, L., Valiente, E. and Ramos-Bueno, A. 2013. Enhancing the potential value of environmental services in urban wetlands: An agro-ecosystem approach. *Cities,* 31:438–443.

Altieri, M. y Nicholls, C. 2008. Los impactos del cambio climático sobre las comunidades campesinas y de agricultores tradicionales y sus respuestas adaptativas. *Agroecología,* 3: 7-28.

Altieri, M. y Nicholls, C. , Henao, A. and Lana, M. 2015. Agroecology and the design of climate change-resilient farming systems. 35(3) *Agron. Sustain. Dev.* 35(3): 869-890.

Aranda, M. 2004. Ficha Informativa de los Humedales de Ramsar. Sistema lacustre "Ejidos de Xochimilco y San Gregorio Atlapulco". Secretaria de Medio Ambiente. México.

Barthel, S. y Isendahl, C. 2013. Urban gardens, agriculture, and water management: Sources of resilience for long-term food security in cities. *Ecological Economics,* 86:224-234.

Benavides, L: y Severiano, R. 2012. Revista Digital de Gestión Cultural, 2(6): 1-15.

Bennett, E. and Balvanera, P. 2007. The future of production systems in a globalized world. *Frontiers in Ecology and the Environment,* 5:191-198.

Caballero, M. D. 2010. *Estudio de gran visión y factibilidad económica financiera para el desarrollo de infraestructura de almacenamiento y distribución de granos y oleoginosas para el mediano y largo plazo a*

nivel nacional. México. Colegio de Postgraduados.
Caraballo, C. 2006. Xochimilco ¿Un atractivo turístico con destino saludable?. *Cuadernos del Patrimonio Cultural y Turismo,* 14, 118-135.
Clauzel, C., 2009. Between urban pressure and heritage: which place for agriculture in the Chinampas of Xochimilco (Mexico)? *Cahiers agricultures,* 18, 323–328.
Contreras, V., Martínez-Meyer, E., Valiente, E. and Zambrano, L. 2009. Recent decline and potential distribution in the last remnant area of the microendemic Mexican axolotl (*Ambystoma mexicanum*). *Biological Conservation,* 142(12): 2881–2885.
Cordero, R. 2006. *Mitos y Leyendas de Xochimilco.* Ed. Leyenda. México.
De Acosta, J. 1590. *Historia natural y moral de las Indias.* Tomo II, p.p. 167-168, ed. de 1972. México.
Drechsel, P. and Dongus, S. 2010. Dynamics and sustainability of urban agriculture: examples from sub-Saharan Africa, *Sustain Sci,* 5:69–78.
Food and Agriculture Organization. 1988. *Apoyo de emergencia a la zona lacustre de Xochimilco-Tlahuac*. Informe final, FAO, Mexico.
Food and Agriculture Organization. 2014. *Growing greener cities in Latin America and the Caribbean*. FAO, Roma.
Figueroa, M; Salazar, M.; Ramos, M; López, M; Ferrara M; Vargas, R, C, 2014. Manejo integral de cuencas hidrológicas: una aproximación ecológica. En Figueroa, M; Linares, F; Ferrara, M; Castro, J (Eds.), *Manejo integral de la Cuenca de Xochimilco y sus afluentes.* Ciudad de México: UAM.
Gobierno del Distrito Federal, 2006. *Acuerdo por el que se aprueba el Programa de manejo del área natural protegida con carácter de zona de conservación ecológica "Ejidos de Xochimilco y San Gregorio Atlapulco*. Gaceta Oficial del Distrito Federal. México. Gobierno del Distrito Federal,
González-Pozo, A. 2010. *Las chinampas de Xochimilco al despuntar el siglo XXI: inicio de su catalogación*. México, UAM-X.
González-Pozo, A. 2014. *Estudio para la catalogación de chinampas de la zona de monumentos en Xochimilco, Tláhuac y Milpa Alta, D.F., inscrita en la lista del patrimonio mundial, cultural y natural de la humanidad*. Reporte final. Convenio # 35311322, Autoridad de la Zona Patrimonio Mundial Natural y Cultural de la Humanidad en Xochimilco, Tláhuac y Milpa Alta-UAM-X. México.
Guerrero, M. 2006. La agricultura chinampera. Reporte incluido en UNESCO-Xochimilco. *Xochimilco: Un Proceso de Gestión Participativa.* Gobierno del Distrito Federal-Delegación Xochimilco-Proyecto UNESCO-Xochimilco. México, 229p.
Hassan R, Scholes R, Ash N. 2005. *Ecosystems and human well-being. Current state and trends.* Washington, DC: Island Press.
Herrera, M. 2016. Había una vez un canal. La Acequia Real y el Canal de la

Viga, caminos de agua con historia. *Diacronías,* 9(16):49-72.
Icaza, A y Aguilar, R. 2014. Sistema para el tratamiento de aguas negras en la zona chinampera de Xochimilco. En Figueroa, M; Linares, F; Ferrara, M; Castro, J (Eds.), *Manejo integral de la cuenca de Xochimilco y sus afluentes.* Ciudad de México: UAM.
ICLEI. 2015. *Resilient cities report 2015: Global developments in urban adaptation and resilience.* ICLEI, Germany.
INAH (Instituto Nacional de Antropología e Historia). 2016. Cerro Cuahilama, "punta de iceberg" de un espacio arqeuológico mayor en Xochimilco. Boletín 15, 6 de junio. México.
INEGI (Instituto Nacional de Estadística, Geografía e Informática). 2005. *II Conteo de población y vivienda 2005,* INEGI, México.
INEGI (Instituto Nacional de Estadística, Geografía e Informática). 2008. Xochimilco, Distrito Federal, Cuaderno estadísticos delegacional. México.
Jiménez, M. 2013. *Resiliencia y adaptabilidad del sistema chinampero de Xochimilco*. Tesis de licenciatura en Geografía, UNAM, México.
Jiménez-Osornio, J., Rojas, T., del Amo, S. and Gomez-Pompa, A. 1990. Pasado, presente y futuro de las chinampas. In: Gomez-Pompa, A. and Kathleen, T. eds. *Reportes de sostenibilidad Maya.* No. 1. Riverside: University of California, 5–16.
Jimenez-Osornio, J. and Gomez-Pompa, A. 1991. Human role in shaping of the flora in a wetland community, the chinampa. *Landscape and Urban Planning,* 20: 47-51.
Jiménez-Osornio, J., Rojas, T., del Amo, S. and Gomez-Pompa, A. 1995. Conclusiones y recomendaciones del taller, en Rojas, T.(Coord.). *Presente, pasado y futuro de las chinampas.* CIESAS y Patronato del Parque Ecológico de Xochimilco A.C., México.
Koohafkan, P. 2012. *A case of agricultural heritage systems.* Sustainable Development Department, FAO, Rome.
Landázuri, G, y López, L. 2004. Tolerancia religiosa en Xochimilco. *Política y Cultura,* 21:141-160.
Landázuri, G. y López, L. 2012. La fiesta patronal de San Gregorio Atlapulco, México. Espacio de reproducción cultural e identitaria. *Ra-Ximhai,* 8(2): 241-259.
Lumsden, R., García, R., Lewis, J. and Frías, G. 1990. Reduction of damping-off disease in soils from indigenous mexican agroecosystems. In Gliessman, S. (ed.) *Agroecology. Researching the ecological basis for sustainable agriculture*. Springer-Verlag, New York. Pp.104-121.
Merlín-Uribe, Y., González-Esquivel, C., Contreras-Hernández, A., Zambrano, L., Moreno-Casasola, P. & Astier, M.· 2013. Environmental and socio-economic sustainability of *chinampas* (raised beds) in Xochimilco, Mexico City. *International Journal of Agricultural Sustainability,* 11(3):216-233.

Martínez J. 2004. *Manual de construcción de chinampas.* México: Instituto Mexicano de Tecnología del Agua.

Mena, H. And Servín, E. 2014. *Manual básico para el cuidado en cautiverio del axolote de Xochimilco* (*Ambystoma mexicanum). UNAM, México.*

Merlín-Uribe, Y. 2009. Evaluación de dos sistemas de manejo de recursos naturales de Xochimilco con indicadores de sustentabilidad. Tesis e Mastría. Instituto de Ecología.

Merlín-Uribe′ Y., Contreras-Hernández, A., Astier-Calderón, M., Jensen, O., Zaragoza, R. & Zambrano′ L. 2013a. Urban expansion into a protected natural area in Mexico City: alternative management scenarios. *Journal of Environmental Planning and Management,* 56(3):398-411.

Natoure, 2016. Reflexión#Soy Xochimilco. https://www.youtube.com/watch?v=J-QW5YTMm78

Narchi, N. y Canabal, B. 2015. Subtle tyranny. Divergent constructions of nature and the erosion of traditional ecological knowledge in Xochimilco. *Latin American Perspectives,* 42(5):90–108.

Novelo, A. and Gallegos, M. 1988. "Estudio de la flora y la vegetación acuática relacionada con el sistema de chinampas en el sureste del Valle de México." *Biotica,* 13: 121-139.

Onofre, A. 2005, The floating gardens in México. Xochimilco, world heritage risk site. *City & Time* 1(3):5. [online] URL: http://www.ct.ceci-br.org (consultado 8 octubre de 2015).

Paez, F. 2015. *La importancia de indicadores de sustentabilidad para el turismo en la región de Nativitas, Xochimilco* (Tesis de licenciatura). Universidad Autónoma del Estado de México, México.

Pérez-Olvera, M., García-Mateos, R., Pérez Grajales, M., & Navarro-Garza, H. 2014. Sistema de producción y parámetros de calidad agronómica de brócoli en Mixquic, DF. *Revista Mexicana de Ciencias Agrícolas,* 5(8), 1459-1468.

Praxedis, J. 2004. El Tularco ofrenda xochimilca. Disfruta Xochimilco ayer y hoy, número 4. México.

Quiñónez, C. 2005. *Chinampas y chinamperos: Los horticultores de San Juan Tezompa* (Tesis de doctorado). Universidad Iberoamérica, México.

Quintos, J y Quispe, A. 2004. Estrategias de supervivencia de los productores agropecuarios en las áreas periurbanas de la Ciudad de México, El caso de San Andres Mixquic y San Nicolas Tetelco. *Comunicaciones en Socioeconomía, Estadística e Informática*, 8(2):1-26.

Redclift, M. 1987. Raised bed agriculture in pre-Columbian Central and South America: A traditional solution to the problem of sustainable farming systems. *Biol. Agric. Hort. Int. J*. 5(1):51-59.

Renard, D., Iriarte, J., Birk, J., Rostain, S., Glaser, B. and McKey, D. 2012. Ecological engineers ahead of their time: The functioning of pre-Columbian raised-field agriculture and its potential contributions to

sustainability today. *Ecological Engineering,* 45:30-44.
Rodríguez-Alegría, E. and Nichols, B. 2016. Introduction, Aztec studies: Trends and themes. In Nichols. B. and Rodríguez-Alegría, E. (eds.) The Oxford Handbook of the Aztecs. Oxford University Press, Pp. 1-17.
Rodríguez, M. 2016. *Mitos y cuentos de Tláhuac, Milpa Alta y Xochimilco. Patrimonio inmaterial de la humanidad.* Gobierno de la Ciudad de México, México.
Rojas-Rabiela, T. 1991. Ecological and agricultural changes in the chinampas of Xochimilco-Chalco. In H. R. Harvey (ed.). *Land and politics in the Valley of Mexico. A two thousand year perspective.* Albuquerque: University of New Mexico Press.
Rojas-Rabiela, T. 1983. Evolución histórica del repertorio de plantas cultivadas en las chinampas de la Cuenca de México. En Rojas, T. (compiladora). 1983. *La agricultura chinampera. Evolución histórica*. UACH, México, Pp.203-252.
SACMEX (Sistema de aguas de la Ciudad de México). 2014. Infraestructura de aguas tratadas para Xochimilco y Tláhuac. Presentación PowerPoint, abril. México.
Salazar, M; Figueroa, M; Venancio, F; Rubio, G; Salas, A; Rosas, E; Rosas, R; Ocaña, I; Becerril, P; Peñaloza, R; Espinoza, J.P. 2014. Hacia un plan de manejo sustentable y por la regeneración socioambiental de la subcuenca hidrológica de Xochimilco y sus afluentes. En Figueroa, M; Linares, F; Ferrara, M; Castro, J (Eds.), *Manejo integral de la cuenca de Xochimilco y sus afluentes*. Ciudad de México: UAM.
Sanders, W. T., J. R. Parsons, and R. S. Sanfley. 1979. *The basin of Mexico. Ecological processes in the evolution of a civilization.* New York: Academic Press.
Sanders, W.T. 1957. *Tierra y agua: A Study of the ecological factors in the development of Meso-American civilizations.* PhD. Dissertation. Harvard University
SIAP (Agri-Food and Fishery Information System). 2014. Agricultural production program of the Federal District. SAGARPA, Mexico.
Santoyo, J., & Martínez, C. 2011. *Tecnología de producción de brócoli.* Fundación Produce Sinaloa.
Soriano, R., 1999. *The chinampa system as a model of sustainable agriculture.*Thesis (PhD). Wye College, University of London.
Steinberg, F. 2005. Strategic urban planning in Latin America: experiences of building and managing the future. *Habitat International,* 29: 69-93.
Stephan-Otto, E. 1997. La chinampa "cosa jamás vista en este mundo", y sus creadores. VI Curso Internacional de Agroforestería Para el Ecodesarrollo. Centro de Agroforestería para el desarrollo sostenible de la Universidad Autónoma Chapingo, México.

Palerm, A. 1990. *México prehispánico. Ensayos sobre evolución y ecología.* Ciudad de México: Conaculta.

Parsons, J. 1991. Political implications of prehispanic chinampa agriculture in the Valley of Mexico. In Harvey, H. (ed.) *Land and politics in the Valley of Mexico. A two thousand year perspective.* Albuquerque: University of New Mexico Press.

Tavarez, C. 2015. Dictamen Técnico. Levantamiento Agrológico en la Zona Piloto de 1301 ha en cuatro ejidos de la Delegación Tláhuac, D.F. in FAO. UTF/MEX/120/MEX *"Proyecto Piloto para la Reactivación Productiva del Perímetro no Urbano de la Delegación de Tláhuac incluida en la Zona Patrimonial Mundial, Natural, Cultural y de la Humanidad en Xochimilco, Tláhuac y Milpa Alta",* México.

Torres-Lima, P., Canabal-Cristiani, B. and Burela-Rueda, G. 1994. Urban sustainable agriculture: The paradox of the chinampa system in Mexico City. *Agriculture and Human Values,* 11:37-46.

Torres-Lima, P. y Rodríguez-Sánchez, L. 2008. Farming dynamics and social capital. A case study in the urban fringe of Mexico City, *Environment, Development and Sustainability,* 10:193-208.

Torres, C; González, E. 2014. La sustentabilidad agrícola de las chinampas en el Valle de México: caso Xochimilco. *Revista Mexicana de Agronegocios,* XVIII:699-709.

UN, 2014. *Open Working Group proposal for Sustainable Development Goals.* United Nations. Available at: https://sustainabledevelopment.un.org/content/documents/1579SDGs%20Proposal.pdf.

Verhoeven, J. and Setter, T. 2010. Agricultural use of wetlands: opportunities and limitations. *Ann Bot,* 105(1):155-163.

West, R. Armillas, P. 1950. Las chinampas de México. *Cuadernos Mexicanos, 40:165-82.*

VI. Dynamic Conservation Plan

Government of Mexico City/Authority of the World Natural and Cultural Heritage Zone in Xochimilco, Tláhuac and Milpa Alta

Name	Chinampa agricultural system of Mexico City, MEXICO
City	Mexico City
Institution	Government of Mexico City/Authority of the World Natural and Cultural Heritage Zone in Xochimilco, Tláhuac and Milpa Alta.

Potential GIAHS site	Mexico is the third city most populated in the world, however, in the hearth of this great mega-city, chinampas are preserved since more than 1000 years. The chinampas system is an articulated set of artificial floating islands built with craftsmanship based on the oral transmission of the chinampas culture that prevails since pre-Hispanic times.
Brief summary information	Chinampa is the Aztec name for an ancestral system worked on pieces of land in the middle of lake with high-intensity agroproduction. It is an island surrounded by three or four small canals. These channels are drainage or lane. It is a form of very productive agriculture that allows 5 crops per year. Also called floating gardens, chinampas are used today for floriculture and vegetable planting. (I) They are agriculturally diversified, producing and offering horticultural and ornamental goods to Mexico City consumers. (II) They are biodiverse, because besides of the horticultural and ornamental products, they still offer ecological niches for aquatic fauna and endemic or transient bird population. Some amphibious fauna like the Ajolote (*Ambystoma mexicanum*), frogs and several species of reptiles can still be found. And when the chinampas are temporary abandoned or flooded, they give their place to the ancient reeds that originally were part or the lakes, thus giving excellent environments for the visiting birds, some of them coming from as far as Canada, United States of America, North of Mexico or Central America. Moreover, there are thousands of ahuejotes (slim willow trees) that form natural curtains that protect the cultivated fields from winter strong winds. These are also prime locations for many other species of birds. (III) The landscape follows a special pattern of elongated islands with a predominant direction that shows a slight deviation of 15° from North to East. That master direction coincides with other prehispanic patterns, among them the urban pattern of Teotihuacan. The accumulation of thousands of cultivated chinampas, ahuejote

	trees and hundreds of kilometers of waterways in a vast territory is no only an impressive cultural and productive site by itself, but it adds the tranquility and solitude of many natural features together: water, land, trees, local fauna and atmosphere that is inconceivable being so close to an important capital of more than 20 million inhabitants. (IV) Altough the chinampa system is officially managed by local authorities, its productivity is still in the hands of the local farmers and original landowners, most of them from natives indian or mestizo origin. They have kept the system for centuries and are the most interested in its preservation, sometimes even against political measures to change land uses or to introduce new urban infrastructures that menace to change drastically their agroproductive territory. (V) Provided by history of sustainability paths: economic viability and adaptation capacity, against change processes such as urbanization. Besides the millennium evolution of the chinampa system already described, several new adaptive features can be added: a. Technological and cultural changes after the Spanish Conquest introduced new labor instruments and European edible plants without altering neither the essential agroecological practices nor the regional productive profile. b. The same occurs in the XXth Century, when new practices have been slowly introduced. Some of them like pest-control measures through chemical products that contaminate soil and water show great resistance among chinamperos to adopt them. Other, like wind protections with networks or plastic are gradually adopted. Big agricultural machines are avoided, but hand-held mechanical tools (motocultores) or gasoline water pumps are of general use. Besides, the water management reflects itself in the trend to

	close small canals or ditches, thus leaving wider chinampa fields. Undobutedly, the system continues its dynamic and agroproductive evolution. (VI) Cultural diversity that provides diversity of products and services. The chinampas system associated to the Lake area, formed by natural flooded plains and a water landscape that determines a series of habitats, including agricultural biodiversity genetic resources (species, varieties and breeds) associated with the farming system and geographical landscape.
Main threats faced by the site	The expansion of the city on this periurban territory, the occupation of the territory by irregular settlements and the loss of land use value, which is surpassed by its exchange value. The lack of local systems, networks or marketing circuits, to encourage local producers. The chinampas are threatened by the strong presence of markets that demand commercial agricultural products, which require different technological management, including the greater use of agrochemicals and short-term production with greater capital investments and specialization in monoculture systems. The decrease of the intergenerational transmission of the ancestral agricultural culture in chinampas, which has lasted for more than a thousand years. The rupture of exchange networks and economic cooperation, due to the difference between urban and rural income. The poor articulation of educational activities within agricultural production and a weak focus on cultural, ecological and tourism conservation.
National focal point institution	Government of Mexico City, and its Authority of the Natural and Cultural World Heritage Zone in Xochimilco, Tláhuac and Milpa Alta, Mexico City (Dr. Norma Ruz Varas, zur.maye@gmail.com). Phone number 55 85 68 92 36
Other potential partner institutions	Autonomous Metropolitan University of Xochimilco. Mexico Autonomous National University.

1. General Action Plan.

As context and prior to the formulation of the following general action plan and dynamic specific actions plan (2017-2022), they have been carried out before three stages of work, corresponding to: 1) Participatory Project of socialization of Globaly Important Agricultural Heritage Systems, GIAHS[12], with the intervention of ICOMOS Mexico, UNESCO consultant from January to April 2016; 2) Preparatory Workshop SIPAM, led to federal and local officials, in March 2016; and 3) GIAHS International Workshop for Latin America and the Caribbean in April 2016.

In particular, the Participatory Project of Socialization of Major Systems Agricultural Heritage Systems, SIPAM, with the intervention of ICOMOS Mexico, an advisory body to UNESCO, presented to the residents of Mexico City the concept of GIAHS as well as to the chinamperos the strengths that offers its recognition, particularly in the 5 chinamperas areas. A total of 20 participatory workshops were held with different groups of chinamperos, focusing primary issues identified for these sites recognized as SIPAM, highlighting the following five characteristics:

- Biosafety and ecosystem function
- Food and livehood security
- Knowledge systems and adapted technologies
- Culture, value systems and social organizations (Agriculture)
- Exceptional landscapes and features of the management of land and water resources.

Likewise, the Government of Mexico City, through the Authority of the Natural and Cultural World Heritage in Xochimilco, Tláhuac and Milpa Alta, was selected by FAO as the venue for the realization of the GIAHS International Workshop for Latin America and the Caribbean.

During the workshop managers from GIAHS-FAO Programme Rome, the FAO Representative in Mexico, the Secretary of SEDECO, the Attorney PAOT, the Delegates of Xochimilco and Tláhuac, the Historical Center Authority, ICOMOS Mexico, researchers from Universities UAMX and UNAM, and representatives, men and women, from 28 countries in Latin America and the Caribbean participated. The realization of these workshops makes

[12] GIAHS translation in spanish corresponds to SIPAM

it possible to sensitize producers, revalue their agro-capital and strengthen pride in their ancestral values, while comparing with systems that are preserved in other countries and that are similar to theirs. This action facilitates the participation of the agricultural sector in the revitalization of agriculture in the Chinampera area, since it allows the different actors to be motivated to work in the formation of self-managed human resources, for which new local market niches can be generated and Mexico City.

In order to achieve inter-agency coordination for the chinampa agricultural system, the Government of Mexico City created the Authority of the Natural and Cultural World Heritage Zone in Xochimilco, Tláhuac and Milpa Alta (Decree of December 11, 2012) with the sole mandate of ordering and coordinating the conservation and protection efforts of the Area, including its chinampas, which represent the core heritage patrimonial asset to be safeguarded[13].

- This Heritage Zone Authority is directly attached to the Head (Governator) of Government of Mexico City and has attributions for the territorial ordering of the Patrimonial Zone.
- Coordinates agencies with interference in the site, both international, federal and local. Among the main ones are the Ministry of Rural Development and Equity for Communities (SEDEREC) and the Ministry of the Environment (SEDEMA), the Ministry of Culture and the Water System of Mexico City (SACMEX), as well as the three Delegations or Municipalities of the area.
- The Heritage Zone Authority is linked to the academic (universities and research institutes), international cooperation agencies, civil society organizations, legislative power, as well as instances of the federal executive.
- The Heritage Zone Authority has an Advisory Council, as an organ of consultation, advisory and inter-institutional coordination, in charge of issuing opinions and recommendations to comply with the Integral Management Plan.
- The Advisory Council is composed of the Authorities with interference and representatives of the Private and Social sector, with representation in the Heritage Zone.

[13] FOURTH.- For the fulfillment of their attributions, the administrative units of the dependencies that specifically have their territorial jurisdiction material in your area of competence, are subordinated operationally to the Authority of the Natural and Cultural World Heritage Zone in Xochimilco, Tláhuac and Milpa Alta. Agreement Creation AZP, Official Gazette of the Federal District, December 11, 2012.

    - According to the UNESCO Convention, sites with a Declaration of World Cultural Heritage must draw up an Integral Management Plan as a guiding instrument for their conduct.
    - In this way, the Patrimonial Zone has an Integral Management Plan, which represents the general planning tool for the World Natural and Cultural Heritage Area of Humanity in Xochimilco, Tláhuac and Milpa Alta, defined according to the indicated principles By the UNESCO Convention, United Nations Educational, Scientific and Cultural Organization, on the Protection of the World Cultural and Natural Heritage. Its level of definition is general and basically indicates the core zone and buffer zones. It determines that 3 types of patrimonial assets must be protected: 1. productive: the chinampas, 2. materials: historical monuments and archaeological sites and immaterial: festivals and traditions and 3. natural: wetlands. (Annex 27).
- This Comprehensive or Integral Management Plan as a guiding tool for planning, articulates the management and management of the 3 types of assets, through the normative figures established according to the patrimonial property to be guarded. In this way, in the case of the Ramsar Site, it has a Management Program for the Wetland of International Importance, which regulates the environmental and ecosystem aspects of the wetland, under the name of Protected Natural Area.
- In the case of the proposed GIAHS Site, it will be governed by the Plan of Action established at its two levels, general, applying the general measures defined to obtain the 10 products indicated and specific, to achieve the implementation of the four projects short and medium term, as described below.

General Action Plan:

Product 1: Institutional strengthening y Sensibilization
Activities:

- Strengthen the Advisory Council of the AZP, incorporating a representative of FAO in Mexico, to the joint effort of the local government with the international organizations with presence in the Zone.
- Implement the Action Plan for the proposed GIAHS Site, at its two levels, general and specific, and incorporate it into the Comprehensive Management Plan.
- Facilitate the actions of the various actors in the definition of priorities of concurrent programs and projects for the common good of the GIAHS Site.
- Disseminate the Integral Management Plan, in conjunction with the Ramsar Site Management Program and the GIAHS Site Action Plan.
- Design and implement a permanent system to strengthen the dissemination of: (a) the material and immaterial heritage, natural and productive, as well as the cultural and social dimension transmitted by the communities; (b) the ecological resilience, biodiversity, environment, and ecosystem goods and services that are used and stored; (c) agricultural systems, food security and livelihoods, including traditional knowledge; and (d) the assets, resources and public services, social and environmental governance systems and institutional setting for the decisions that outline the paths of evolution, development and change of the site.
- Design and implement information about GIAHS site through TV, internet, books, documents, magazines and other communication materials, as well as workshops, seminars and regional and international events on GIAHS.

Product 2: To promote the recovery of potential chinampas through rehabilitation plans. (Annexes 19-23)
Activities:

- To rescue currently blocked channels, siltated, or blinded, so that the water returns to moisten the soil and allow producers navigation.
- Reforestation by the traditional woodland "ahuejotes" whose roots protect and leverage their edges and form protective curtains for the season in late winter winds.
- Rehabilitation the agricultural soil in parts where it is affected by salinity or inadequate fillings.
- Combating the presence of harmful plant or animal species and

pests afflicting the trees.
- Control proliferation of greenhouses, condition the permanence of unauthorized houses by practicing permacultural measures as regards its sanitation and water supply.

Product 3: Rehabilitation of active chinampas through management plans (see Annexes 19-23)
Activities:
- Fund low interest credit for the purchase of equipment, machinery and infrastructure for the development of agricultural and ecotourism activities.
- Rehabilitate the agricultural soil and channels in order to maintain the agro-ecological production profile of the chinampas.
- Subsidy payment of agricultural income in urban areas with high pressure where traditional agriculture free of chemicals is practiced.
- Preparation and publication of a program of payment for ecosistemic services for conservation and natural restoration of the region, wetlands, water resources and the integrity of the chinampas.
- Financing for hydraulical and agricultural irrigation works, agroproductive rehabilitation, infrastructure and equipment.

Product 4: Measures for the conservation of agrobiodiversity/biodiversity and ecosystems in the GIAHS site.
Activities:
- Design of a regulatory framework and legal system that links public policies for the protection of agricultural biodiversity, biodiversity and ecosystems in the GIAHS site avoiding land use change.
- Promotion of sustainable development on the site, under the framework of support strategies to maintain the rural landscape as an area of conservation and restoration of natural resources, agricultural biodiversity and local biological populations and environmental services; and as an important area of rural and agroindustrial production, to reduce the processes of continuous development and regional environmental degradation.
- Development of methods for evaluation and monitoring of agricultural biodiversity in the GIAHS site.

Product 5: Measures for the preservation of traditional agricultural practices, techniques and knowledge.

Activities:
- To strengthen and consolidate networks of social exchange and

economic cooperation allowing an integration of knowledge of different regional production and cultural processes by improving traditional farming practices with the help of modern technologies.

- Systematic recording of intangible traditional agricultural technologies and their dissemination (i.e. local technological development to produce rustic seeds and inputs).
- Promotion of a system of technical and scientific support to enable tracking, monitoring and promotion of sustainable models and agricultural practices of organic or environmentally compatible with the regional vocation.
- Promotion of social and economic structures (i.e. local companies) of integration and partnership between chinampa farmers to provide quality services for agricultural development (technical assistance, management and sale of technology, financing, market management).

Product 6: Measures to foster economic development of the GIAHS site.

Activities:

- Participatory design strategies operationally oriented to specific demands and to achieve results in reducing poverty and increasing local food security.
- Provide equitable access to public services, housing, technology and regional market of fresh or industrialized agricultural products.
- Reactivate cooperation networks between primary producers and consumers in Mexico City, and to encourage the flow of goods and services of agricultural and environmental type within the metropolitan region seeking to generate an economy less dependent on markets and extra-regional inputs with a smaller ecological trace.
- Design economic strategies and local community development that respond to the diversity of chinampa agroecosystems and its potential resources (i.e. horizontal and vertical integration of production, diversification of supply, creation of value networks and transformation of agricultural products to enter new regional urban markets, promotion of the brand products image, and promotion of the ecotourism industry).

Product 7: Measures for the landscape conservation of the GIAHS place.

Activities:

- Due to the high vulnerability of the chinampas, both the

environmental components and the fragility of their specific habitats, actions will be implemented: the protection of their areas with a high degree of naturalness or quality of the environment; maintenance of existing applications and development of the potential for productive different uses consistent with attitudes; and the recovery of degraded areas.

- Preventing soil of the region becomes part of real estate development by investing in infrastructure works and programs for research and impact of technological development in the medium and long term (i.e. works of soil and water conservation; dams and water captors; renewable energy pumps; machining centers for composting of urban solid waste; marketing centers; and inexpensive water treatment plants).

Product 8: Measures for the preservation and promotion of cultural activities of the GIAHS site.

Activities:

- Generation of a permanent, effective and high quality training and technical advice to consider aspects of environmental education and the preservation and promotion of cultural activities associated with the chinampas.
- Design of strategies and actions to the supply of ecotourism, rural tourism, nature tourism and cultural tourism consistent with the environmental, cultural and economic conservation in the area where agricultural activities, marketing products and services, environmental restoration and conservation and chinampería, parks and recreation centers, payment for environmental services, environmental monitoring and active social participation are contemplated through the promotion of regional business culture and low levels of social and economic integration of rural microenterprises and the formation of local bodies for social comptroller.

Product 9: Measures to strengthen collaboration and partnership to implement the measures described above.

Activities:

- Participation of local communities to move from a reactive attitude of the rural landscape management to a proactive in the formulation of local policies for the promotion of agricultural systems under the framework of a regional strategic planning.
- Creation of autonomous decentralized entities as part of GIAHS, that has to be linked to institutional strengthening local governments in making decisions on protection of watershed, buffer zones and land use, among others.

➢ Strategies and mechanisms of engagement and collaboration with potential partner institutions linked to local problems, such as universities and research centers, that meet the demands of the site producers under appropriate technology transfer schemes and advice.
Product 10: Monitoring and evaluation. Activities: ➢ Generation of a permanent, effective and high quality data collection and the establishment of a methodology for monitoring and evaluation of GIAHS program on the site. ➢ Establishment of a specialized agency in collaboration with the local government to monitor the state of the GIAHS and the effectiveness of measures taken for dynamic conservation, including the application of resources and transparency in the use of institutional support

2. Dynamic Plan of Specific Actions (2017-2022)

The incidence of urban processes in the five areas of chinampas agriculture in the delegations of Xochimilco and Tláhuac, affects the relevant regional attributes that require special attention, such as biodiversity, ecosystems and peri-urban rural landscapes, which are part of the potential for sustainable development. This type of development in chinampas agriculture is limited by various human activities, including the different forestry, agricultural production activitites with minimal environmental safeguards and tourism that does not always meet the characteristics of ecosystems.

Some possible actions to achieve greater environmental sustainability in the regional development of the five areas of chinampas agriculture are: the implementation of integrated watershed management programs; implement biological corridors to protect interconnected areas; consolidate agricultural, livestock, forestry and agro-industrial zones in soil conservation; ecotourism; sustainable agriculture and rehabilitation of the lake system, among others.

Therefore, the socio-territorial arrangement of the five areas of chinampa agriculture, from the approach of integrated management of the basin, lies in ensuring time of water resources and associated investments, conservation of natural resources, improvement of productive activities and the need to promote a better life quality for the population.

In particular, it requires a planning based on the integration of human activities, current and future regional developments, and the physical and natural characteristics and vulnerability of the region.

The main four projects of short and medium term (2017-2022) responding to the context above consist of the following:

1. Storage and Marketing Center
   The main objective to create two supply and marketing cemters, both in Xochimilco and Tláhuac, is to strengthen agricultural activities in soil conservation through open channels of direct marketing with wholesalers and retailers from nearby delegations, thereby achieving to distribute its products with fair prices and reduce the intermediarism.
   According to the above, also other marketing options can be promoted, registered under the logic of short marketing channels[14],

[14] For example, in the case of Mexico City, the project "Creating Circuit-short marketing of sustainable and traditional agricultural products of the south area of Mexico City "it is a joint initiative of the United Nations

which involve: i) direct selling in the chinampas (basket, harvest, etc.); ii) direct sale at local fairs; iii) sale in shops (collective sales outlets, restaurants, retail traders, others); iv) direct selling in supermarkets; v) Delivery; vi) advance sale; vii) mail order (Internet, etc.); viii) direct consumption on the farm (agrotourism); ix) retail sector; and x) export under the rules of fair trade.

Storage and Marketing Center is composed by two projects: The supply Xochimilco center and the supply Tláhuac center:

The supply center will be located in Xochimilco in Muyuguarda Street near the corner of Barrio 18, with an area of 1 ha. The direct beneficiaries will be more than 600 producers and 25 vegetable farmers' cooperatives, which produce in an approximate area of 1,123 hectares. It will also benefit the population that lives near the storage center as the delegations of Coyoacán, Tlalpan and Iztapalapa.

The Tláhuac supply center will be located on Av. Eje 10 in the common public land of Tlaltenco, with an area of 1 ha. The direct beneficiaries will be more than 1,617 producers from Tlahuac, Tetelco, Mixquic and San Juan Ixtayopan, which produce in an area of 1,321, has a volume of approximately 301,460.68 tons annually. Indirectly, it would benefit with lower prices of agricultural products to the population living in the Valley de Chalco, Chalco, Ixtapaluca and the delegation of Iztapalapa.

In both centers there must be a minimum capacity of commercialization of 1,000 tons per year and it will consist with a parking area, reception area of vegetables, laundry area and packing area. They must have a plan for management of generated solid waste that considers the implementation of a composting area for organic waste.

The main issues to address will include: the organization of producers in the area to admnistrate the supply center and ensure the viability of the project; the small number of regional vegetables species involves considering an adoption and production program of new crops to achieve a more diversified and permanent supply of products, also, agreements may

---

Food and Agriculture Organization (FAO) and the Ministry of Rural Development and Equity for Indigenous Peoples (SEDEREC), which aims to "provide tools that encourage the creation of short circuits: (1) business models, (2) design of public policies and (3) participation of civil society; by experimenting with the implementation of marketing platforms of sustainable agricultural products produced in the south of Mexico City; and thereby encouraging consumption habits and sustainable production methods and promoting production units, family farming more profitable". The project will focus on the marketing of cultivated agricultural products in southern Mexico City, and will last approximately 18 months, tentatively from January 2016.

be made with producers of other states to supply other products. Finally, it must be realized a study of social and environmental impact and economic feasibility; a consultation to determine volumes and more specific interests of producers; and look into the design of the building using eco-technologies and biodegradable materials.

2. Research and Production center of seeds and vegetative material of Xochimilco

Given the risks of plant production feasibility and in order to ensure the profitability of the marketing of ornamental plants, the objectives of creating a research and production center of seeds and planting material in Xochimilco consist of: providing seedlings and seeds adapted to the production area; have a production schedule to meet the demand of the producers; diversify species and varieties of seedlings to expand the range of flowers offered to the market; obtain good quality seeds; and sell quality plants with minimal cost for producers.

This type of facility will be located on the premises of the CORENA nursery located in the town of San Luis Tlataltemalco. The beneficiaries will be the 60 organizations registered in the program-product system made up of more than 600 flower growers and more than 1,500 vegetable growers. It will benefit the producers of the villages of San Luis Tlaxialtemalco, San Gregorio Atlapulco, Caltongo neighborhood, downtown neighborhoods of Xochimilco and producers of the villages of Mixquic, Tetelco and Ixtayopan.

The area for the production of vegetative material (seedlings) is 1 ha. The 10 ha. remaining will be for experimental fields and seed production fields. A reconditioning of existing greenhouses is required. Also, there must be qualified personnel to carry out the production of seeds and seedlings, as well as conducting the research processes and technology transfer, considering the establishment of collaboration agreements with universities and institutes.

3. Chinampas agriculture Park of Mexico City (common public lands of *Xochimilco y San Gregorio)*

The natural as well as cultural, regional history is the foundation to draft a park of agriculture in Mexico City that includes, from an anthropological point of view, the ability to reflect and evaluate paths traveled by local societies and its adaptation to the geographical environment. The main objectives of this park include: a) Create a

Living Chinampa Museum as the center of reflection, dissemination and research for the preservation of the Chinampa as a national symbol; b) To promote agricultural activities in the region through research, reflection and diffusion of the Chinampa's bio-dynamic system; c) To strengthen the tourism promotion through rustic and environmentally friendly lodges; d) Promote tourism activities and services by creating an integrative enterprise promotion, training and financing of projects of cultural tourism, agritourism and ecotourism with new products for the visitor through the creation of routes with guided and agro cultural tours that allow incidence of low environmental impact and high economic and educational impact; e) Enable a water reflect surface of 250 ha as habitat for birds, which will allow its sighting and contemplation of aquatic flora as well as it will give an opportunity to show in a practical way the role of ecosystems; f) Establish a wooded buffer zone with regional species such as cypresses in the northern part of the proposed area; g) To build a research center in collaboration with national and international academic institutions, which will hold: laboratories for reproduction of microorganisms and bio-fertilizers, composting center, demonstrative and didactic Chinampa Farm model (cows, chickens, rabbits, etc.); h) Creation of a training center fro chinamperos where they will impart their experience to new generations; i) Diversification of productive activities as of tourist services with an educational focus, environmental and cultural conservation.

The park will be located in the suburbs of Xochimilco, in the part of differential subsidence form the common public land of San Gregorio and some privately owned areas of San Luis Tlaxialtemalco. The target population would be mainly the one that lives and produces in the town of San Luis Tlaxialtemalco, San Gregorio Atlapulco, Barrio de Caltongo and downtown neighborhoods of Xochimilco, in addition to the 60 organizations registered in the program-product system made up of more than 600 flower growers and producers and more than 1,500 vegetable growers. The main features of the park include: 1. Museum Area and Cultural Center (common public land (ejido) of Xochimilco); 2. Hosting areas (ejido Xochimilco); 3. A living museum of livestock production (ejido Xochimilco); 4. Production plots of usufruct farmer with different production systems: tables, greenhouses (ejido Xochimilco); 5. School Museum of traditional chinampa (San Gregorio ejido and small property of San Gregorio and San Luis); 6. Area of ecotourism tours and bird watching in the lagoon of San Gregorio (Ejido San Gregorio) joint ownership with government); 7. Agroforestry production area (north of the ejido of San Gregorio joint ownership with government).

The main problems to address are to achieve political agreements which are required for the purchase of parcels of the ejido of Xochimilco and based on the acceptance and participation of the local people to strengthen not only the natural landscape but also the cultural in the offering of the region as a tourist attraction. The appropriate mecanisms should be consolidated for the co-administration of the various types of property (ejido (common public land), private and governmental) and the various facilities and production sites and service mechanisms.

Below are the technical data sheets for the main three short- and medium-term projects (2017-2022) for the five chinampas agriculture zones in the Xochimilco and Tláhuac delegations.

Data Sheet for the Supply and Marketing Center in Xochimilco (Muyuguarda)

PROJECT´S NAME: **SUPPLY AND MARKETING CENTER** TITLE AND SUBTITLE: XOCHIMILCO (MUYUGUARDA)	
DESCRIPTION	INSTRUMENTATION
Answers to the questions: WHAT? WHY? AND WHAT FOR? **Background** There are restrictions on the marketing of regional agricultural products due to high competition in the central supply and to the conditions of marketing disadvantage. Xochimilco has a very extensive chinampas area covering more than 1,000Ha engaged in agricultural activities, mainly the cultivation of vegetables, 704 hectares of ejido area and 300-chinampa area. There is an important regional agricultural production in both volume and quality that is not sold directly to consumers, especially under a high demand presented in the Federal District (i., e., Coyoacán, Tlalpan and Iztapalapa). In addition, the intermediarism must decrease in the marketing of agricultural products and provide added value in the operations of disinfection and packaging of this production. It is noteworthy that the facility will have a network of collection and storage of rainwater that will help keep supply in much the same. Likewise, there will be a water treatment plant (reverse osmosis). **Importance** The supply and marketing centers will grant value added to the production; They will be a means of direct marketing with urban populations and provide a quick and effective output of regional agricultural products. Its location will be on the street of Muyuguarda near the corner with Barrio 18, near the Xochimilco community center, with an area of 1 hectare, An easy access and distribution of production is contemplated by offering a large volume of sales. **Justification** The supply and marketing centers will consist of a viable alternative for the concentration of products of plant origin offered to alternative urban populations of	Answers the question: HOW? Brief description of how the proyect will be carried out. It must be discussed and agreed with the farmers of Xochimilco, as well as the government of Mexico City, the spaces and infrastructure to build and operate these centers, which will be governed by its own specific regulations for supply and marketing processes.

Coyoacán, Tlalpan, Iztapalapa.	

AGENTS	REGULATORY FRAMEWORK
Answers to the questions: WHO? Agents that participate in the following sectors: PUBLIC / PRIVATE / SOCIAL AND ACADEMIC. The finance will be requested through different government entiites such as: SAGARPA: Who supports investment in capital goods through the implementation of productive projects that facilitate the application of appropriate technologies, supply, packaging and processing of products. This will be through the acquisition program of productive assets, providing up to 50% of the required to install the supply center infrastructure. SEDEREC: Entity that promotes rural development in an area of environmental and productive compatibility. Participating with a percentage to the supply center's infrastructure. CORENA: Participating with the remaining percentage for the acquisition of infrastructure. DELEGATION OF XOCHIMILCO: Creating programs to support productive projects focused on the commercialization of products generated in the area. SECRETARY OF THE LAND REFORM: Through the Fund program to support productive projects in the agricultural centers, which is aimed at women and men who live in agrarian settlements and intend to implement productive projects to generate employment opportunities and income for their family and community. CDI (National Commission for the Development of Indigenous People for its acronym in Spanish): They serve the needs of financial support of indigenous organizations to carry out productive	According to its nature and scope of the project, which rules of the game must respect: Partial Programs, Delegational Programs or Municipal Urban Development, Mexican Constitution, the General Law of Human Settlements, General Law on Environmental Protection, Natural Protected Areas, etc. General Law on Environmental Protection, General Ecological Management Program and Urban Development Program of Xochimilco. Of primary way it must be taken into account the regulations managed by the Law of Ecological Management, which is a planning instrument that establishes the environmental legislation to regulate or induce land use and productive activities in order to achieve the protection of the environment and the preservation and sustainable exploitaiton of natural resources from the analysis of the trend of deterioration and the potential use of them. In addition, it must be taken into account the Mexican Official Standard NOM -060 Plant Protection-FITO-1995, in which the notice of commencement of operation of orchards, greenhouses,

activities, promoting community productive processes that positively impact the economy of producers in indigenous communities. Other sources of funding are: RURAL FINANCIAL, FONAES, FONDESO and SEDESOL and the private sector. The operation must be carried out by an administrative body and the marketing by the producers of Xochimilco.	nurseries, farms, packing houses, gins, supply centers, beneficiaries for plants, their products and by-products subject to phytosanitary regulations.

<table>
<tr><th>STAGES</th><th>TIME, COST AND FINANCING</th></tr>
<tr><td>Answers to the question
WHEN?

Deadlines:
Short (2017-2018)
• Management of the supply center with the appropriate institutions.
• Conditioning of the land where the facility will be placed
• Construction of facilities of supply center.
• Form an administrative council for the operation of the center.
• Start up the center.
Medium (2019-20121)
• Maintenance of the center’s infrastructure.
• Renewal of the board of the center or the center’s administrative council</td><td>Answers to the question:
HOW MUCH?

An estimate of time is made which it would take to do this and the criterias are established by which the cost of the project and possible funding sources are determined.
<table>
<tr><th>PERIOD (2017-2018)</th><th>ACTIVITY</th><th>COST</th></tr>
<tr><td>January-March</td><td>Market Study</td><td>$160,000.00</td></tr>
<tr><td>March-May</td><td>A corresponding Environmental Impact Study.</td><td>$200,000.00</td></tr>
<tr><td>March-November</td><td>Construction Installation of 5,000 m2.</td><td>$2,800,000.00</td></tr>
<tr><td>October-November</td><td>Construction of loading and unloading area. (1,000m2).</td><td>$240,000.00</td></tr>
<tr><td></td><td>Total investment required</td><td>$3,700,000.00</td></tr>
</table>
</td></tr>
</table>

Data Sheet for the Supply and Marketing Center in Tláhuac (Tlaltenco)

PROJECT´S NAME: **SUPPLY AND MARKETING CENTER** TITLE AND SUBTITLE: Tláhuac (Tlaltengo)	
DESCRIPTION	INSTRUMENTATION
Answers to the questions: WHAT? WHY? AND WHAT FOR? **Background** There are restrictions on the marketing of regional agricultural products due to high competition in the central supply and to the conditions of marketing disadvantage. Tláhuac is the most important vegetable-producing region in Mexico City, as it has chinampas found in the villages of Tetelco and Mixquic, in addition to agricultural land in the common public lands (ejidos) of Tulyehualco, San Juan Ixtayopan and Mixquic. Of which have an area of 1,321 Ha devoted to vegetable production, where it has a production of 301,460.68 Ton, approximately a year. In addition, the intermediarism must decrease in the marketing of agricultural products and provide added value in the operations of disinfection and packaging of this production. It is noteworthy that the facility will have a network of collection and storage of rainwater that will help keep supply in much the same. Likewise, there will be a water treatment plant (reverse osmosis). **Importance** The supply and marketing centers will grant value added to the production; They will be a means of direct marketing with urban populations and provide a quick and effective output of regional agricultural products. Its location will be on Av. Eje 10 as part of the ejido of Tlaltenco with an area of 1 hectare, contemplating n easy access and distribution of production by offering a large volume of sales. **Justification** The supply and marketing centers will consist of a viable alternative for the concentration of products of plant origin offered to urban populations of the delegations of Iztapalapa and Valle de Chalco, Edo. de México.	Answers the question: HOW? Brief description of how the proyect will be carried out. It must be discussed and agreed with the farmers of Tláhuac, as well as the government of Mexico City, the spaces and infrastructure to build and operate these centers, which will be governed by its own specific regulations for supply and marketing processes.

AGENTS	REGULATORY FRAMEWORK
Answers to the questions: WHO? Agents that participate in the following sectors: PUBLIC / PRIVATE / SOCIAL AND ACADEMIC. The finance will be requested through different government entiites such as: SAGARPA: Who supports investment in capital goods through the implementation of productive projects that facilitate the application of appropriate technologies, supply, packaging and processing of products. This will be through the acquisition program of productive assets, providing up to 50% of the required to install the supply center infrastructure. SEDEREC: Entity that promotes rural development in an area of environmental and productive compatibility. Participating with a percentage to the supply center's infrastructure. CORENA: Participating with the remaining percentage for the acquisition of infrastructure. DELEGATION OF TLÁHUAC: Creating programs to support productive projects focused on the commercialization of products generated in the area. SECRETARY OF THE LAND REFORM: Through the Fund program to support productive projects in the agricultural centers, which is aimed at women and men who live in agrarian settlements and intend to implement productive projects to generate employment opportunities and income for their family and community. CDI (National Commission for the Development of Indigenous People for its acronym in Spanish): They serve the needs of financial support of indigenous organizations to carry out productive activities, promoting community productive processes that positively impact the economy of producers in indigenous communities. Other sources of funding are: RURAL FINANCIAL, FONAES, FONDESO and SEDESOL and the private sector.	According to its nature and scope of the project, which rules of the game must respect: Partial Programs, Delegational Programs or Municipal Urban Development, Mexican Constitution, the General Law of Human Settlements, General Law on Environmental Protection, Natural Protected Areas, etc. General Law on Environmental Protection, General Ecological Management Program and Urban Development Program of Tláhuac. Of primary way it must be taken into account the regulations managed by the Law of Ecological Management, which is a planning instrument that establishes the environmental legislation to regulate or induce land use and productive activities in order to achieve the protection of the environment and the preservation and sustainable exploitaiton of natural resources from the analysis of the trend of deterioration and the potential use of them. In addition, it must be taken into account the Mexican Official Standard NOM -060 Plant Protection-FITO-1995, in which the notice of

The operation must be carried out by an administrative body and the marketing by the producers of the delegation of Tláhuac.	commencement of operation of orchards, greenhouses, nurseries, farms, packing houses, industrializadotas, gins, supply centers, beneficiaries for plants, their products and by-products subject to phytosanitary regulations.

<table>
<tr><th>STAGES</th><th colspan="3">TIME, COST AND FINANCING</th></tr>
<tr><td rowspan="2">Answers to the question
WHEN?

Deadlines:
Short (2017-2018)
• Management of the supply center with the appropriate institutions.
• Conditioning of the land where the facility will be placed
• Construction of facilities of supply center.
• Form an administrative council for the operation of the center.
• Start up the center.
Medium (2019-20121)
• Maintenance of the center’s infrastructure.
• Renewal of the board of the center or the center’s administrative council</td><td colspan="3">Answers to the question:
HOW MUCH?

An estimate of time is made which it would take to do this and the criterias are established by which the cost of the project and possible funding sources are determined.</td></tr>
<tr><td>PERIOD
017-2018)</td><td>ACTIVITY</td><td>COST</td></tr>
<tr><td></td><td>uary-March</td><td>Market Study</td><td>$160,000.00</td></tr>
<tr><td></td><td>rch-May</td><td>A corresponding Environmental Impact Study.</td><td>$200,000.00</td></tr>
<tr><td></td><td>rch-
vember</td><td>Construction Installation of 5,000 m2.</td><td>$2,800,000.</td></tr>
<tr><td></td><td>tober-
vember</td><td>Construction of loading and unloading area. (1,000m2).</td><td>$240,000.00</td></tr>
<tr><td></td><td></td><td>Total investment required</td><td>$3,700,000.</td></tr>
</table>

Data Sheet for the Research and Production Center of seeds and planting material of Xochimilco.

PROJECT´S NAME: **RESEARCH AND PRODUCTION CENTER OF SEEDS AND PLANTING MATERIAL OF XOCHIMILCO** TITLE AND SUBTITLE: Agricultural experimental fields	
DESCRIPTION	INSTRUMENTATION
Answers to the questions: WHAT, WHY? AND WHAT FOR? **Background** One of the agricultural activities of major economic importance takes place in soil conservation in the delegations of Xochimilco and Tláhuac, is the cultivation of ornamental plants, among which are: Christmas Eve, Petunias, Clavellinas, Thoughts, Gazanias, Chrysanthemum, as well as lettuce, broccoli pumpkin, spinach, purslane, among others**.** Likewise, local producers use external inputs such as seeds and seedlings with a high cost and a consequent loss of regional plant biodiversity Also, there are production problems to ensure the quality of seeds and seedlings, which reduces yields and therefore the income of producers. **Importance** The production center of seeds and seedlings will provide with vegetative material used in the region at a low cost and with high quality in its agricultural performance. According to the Law of Ecological Management, pesticides and fertilizers that will be used for the operation and maintenance of plant material will be based on the manual of CICOPLAFES. It is noteworthy that the greenhouse area will have a capture and storage network of rainwater, which will pass through the reverse osmosis treatment plant, since CORENA has this plant. When used for agricultural purposes the CORENA facilities, which is located on Av. Juarez # 1,100 Year Col. Quirino Mendoza, urbanization is prevented in the strip of the corresponding communication pathways.	Answers the question: HOW? Brief description of how the proyect will be carried out. It should be discussed and agreed on with the CORENA the establishment of the center in order to access its infrastructure, its institutional financial funds to support regional production and the different mechanisms of dissemination, technical assistance and promoting the conservation of natural resources and of agriculture. It shall be carried out inter-agency collaboration agreements for study, research and production of vegetative material with centers and universities.

Likewise, it must be established production agreements with regional producers for the same purpose of the production of seeds and seedlings. **Justification** The services and products offered by this center will impact both agricultural yields and consequently in revenue producer in the conservation of plant biodiversity and in promoting the rescue and maintaining the land use for agriculture.	

AGENTS	REGULATORY FRAMEWORK
Answers to the questions: WHO? Agents that participate in the following sectors: PUBLIC / PRIVATE / SOCIAL AND ACADEMIC. CORENA will be in charge of operating the project, as well as its financing. The producers of the Federal District will be the main beneficiaries, plus the sale and purchase of plant materials produced (seeds and seedlings) to farmers from other states will be feasible, primarily from the Center of the Country. With this it, it can count on funding for the support of IDB CORENA nursery.	According to its nature and scope of the project, which rules of the game must respect: Partial Programs, Delegational Programs or Municipal Urban Development, Mexican Constitution, the General Law of Human Settlements, General Law on Environmental Protection, Natural Protected Areas, etc. Of primary way it must be taken into account the regulations managed by the Law of Ecological Management, which is a planning instrument that establishes the environmental legislation to regulate or induce land use and productive activities in order to achieve the protection of the environment and the preservation and sustainable exploitaiton of natural resources from the analysis of the trend of deterioration and the potential use of them. In addition, it must be taken into account the Mexican Official Standard NOM -060 Plant Protection-FITO-1995, in which the notice of commencement of operation of orchards, greenhouses, nurseries, farms, packing houses, industrializadotas, gins, supply centers, beneficiaries for plants, their products and by-products subject to phytosanitary regulations.

<table>
<tr><th>STAGES</th><th colspan="3">TIME, COST AND FINANCING</th></tr>
<tr><td rowspan="7">Answers to the question
WHEN?

Deadlines:
Short (2008-2012)
Medium (2013/2018)
Long (2019/2030)

Short (2017-2021)
• Project management for the rehabilitation of greenhouses.
• Rehabilitation of greenhouses and experimental fields conditioning.
• Implementation of greenhouses and experimental fields.
Medium (2019-20121)
• Renewal of plastics for greenhouses.
• Maintenance of equipment used in greenhouses.
• Construction of a research laboratory</td><td colspan="3">Answers to the question:
HOW MUCH?

An estimate of time is made which it would take to do this and the criterias are established by which the cost of the project and possible funding sources are determined.</td></tr>
<tr><td>PERIOD</td><td>ACTIVITY</td><td>COST</td></tr>
<tr><td>(2017)
Three months</td><td>Market Study</td><td>$160,000.00</td></tr>
<tr><td>(2017)
Two months</td><td>A corresponding Environmental Impact Study</td><td>$200,000.00</td></tr>
<tr><td>2017-2021)</td><td>.Rehabilitation of the greenhouse</td><td>$2,000,000.00</td></tr>
<tr><td>2017-2021)</td><td>Rehabilitation of Experimental Fields</td><td>$6,000,000.00</td></tr>
<tr><td>2022/2023</td><td>Construction and laboratory equipment</td><td>$4,000,000.00</td></tr>
<tr><td>Total nvestment equired</td><td></td><td>$12,360,000.00</td></tr>
</table>

Data sheet for the chinampa agricultural Park of Mexico City

PROJECT´S NAME**: CHINAMPA AGRICULTURAL PARK OF MEXICO CITY** TITLE AND SUBTITLE: Research Park, promotion and rural productive training. Rehabilitation and diversification of economic and productive chinampas agriculture.	
DESCRIPTION	INSTRUMENTATION
Answers to the questions: WHAT, WHY? AND WHAT FOR? **Background:** In particular, in the irrigation district of Xochimilco it has an extension approximately of 200 has. The main comficts are : 1. Lack of irrigation water despite the existence of a basic network of water treated distribution that does not work. 2. Filling with gravel and deterioration of areas that were flooded 3. . Small-scale farming (800 m2 smallholding by owner) 4. Aging ejidatarios (on average most are over 50 years) 5. Remoteness of parcels regarding current addresses of the owners. 6. Abandonment of land and interest in most homeowners to sell them. 7. Low socio-economic integration and organization from land owners that will allow to develop productive projects jointly, to overcome the situation of crofting. 8. Different groups of land owners without a common vision of how to reactivate the parcels with a focus on environmental conservation **Importance** The research and rural productive promoting chinampas agriculture Park in Xochimilco will constitute a benchmark for the production and cultural, technological and microenterprise	Answers the question: HOW? Brief description of how the proyect will be carried out. The park must combine the agro-productive uses most of its surface with research activities, development and technology promotion and preservation of culture and technical training. For it, it's considered the possible acquisition of a small portion of surface (between 5 and 8 hectares) by the Government of Mexico City for the construction of the infrastructure to ensure the provision of training services and promotion with a high level of quality. Technological scientific documentation and cultural center of soil conservation of Mexico City. - Spaces, classrooms and offices. - Main Auditorium - Gallery exhibition - greenhouses and small parcels' zone - Cellar - Water-treatment plant of artificial wetland. - Parking and guardhouses - Educational Space livestock and agro-industrial production - Conservation of flora and fauna strip located in the area bordering the Canal Board. The coordination of research activities and service with

promotion of the region based on economic and cultural activities that consist of the use of natural resources and cultural local with a focus on sustainability: agriculture, small livestock, agribusiness, handicrafts, ecotourism, agrotourism. **Justification** By not developing appropriate actions the pressure on this polygon will carry out in the coming years to an informal urbanization and the consequent loss of permeable space and the agricultural land currently occupied. This will generate greater pressure on the chinampas zones and surrounding wetland áreas.	Nezahualcoyotl nursery will be located with the composting area of the Delegation sought. This section may be located in the northern area currently occupied with gravel. The rest of the property will be leased or purchased (as suits the GDF) for diversified agricultural production of corn, vegetables, and flowers; for it contracts with producers interested will be signed to have the enjoyment of these spaces with an average proportions of 3 hectares per family. Some areas of the site may also be aimed at the implementation of small pilot projects agribusiness, agro-tourism or ecotourism. The operation of the project involves the recruitment of old chinampas farmers to be part of the training and researching staff of the Park

AGENTS	REGULATORY FRAMEWORK
Answers to the questions: WHO? Agents that participate in the following sectors: GOVERNMENTAL/ SOCIAL AND ACADEMIC. SOCIAL: Agricultural Producers of Xochimilco, mostly former ejidatarios and old chinamperos ACADEMIC: Creation of a multidisciplinary team of academics from the Autonomous Metropolitan University, the Graduate College, the University of Mexico City and the National Autonomous University of Mexico. GOVERNMENTAL The Government of the Federal District, through the SEDEREC will be responsible for managing and co-financing the project	Environmental Law of the Federal District, Law on Sustainable Rural Development, General Law on Environmental Protection, Management Plan for the Cultural Heritage Xochimilco, Management Plan for the Protected Natural Area Ejidos of Xochimilco and San Gregorio Atlapulco, the Ecological Management General Program and Urban Development Program of Xochimilco

STAGES	TIME, COST AND FINANCING
Answers to the question WHEN?	Answers to the question: HOW MUCH?

	years
Consultation and participatory planning with general political agreements	2017-
Elaboration of executive project	2017
Purchase of land and definition of leases	2018
Construction of productive rehabilitation, infrastructure and equipment	2018
Formation of structure and management team	2018-2019
Starting operation and maintenance of Project.	2018-2019

Due to the total purchase of the polygon would result in high investment cost it is recommended as a second option that the DF government lease to the landowners. This means renting to the former ejidatarios its 800 m2 that on average have contracts of 10 to 18 years to create surfaces of 3 ha and provide them through a renewable lease agreement of 3 years, for another 5 years, and so on, to the producers really interested in working these areas. This route is recommended to make the production economically viable, that way the agricultural vocation of the land would remain and no major social conflicts will result from the purchase of the land.
The annual income the GDF woluld pay the owners would range between 2,000 and 4,000 pesos per parcel of 800 m2.

It is considered that for the consultation process, planning, executive design and final project agreement it would require the services of one or more external consultants, the cost would be about 1, 500,000 pesos.

In the operation phase, the academic institutions would provide laboratory services and the salary of its researchers and administrators. The cost of maintenance of the public service spaces, purchase of research materials, as well as the payment to the "chinamperos teachers" and grant holders would be in charge of the GDF in conjunction with international funds

	from IDB, WB, FAO-UNESCO, in a start. In the medium term, the assisted producers would pay an annual fee to contribute to settle the operation of the park. Similarly, the GDF would pay through the Fund for the Support of Agricultural Production in Soil Conservation would subsidize a percentage of the rent of the land and hiring day laborers to producers holding the agriculture within the park with a high level of productivity. The investment in irrigation infrastructure required, as well as equipment needed for collective use by producers (agricultural machinery) it would be done through concurrent special programs of Xochimilco.

VI. Complementary data

1. Evolution of the Mexico City's lacustrine zone and its chinampa system

a. Evolution of the Mexico City's lacustrine area and its chinampa system (1325 – 2017)
b. The chinampa system layout
c. References

a. Evolution of the Mexico City's lacustrine zone and its chinampa system (1325 – 2017)

Figure 1. View of Valley of Mexico Basin 14th century. (Tomás Filsinger, 2005).

Mexico City's basin is a 9,600 km^2 (960,000 ha), endorheic (closed drainage) basin located at an altitude of 2,240 m above sea level. It is enclosed by several mountain ranges: the Pachuca and Tepontlalpan range to the north, the Chichinautzin range to the south, the Sierra Nevada to the east and the Las Cruces range to the west, lacking a natural hydrologic exit.

Figure 2. Original characteristics of the Valley of Mexico Basin in the 14th century. (Bassin du Mexique. CEMCA, México, 1987)

The Valley of Mexico basin, used to contain five interconnected lakes (known as lacustrine area): the three lakes in the north were salt-water body and the two to the south containing fresh water lakes.

The former Xochimilco-Chalco subbasin (known today as Xochimilco-Tláhuac) was a fresh water basin rich in lacustrine products and an ideal setting for hunting resident and migratory birds; a shallow-water area that allowed for the construction of chinampas for growing crops. The central island of the lake system was where the Aztec founded Tenochtitlan, currently México City.

In 1450, during the apogee of the Aztec Empire, the Mexicas built the dam known as Nezahualcóyotl's *albarradón*. The work separated sweet water from salt water in the lake area, allowing for the development of productive activities in the Xochimilco-Tláhuac lake.

Evolution of the Mexico City's lacustrine area

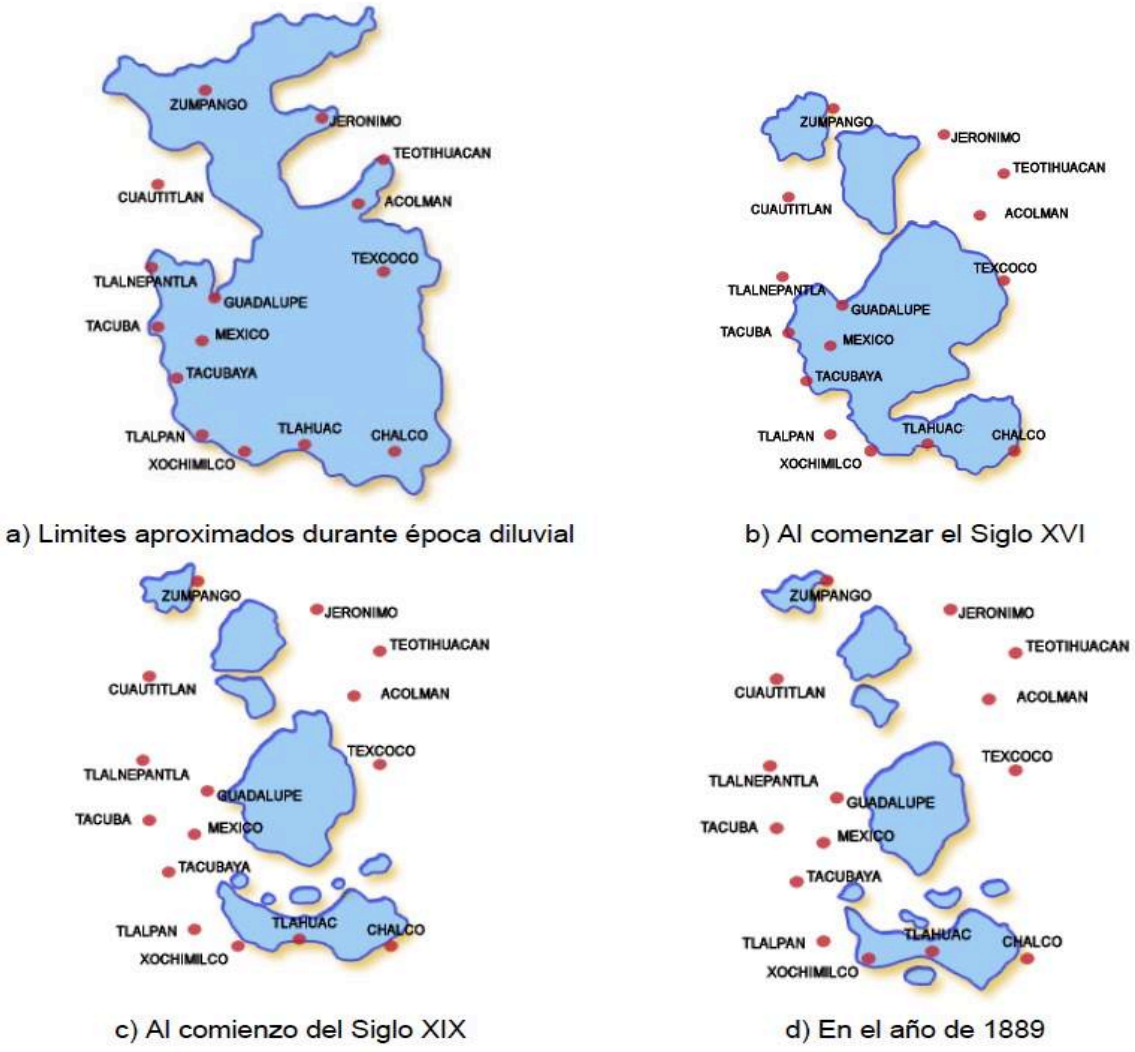


Figure 3. Evolution of the lakes of the Valley of Mexico until the 19th century; a) the original system, b) at the beginning of the 16th century, c) at the beginning of the 19th century and d) in 1889. (Shiell, 1975 en Pérez, 2009).

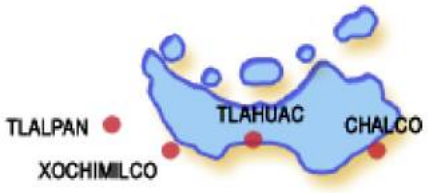


Figure 4. The lakes of the Valley of Mexico today (Shiell, 1975 en Pérez, 2009).

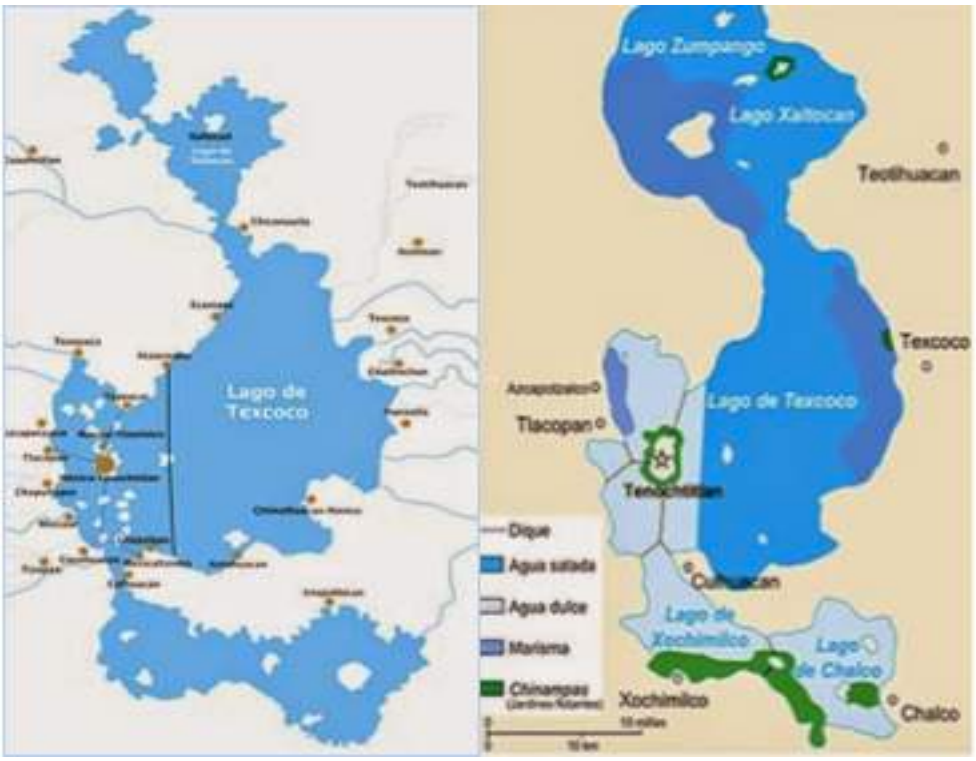


Figure 5. Evolution of the lacustrine area and expansion of the chinampa system. (Bassin du Mexique. CEMCA, México, 1987)

Tenochtitlan, founded in 1325, became a powerful state that dominated large parts of Mesoamerica for nearly two centuries until the arrival of the Spanish. Cuauhtémoc, the last tlatoani –the civilization's supreme leader-, lead the resistance against the European conquerors lead by Hernán Cortés in 1521.

In order to expand their farmable land, the Aztec (also known as Tenochca Empire or Mexica Empire) began to build artificial islets, developing a unique system of intensive agriculture. Xochimilco and Chalco became areas of great agricultural production, turning these areas into the main food suppliers of Tenochtitlan. The city was mainly concentrated in its urban core, the seat of the most important political, religious and economic powers in what is today Mexico City's *Centro Histórico* (old town).

In Mexico's basin, the height of the chinampa system coincided with the construction of water control works in the lakes, technological infrastructure that increased the chinampa system to levels never before seen in Mesoamerica's history (IMTA, 2004).

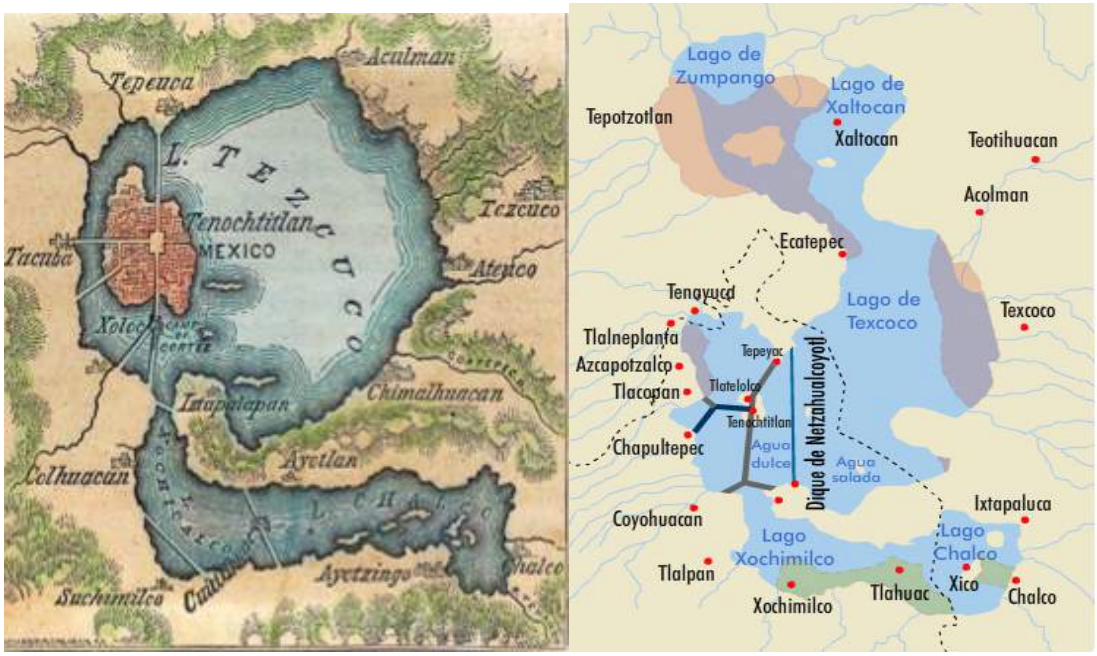


Figure 6. Lake system in 1325 and the development of causeways, waterways and hybrid pathways in 1450. (Bassin du Mexique. CEMCA, México, 1987)

México-Tenochtitlan, the Aztec Empire's capital, developed around the lake system. The islets were joined to the mainland through three large causeways with north-south and east-west orientations. In 1466 the Mexicas built the Chapultepec aqueduct to transport water from the pheripheral springs to Tenochtitlan's center.
During the mid 15th century, a causeway that joined the central city to the agriculturally productive chinampa areas of Xochimilco and Tlahuac. This causeway also served as a ditch dividing the Chalco and Xochimilco lakes, regulating their waters.

Based on different studies (1957, v. Rojas, 1983; Parsons, 1982 in Serra Puche, 1994) the total population of the Empire towards 1521, year of the Spanish conquest, is estimated between 5 and 6 million inhabitants for an area of approximately 200,000 km^2 (20,000,000 ha). The Valley of Mexico, with a surface of 8,000 km^2 (800,000 ha), concentrated an amount in excess of the two million inhabitants while Tenochtitlan had 300,000 inhabitants and extended over an area of 14 km^2 (1,400 ha).

Scholars have pointed out that it would be hard to understand how some of the largest settlements of the time could have supported such populations without the aid of an intensive agricultural system such as the chinampas.
The chinampa system is estimated to be over two thousand years old; the first chinampas are believed to have emerged around the year 200 BCE.

The system reached its maximum extension with the founding and consolidation of Tenochtitlan in 1325 and peaked during the XIV and XVI centuries (Sanders, Parsons y Stanley, 1979).

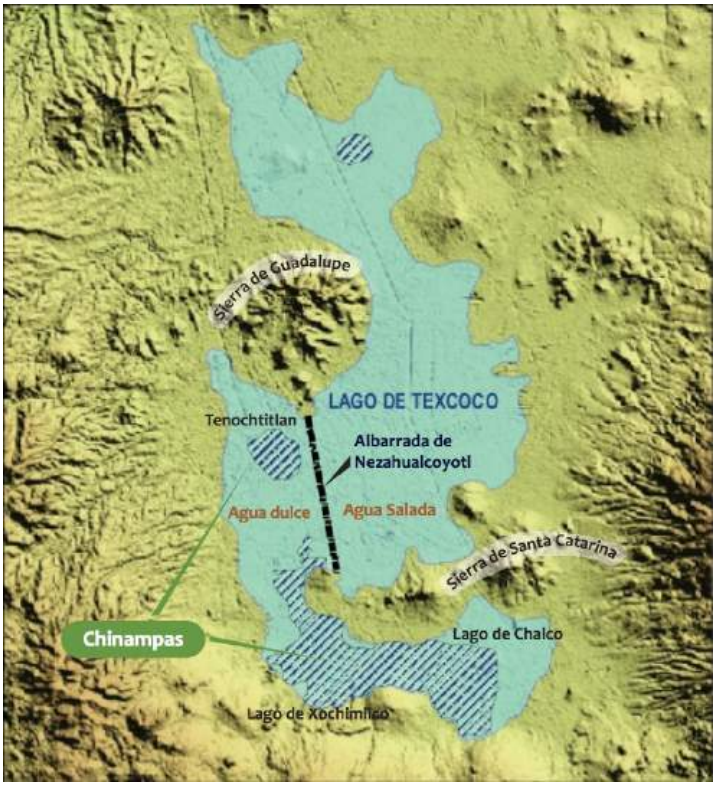


Figure 7. The first nahuatlaca tribe to arrive in the Mexico Basin were the xochimilcas. Towards 1194 CE the settlement had consolidated as an urban and chinampa agricultural center (Plan hídrico de las subcuencas Amecameca, La compañía y Tláhuac-Xico, UAM, 2011)

Theearliest indications of hydraulic works and farming on raised plots over the wetlands of the Valley of México's basin are connected to Cuicuilco. This settlement south of the valley (800 BCE to 250 CE) was abandoned due to the eruption of the Xitle volcano (Palerm, 1957). In addition to Cuicuilco, hydraulic works such as irrigation channels and platforms have been located north of the Valley of Mexico; these works belong to Teotihuacan and date back to the beginning of our common era and were used for agriculture (Sanders, 1979).

Evidence indicating the existence of chinampas has been found in archeological excavations carried out in areas surrounding Teotihuacan; its emergence and climax –which lasted for centuries- is estimated to have taken place between the years 1 and 750 CE. Historical evidence has been found in murals located within this ancient city's residential complex known as Tepantitla palace –formerly inhabited by the city's upper classes-,

located at door four, discovered around 1940, east of the Pyramid of the Dun, approximately 500 m away. The murals depict the construction of chinampas in the swamp areas during the late formative stage (300-100 BCE) as described in the studies published by Sanders, Parsons Stanley in 1979. The authors consider that despite their resemblance to Aztec chinampas, their development pattern was isolated and sporadic (ADM, 2015).
The same authors believe that it was during the expansion of the Mexica state in the 14th century when the xochimilca tribe systematized the chinampa system achieving large-scale agriculture using the chinampa system. They find that land reclamation from swamp areas in the lake was planned in order to secure food supply to Tenochtitlan.

In 1256, they founded their city-state under Acatonalli, their first lord. Presiding over the council of elders he proposed a solution to the food-supply problem: adopting an intensive farming technique in the areas close to the shores of the lake, using canes to enclose them. These areas were covered by reed mats and then covered with mud extracted from the lake's bottom thus creating a very fertile artificial substrate, which was irrigated by direct water-absorption, the basis of the chinampa technology.

The Mexica groups that settled on the lakeshores developed hydraulic engineering techniques to exploit lacustrine resources, building a system of dams that allowed them to control water-levels, thus avoiding flooding during rain seasons and scarcity during dry seasons. The lakes in the south received abundant and constant inflows of water through some rivers in the Sierra Nevada and numerous springs.

The lakes of Xochimilco and Chalco offered natural settings that were particularly favorable for the development of hydraulic agriculture in general but specially for chinampas: abundant and permanent freshwater sources in shallow waters with a natural drainage to Mexico (Palerm, 1974). According to data obtained in research projects carried out in the Basin of Mexico, studied by Sanders an his associates in the seventies, the first signs of chinampas in the Xochimilco and Chalco lakeshores date back to between 750 and 1350 CE, a time window coinciding with the collapse of Teotihuacan and the first Aztec occupations.

Figure 8. The state-planned construction of chinampas took place during the expansion of the Mexica state. The map shows dams/causeways and the Xochimilco and Tlahuac chinampa areas during colonial times (Atlas General del Distrito Federal, 1930).

This productive management reached its largest extension in Tenochtitlan (1325) and during the following two or three centuries; even when it was well known and practiced during the firs millennium of our common era, chinampa agriculture wasn't extensively practiced until the post-classic stage (900 – 1521 CE).

The oldest chinampa area is the one extending along the southern shores of the Chalco and Xochimilco lakes in the south of the Valley of Mexico (West and Armillas, 1950). This system reached its greatest productivity between the years 1327 and 1400. Maize, different types of beans, chili peppers, squash, chayote, amaranth, chia were all grown with the system. Xochimilco means "in the land of flowers" and several types of them were also grown: chrysanthemums, pansies, carnations, wallflowers, peas, amaranth, roses, marigolds and daisies. Other edible plants, such as algae, were obtained from the lakes and also animals like frogs, axolotls, crayfish, snakes, stink bugs and other insects and their larvae, which rounded off a very well-balanced, nourishing diet.

Four maps (figures 9, 10, 11 y 12) depicting the situation in which Tenochtitlan was found when the Spaniards arrived in the 16th century are considered original works created by the Spaniards themselves between 1524 and 1558. These maps show the landscapes and natural riches of the Mexico Valley and the conditions of the region when they arrived in 1519 and when the city was conquered in 1521 (Mapa de México Tenochtitlan, Miguel León Portilla, 1987).

Figure 9. Uppsala Map. Map of Tenochtitlan in 1550
A section of Alfonso de Santa Cruz's , official cartographer to CharlesV. The original is kept in the Uppsala University, Sweden.

The foundation of Tenochtitlan in the middle of the lakes and its accelerated rise to power had a direct impact in the environmental transformation process that included hydraulic works designed to control water levels. These works were intended to handle the flooding/drying of canals, chinampas, settlements on the islands, peninsulas and shores. Others were built to provide water to these settlements and irrigate farmlands in the hillsides and surrounding areas and yet others were constructed to create artificial bodies of water (Semblanza histórica del agua en México, Semarnat, Conagua, 2009).

The hydraulic complex the Spaniards found on their arrival was particularly dense, intricate and interconnected in the lake of Mexico. It is depicted in the *Uppsala map*, composed of a series of dams (*albarradas* or *albarrradones*); causeway-dams (serving this double function); channels of different sizes, shapes and materials ere used for navigation, irrigation and drainage; diversionary and reservoir dams; bridge decks; lock gates and docks, among the main ones.

Figure 10. Map of Tenochtitlan in 1554.
Also by Alfonso de Santa Cruz, included in the the book *Islario general de las islas de todo el mundo*, National Library, Madrid, Spain.

The hydraulic infrastructure enabled urban life, communication among the lakes and, using small wharfs -canoe jetties-, the connection of the basin and its surrounding areas with the rest of the empire. But most of all, this infrastructure laid the foundations for the construction of chinampas, man-made farmland for intensive cultivation using techniques that combined drainage and land reclamation that enabled an expansion of production and the sustainability of the Mexica state (Semblanza histórica del agua en México, Semarnat, Conagua, 2009).

Figure 11. Map in maguey paper showing the city of Tenochtitlan in 1588 . A section of the map showing some chinampas zones. (Biblioteca Nacional de Antropología e Historia, Mexico City).

The map in figure 11 shows the city of Tenochtitlan in 1588, crossed by roads and canals that form a grid of plots over which the head of the owner, glyph and their Spanish name were drawn and written. It depicts the way the native population used the lakes in the area as transportation systems through which goods were shipped between the great city and the settlements along the coastline. They were mainly used to support farming, particularly using the chinampa system.

The chinampas area, particularly Xochimilco and Chalco, has been acknowledged as one of the main sources of produce supply to the Mexica capital. The provinces that were subjects of the Aztec Empire were considerably far and were not easily accessible, thus unable to provide these much needed agricultural products. This readily available source and the highly sophisticated Mexica social organization allowed the city to survive and thrive (Serra Puche, 1989).

Before the arrival of the Spanish, agricultural production in chinampas constituted the real basis of economy on the Basin of Mexico. The Aztec Empire relied on the high yields of the chinampa system for its food supply. The produce, seeds and animals it received was often a form of taxation on its subjects; this was the case of the goods they obtained from the people of Xochimilco.

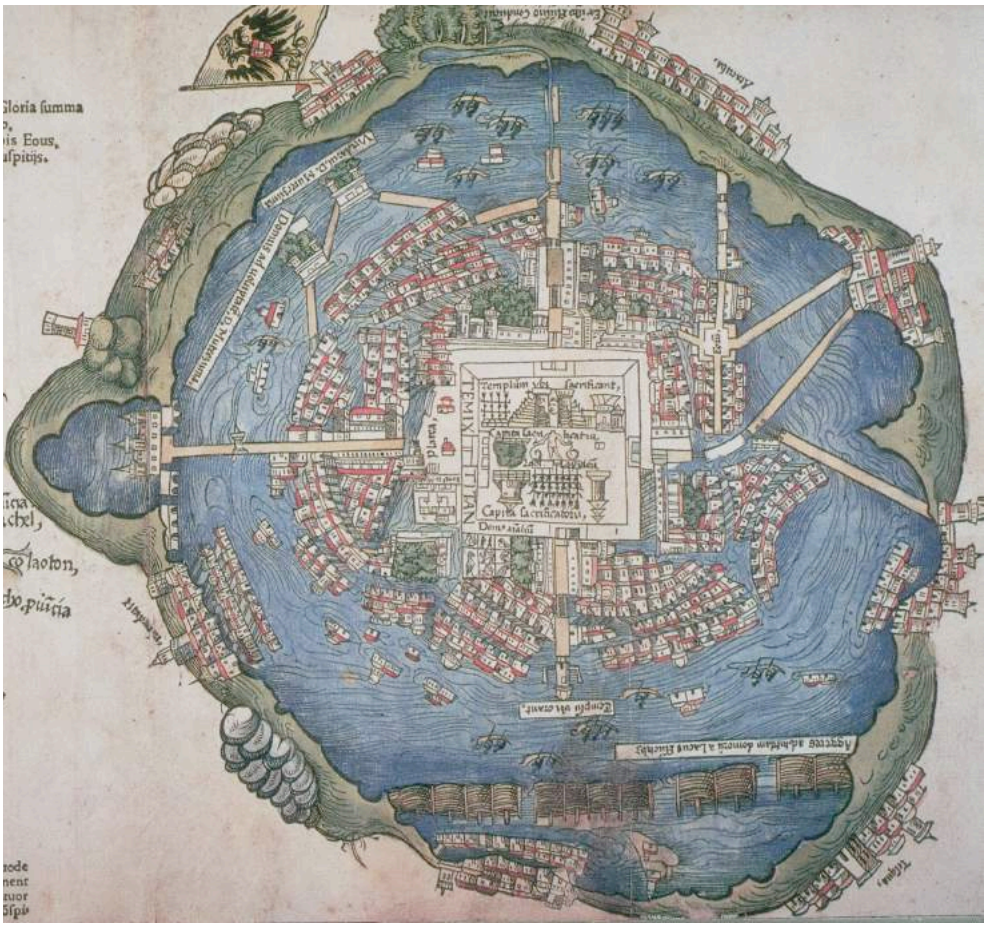


Figure 12. A section of the *Nuremberg Map* depicting Mexico City towards 1520. The map was published in Nuremberg, Germany in 1524 with a translation of conqueror Hernán Cortés' *Cartas de relación*.

When Tenochtitlan was founded, the Mexicas could not rely on these means of survival, their only domains was the vast lake. This lake only had a few islands of different sizes with muddy and flood-prone soil that was often covered with useless vegetation and surrounded by marsh vegetation. Timber was used to fence shallow portions of the lake that, reinforced by rocks and filled with soil and grass, became firm ground. In this way, smaller portions of land were created and combined into the smaller islands, reclaiming land from the lakes (Santamaría, 1912). The expansion of chinampa agriculture was boosted by the lack of farmland among in these wetlands. This fact stimulated the emergence and evolution of the chinampa system in this specific area of the basin.

In reference to the construction of chinampas in the Xochimilco-chalco subbasin, Armillas considers that this adaptation was so successful that, towards the beginning of the 16th century, most of the extension of both lakes had been converted by man into a prodigious complex of several thousand islands devoted to the practice of horticulture (Armillas, 1971).

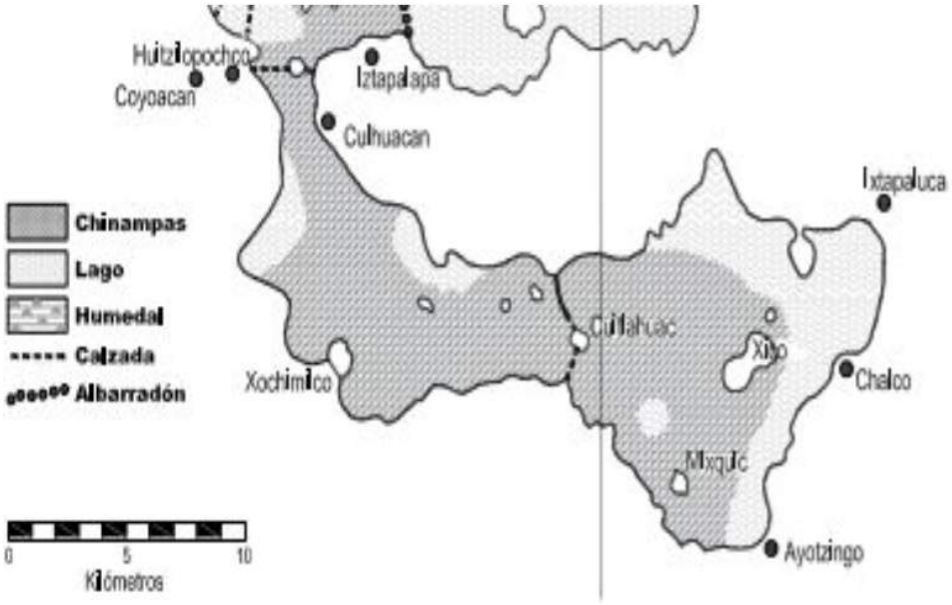


Figure 13. Chinampa production areas in 1521 (Armillas, 1970 in González, 2014).

The foundation of Tenochtitlan in 1325 and the consolidation of the Aztec Empire in the century preceding the arrival of the Spaniards coincides with the maximum extension of the chinampa-covered territory. It is believed that at least two thirds of the Xochimilco-Chalco lake were covered with tens of thousands –perhaps even a hundred thousand- chinampas, which partly explains the economic and logistical strength of the Mexicas (González Pozo, 2014)

Sanders (1957, in Rojas, 1983) and Parsons (1982, in Serra Puche, 1994) both consider that the demographic development of the Aztec empire was driven by the important role of the Chalco-Xochimilco lakebed as food supplier for the great urban center that was Tenochtitlan, a role it performed throughout the colonial times until the 13th century.

Figure 14. The lakes of the Valley of Mexico basin were gradually occupied by artificial islets built by the Aztec. This image was created using the letters that Alfonso de Santacruz, royal cosmographer to Charles V, sent to the king (Tomás Filsinger, 2005).

When the Spanish arrived in 1519, the basin was settled by a well-developed civilization whose economy was centered around agricultural production using the chinampas that covered the lake. The magnificence of its gardens impressed conqueror Hernán Cortes so much that he included several long descriptions of them in his letters to Emperor Charles V (Ezcurra, 2003).

By then, it is estimated that there were around 12,000 ha of chinampas of which 75% were fully operational (9,000 ha); these production levels had favored a considerable increase of the xochimilca population. The chinampa system was able to feed a population of between 150,000 and 200,000 inhabitants with an average individual consumption of 160 kg (Sanders, 1976).
The Spanish conquest halted the expansion process of the chinampa system and introduced a new paradigm that signaled the decline an agro-productive cultural landscape which was environmentally, socially and economically sustainable.

However, maintaining the chinampas as agro-productive units proved crucial for the survival of the colony because European farming systems weren't fit for the environmental and topographic conditions in the subbasin. The Spaniards relied on plowing, which isn't viable either in mountainous areas like the basin's south, nor in the wetlands and shallow lakes like the ones found in the chinampa-covered areas (González Pozo, 2014).

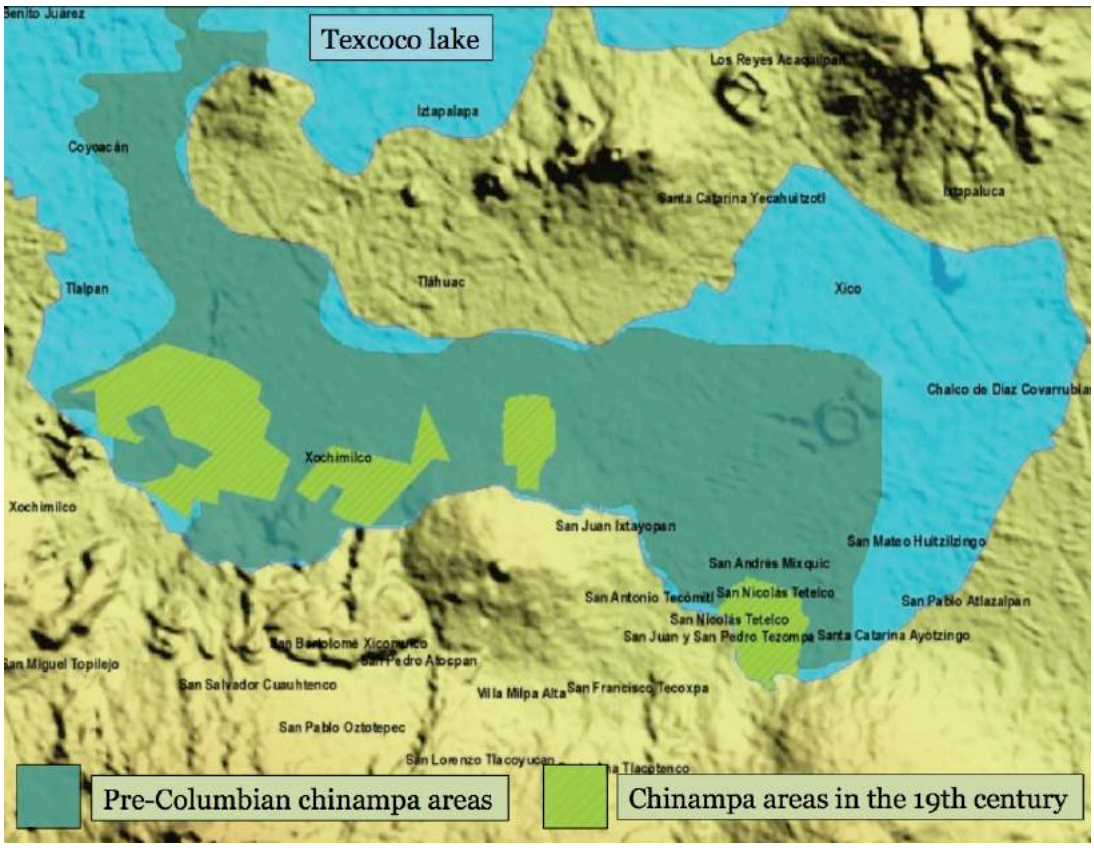


Figure 15. Chianampa areas of the Xochimilco-Tláhuac lake in pre-Columbian times and in the 19th century. (Plan hídrico de las subcuencas Amecameca, La compañía y Tláhuac-Xico, UAM, 2011)

During the three following centuries (17th, 18th and 19th) and under Spanish control –known as the colonial period- which spans between 1521 until the consolidation of Mexico's independence in 1821, production in the chinampas begun to dwindle but it remains constant because the Spaniards kept it as source of much-needed produce.

As Gibson (1983) points out, among the factors for the permanence of the chinampa agro-productive system is the Spanish interest in maintaining the productive capacity of the area to feed the Viceroyalty's capital. (González Pozo, 2010)

Nevertheless, these tax systems and others that forced them to provide services to the conquerors, combined with their vulnerability to new diseases, severely reduced the indigenous population of the chinampas towards the second half of the 16th century and lead to other loses; the productive surface and its food production languished (González Pozo, 2010)

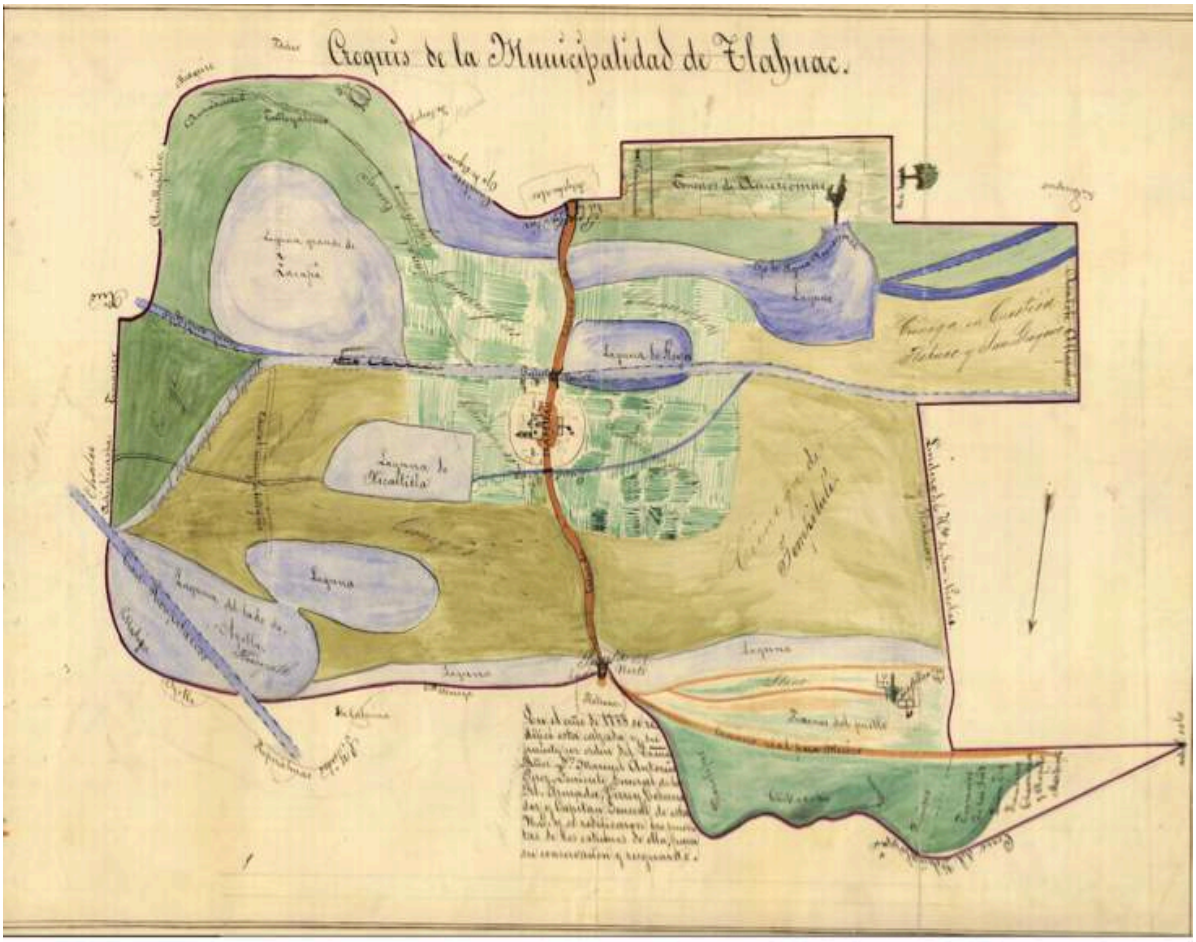


Figure 16. 18th century map of the municipality of Tlahuac, showing its lacustrine area and productive chinampas (shown in green hatching). (Atlas General del Distrito Federal, 1930).

During the 20th century several efforts to better understand and explore its main characteristics were commissioned. Among these are Manuel Santamaría's (1913) recounting of San Gregorio's chinampas –still intact- or the studies regarding superficial or archaeological explorations of ancient and present day chinampa areas by authors such as Schilling (1993), Armillas (1971), Sanders (1957), Parsons (1982), Rojas Rabiela (1983) y Serra Puche (1990). The past century is also the one when the heritage value of the area begun to be recognized as such and it was declared a world Heritage zone.

A century later, (21th century) the lacustrine landscapes in Xochimilco and Tlahuac continue to be protected; this ancestral area constitutes a unique testimony of the traditional way in which territory in the Valley of Mexico basin was settled and inhabited and constitutes the last remnant of the five lakes that once allowed Mexico-Tenochtitlan to thrive.

In 2012, the Government of Mexico City created the Authority of the Natural and Cultural World Heritage Zone in Xochimilco, Tlahuac and Milpa Alta (known by its acronym AZP), charged with preserving the chinampa system and the culture associated with it –the heritage protected by UNESCO-. The AZP coordinates all the entities working in the site, establishes and a Master Plan to safeguard heritage assets.

The AZP, in collaboration with the Xochimilco unit of the Metropolitan Autonomous University, created a chinampa catalogue that records exactly how many chinampas remain in the 21st century. Out of the nearly 20,000 in existence about 3,586 are still actively producing using the ancestral system and occupy an area of 2,215 ha, distributed over 5 zones.

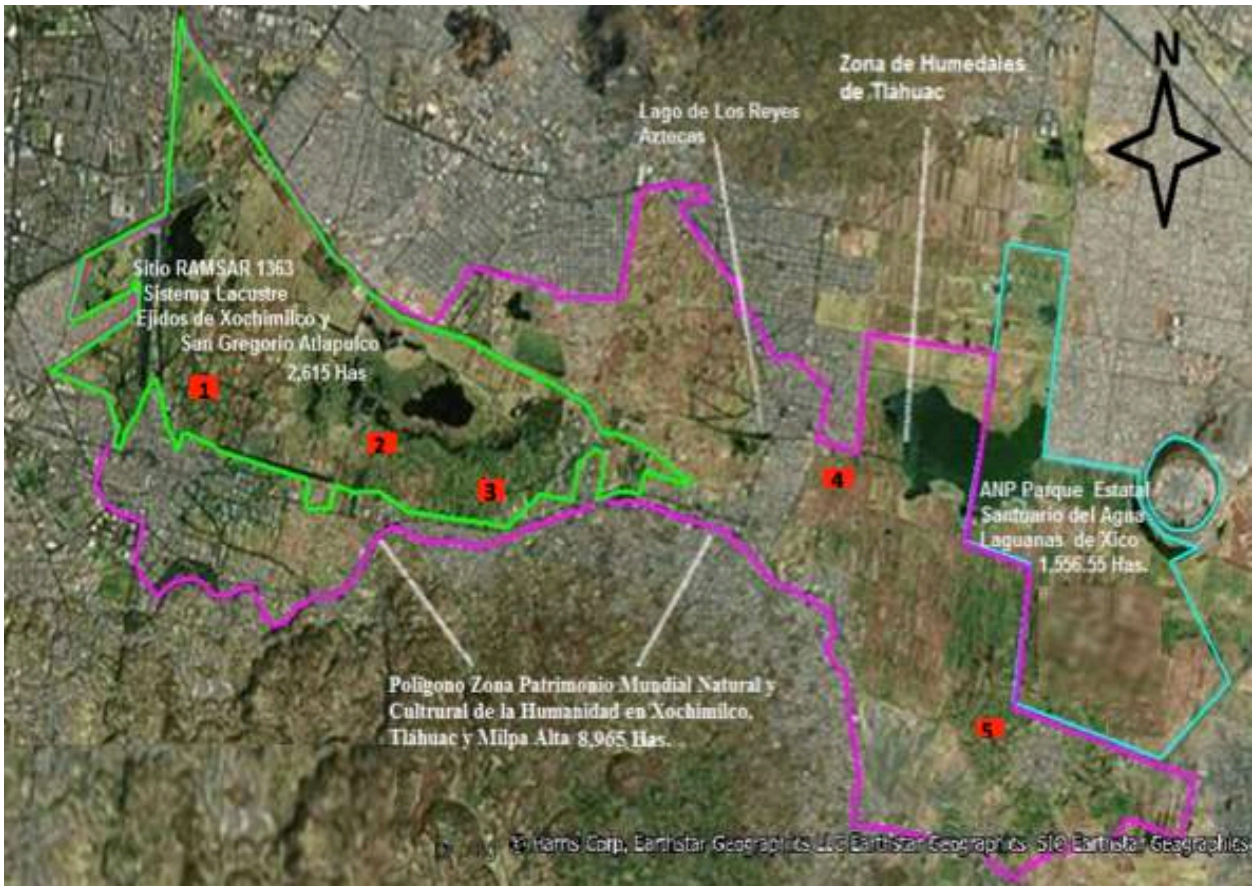


Figure 17. 21st century aerial photograph of the Heritage Zone with the location of the 5 chinampa areas (UAMX, 2014).

In the 21st century, manifest in the network of canals and ahuejotes, canoes and *trajineras,* chinampas and chinampa culture are very much alive. This millenary agro-productive knowledge has served the food needs of Mexico City's inhabitants for a long time. The native peoples of the area have, generation after generation, preserved their cultural values and practices and embodied their pre-Columbian heritage.

The chinampa, Aztec name for an ancestral agro-productive system consisting of man-made plots of land in the middle of a lake, creating islands surrounded by canals, favoring the practice of a millenary agricultural practice that allows for up to five harvests per year.

Chinampas and chinampa culture have supported the existence and resilience of traditional rural communities around them. Their urban wit their natural lacustrine landscapes, historical monuments and archeological sites are strengthened by the strong presence of their immaterial heritage, manifest in their multiple festivities and traditions

Concentrating three types of heritage of exceptional value in the Heritage Zone, chinampas have been recognized an official UNESCO World Heritage site and as a wetland of international importance under the Ramsar Convention. The Zone constitutes -at the same time- productive, natural and cultural heritage. This heritage is sustained by tangible and intangible values preserved through traditional productive practices that are representative of the pre-Columbian culture that survives and that bares witness to the harmonious blending of man and nature.

Chinampa culture remains alive. For some, it is the element around which everyday life revolves, where food is produced and where other activities are carried out. For others, chinampas complete their main activities. The resilience of the chinampa system has been proven for over a thousand years, adapting to the onslaught of a megalopolis as big and complex as Mexico City, one of the most populated in the world.

Figure 18. Superposition Mexico-Tenochtitlan's layout in 1519 over modern Mexico City in 2013 (UAMX, 2013).

Almost seven centuries have passed since Mexico-Tenochtitlan was founded and the chinampa system's capacity for persistence has been proven time and again. The system has been capable of resisting due to its self-sufficiency, operating as a sustainable system where the lakes provide all the elements needed for its construction, functioning and maintenance. Aquatic vegetation and sludge from the lakebeds are used to build the chinampas and seedbeds and to nourish the soil, water used for irrigation and to maintain the unique conditions that favor fertility and productivity of the system.

b. The chinampa system layout

Figure 19. Teotihuacán's layout according to Millon, 1963 (left); chinampas of the last Aztec period, according to Parsons, 1982 (center); a section of San Gregorio Atlapulco's chinampas today, according to González Pozo, 2010. All these examples exhibit the same orientation, approximately 15° east of north (UAM-X, 2014).

Many pre-Columbian civilizations had great interest in astronomical phenomena, which often shaped their cosmogony, and possessed what is considered advanced astronomical knowledge. This knowledge was often used to guide the construction of their cities, using the stars as references, especially the Sun. Many building were built with an east-west orientation –following the path of the Sun in the sky- or orientations related to the solstices, equinoxes and the days of zenithal sun.

In this fashion, the chinampa layout replicates this cosmogonic orientation, creating a culturally-shaped landscape by repeating the chinampa multiple times with this artificial agricultural production unit. The distribution of chinampas over the lacustrine surface followed the special pattern of a 15° east of north orientation, replicating the aforementioned pre-Columbian models.

According to the studies carried out by Pedro Armillas (1971), the construction of agricultural land over the lakes of Xochimilco and Chalco is a sign of a very conscious planning effort to achieve a particular spatial orientation and a controlled urban development scheme that was very similar to the urban grid of other Aztec settlements. Perfectly aligned rectangular lattices facilitated the optimization of the available natural resources and labor. The perpendicular nature of this grid also served the purpose of blocking the water from reaching specific areas of the system to avoid flooding (López Trejo, 2015).

According to Armillas, the orthogonal layout produced narrow and elongated plots surrounded by canals that enabled the absorption of water and facilitated canoe-assisted irrigation when necessary.

Figure 20. Chinampas , canals and ahuejotes (agomezpompa.org).

One of the main features of the chinampa system layout is its network of canals and the use of ahuejotes. The layout of the waterway system defined the general planning of the lots that were allocated for the construction of each chinampa. The distance between canals indicates the existence of a modular pattern in the allocation of space, to which authors like Sanders and Armillas have pointed out.

The canal network serves various purposes: water filters to the roots of the plants, canoes can navigate through it and, if needed, may provide additional irrigation for the crops. The canals are an essential component of the chinampa system because they are vital for irrigation and infiltration; for the formation and accumulation of slime, needed to build the islets and used as cultivation substrate; for transportation, based on the use of canoes and *trajineras* (IMTA, 2004).

Ahuejotes (*salix bonplandiana*) are a fundamental component of the chinampa system and the canal network and shape the its layout. The roots of these native trees are water-resistant, prevent the chinampa from crumbling and allow the plot to remain fixed and compacted (IMTA, 2004).

Their distribution along the margins of the canals creates corridors known as gallery forests (González Pozo, 2014). These serve several functions: they act as buffers against strong winds; they are used as supporting structures for climbing species such as beans and chayote; they provide organic matter and nutrients to the system; they block sediments; they shape and stabilize the soil. These grow up to between 6 and 10 m in height with some specimens reaching 16 m; their growth is considerably fast and their longevity allows them to live for 40 and 50 years.

They provide countless environmental services; they produce oxygen, fix carbon dioxide, provide structural support to the chinampa, capture suspended solids, provide shelter for wildlife species, among others.
Their foliage is vertical and grows upwards, allowing for sunlight to penetrate and reach the crops, creating a microclimate that is ideal for their development. As they are planted in lines they form wind breaking barriers (PEX, 1993).
The grid composed by the canal network, consisting canals of different sizes, drew a peculiar view, a landscape architecture that transformed the lacustrine area into an environment of over 12,000 ha shaped by man, during its splendor in pre-Columbian times (IMTA, 2004).
The chinampa system is currently composed of large islets, delimited by ahuejotes, that are surrounded by wide navigable canals, which are in turn divided by the narrower *acalotes*, likewise intersected by the even narrower *apantles*.

This territorial structure safeguards an ancestral space where the original values of a cultural landscape that still has an active role in contemporary society are still entrusted, associated to a traditional productive system in continuous evolution.

Figure 21. Minor canals, known as apantles, surrounding the sides of chinampas.

Figure 22. The construction of chinampas simultaneously produces the canal network (agomezpompa.org).

Chinampas are characterized for being an intensive agro-hydrologic and sustainable system with permanent water availability and thus independent of the availability of rain.

Chinampas are the emblematic example of an ingenious production system involving particularly creative pragmatic skills achieved in pre-Columbian times and representing a sustainable productive method for our times (RMA, 2014)

Its relevance rests in the design of a production and provision system for produce, using the same productive technique in different eras, first towards the center of Mexica power (1325-1521). provision that remained during the Spanish conquest, persisted during colonial times and continued in the 20th century, standing until the 21st century (Serra Puche, 2009).

Recent studies have estimated that a chinampa in Xochimilco is five and a half times more productive –per surface unit- than a regular rain-fed field. Chinampas are a system that supplies food to families and excess production –if it is the case- may be commercialized (IMTA, 2004).

The high productivity obtained is due to its soil. These soils are abound with nutrients because its substrate is artificially built by the *chinamperos* –those who construct them and farm with them- by accumulating organic soil, rich in natural fertilizers. Decomposing organic matter transforms it into a porous soil with excellent nutrients; the chinampa is capable of reusing its own fertilizers and enriching its soil with the organic matter it produces (Revista Mexicana Agronegocios, 2014). The muds in the lacustrine zone are rich in organic matter and minerals that originate in the volcanic ashes deposited by the eruption of nearby volcanoes.

The lakebeds are covered by fine-grained claylike sediments, composed of nearly 50% volcanic ashes, with textures that vary from sandy to slime. These muds retain moisture, which makes the lake system a permanent wetland. One of the main factors in the construction of a chinampa is the use of ahuejotes encircling it. (RMA, 2014)

The use of organic soil, in combination with the ahuejote trees, makes the chinampa a highly productive agroforestry unit that promotes aquaculture and enables the efficient utilization of solar energy, water, soil and green fertilizers, without affecting the ecosystem that sustains it (Revista Mexicana de Agronegocios 2014).

Chinamperos work with their hands, and intensively use the local workforce. Water is abundant and the crops remain moist to allow for several harvests per year in small areas (between 500 and 1000 m^2), which are considerably large yields.

Chinamperos control all the resources they employ in their practice: water (with selective irrigation), soil (with organic sludge and fertilizer), cultivating (with seedbeds), microclimate (using the ahuejotes) and space (with related crops) (Revista Mexicana Agronegocios 2014).

From a technical perspective the chinampa provides the following conditions: drained soil, a balanced water-air ratio, nutrient availability, a water table that sits below the rhizosphere (favoring a micro-environment where the roots develop; bacteria and fungi intermingle with the roots, generating communities with potential for detoxification) and readily available water for the crops (PEX, 1998).

Figure 23. Constructing the first layer of the chinampa with organic matter (agomezpompa.org).

Figure 24. Constructing the second layer of the chinampa with mud and sludge (agomezpompa.org).

Figure 25. Today's chinampa constucction is preserved since pre-Hispanic times.

Chinampas are still built in the 21st century just as pre-Columbian cultures did, using the same ancestral techniques, reclaiming land from the lakes, producing an agro-productive island that does not alter the ecosystem but preserves it and enlarges it.

Chinampas favor the conservation of water bodies, they preserve and stimulate the biotic wealth of lacustrine environments, they constitute a source of employment that conserves water culture, they form a natural barrier against the expansion of urban areas and prevent deterioration of the wetlands, a vital resource for the purification and replenishment of the aquifers of Mexico City's ecosystems.
In addition to their productive importance, they also provide enormous cultural value, because communitarian practices and a wide range of agricultural, environmental and historic knowledge about the indigenous peoples that have kindled the area since pre-Columbian times and until today revolves around them.

c. References

Aréchiga Córdoba, Ernesto (2004). "El desagüe del Valle de México, siglos XVI-XXI. Una Historia Paradójica", Arqueología Mexicana núm. 68. México.
Armillas, Pedro (1971). "Gardens on swamps". En Science, Vol. 1174, No. 4010.
Arreola Gutiérrez, David Jesús (Coord.) (2014). "San Francisco Caltongo: historia de un barrio ancestral de Xochimilco". Colectivo Antropología Chinampera.
Cervantes Sánchez Enrique (2006). "El desarrollo de la Ciudad de México"· Editorial R.C.C. México.
CEMCA, Centro de Estudios Mexicanos y Centro Americanos. (1987). Aleopaysages et archeologie pre-urbaine du bassin de Mexique. Colección de Estudios Mesoamericanos. México.
Díaz Ruíz, Rafael (2013). "Casas y soluciones del problema de olores en plantas de tratamiento de aguas residuales". Tesis para obtener el título de Ingeniero Civil, Universidad Nacional Autónoma de México. Ciudad de México.
Escobar Ruíz, Verónica (2014). "Análisis instrumental de la variabilidad climática y de la calidad del agua en plantas de tratamiento residual. Caso de estudio". Tesis para obtener el grado de Maestro en Ingeniería, Universidad Nacional Autónoma de México. Ciudad de México.

Ezcurra, Exequiel. (1995), "De las chinampas a la megalópolis (el medio ambiente de la cuenca de México)", Consejo Nacional de Ciencia y Tecnología, Fondo de Cultura Económica y Secretaría de Educación Pública, colección: la ciencia desde México, número 91, México.
Ezcurra, Exequiel y otros (1999). "The Basin of Mexico: Critical environmental issues and sustainability". The United Nations University.
FAO, Organización de las Naciones Unidas para la Agricultura la Alimentación. (1999). Guía para el manejo eficiente de la nutrición de las plantas. Roma.
Filsinger, Tomás. (2005). "Atlas y Vistas de la Cuenca, Valle, Ciudad y Centro de México a través de los Siglos". México.
Gibson, Charles (1964). "Los aztecas bajo el dominio español (1519-1810)". Siglo XXI. México.
Gómez Pompa, Arturo (2016). "Mi vida en las selvas tropicales: memorias de un botánico". México. FUMEX. CONABIO. México.
González Pozo, Alberto et al., (2010). "Las chinampas de Xochimilco al despuntar el siglo XXI: inicio de su catalogación". UAM-Xochimilco. Ciudad de México.
González-Pozo, Alberto et al. (2014). "Estudio para la catalogación de chinampas de la zona de monumentos en Xochimilco, Tláhuac y Milpa Alta, D.F., inscrita en la lista del patrimonio mundial, cultural y natural de la humanidad". Autoridad de la Zona Patrimonio Mundial Natural y Cultural de la Humanidad en Xochimilco, Tláhuac y Milpa Alta. UAM-Xochimilco. Ciudad de México.
González Carmona, Emma; Torres Valladares, Cynthia Itzel. (2014). La sustentabilidad agrícola de las chinampas en el Valle de México: caso Xochimilco. RMA. Revista Mexicana de Agronegocios, núm. 34. Sociedad Mexicana de Administración Agropecuaria A.C. México.
Guzmán Tristán, Judith Esmeralda (2012). "Desarrollo de una metodología para la evaluación de sistemas de tratamiento de aguas residuales municipales". Tesis para obtener el título de Maestra en Ingeniería, Universidad Nacional Autónoma de México. Ciudad de México.
IMTA. Instituto Mexicano de Tecnología del Agua. (2004) Manual de Construcción de Chinampas. Morelos. México.
Jiménez Moreno, Marcela. (2013). "Resilencia y Adaptabilidad del Sistema Chinampero de Xochimilco". Tesis para obtener el título de Licenciada en Geografía, Universidad Nacional Autónoma de México. Ciudad de México.
Jiménez Vaca, Alejandro. (2014). "The dishes of México City and implications on residencial buildings of the XVIII century. Editorial RCC. México.
León Portilla, Miguel. (1986)."Mapa de México Tenochtitlan y sus contornos hacia 1550". Reeditado en 2016. Celanese Mexicana. México.

Lorenzo, José Luis (1975), ”Agro ecosistemas prehistóricos, en Chinampas prehispánicas”, Carlos Javier González (compilador), Consejo Nacional para la Cultura y las Artes e Instituto Nacional de Antropología e Historia, México.
Martínez Ruiz, José Luis (2004). “Manual de construcción de chinampas“. Morelos. IMTA 2004.
Martínez García, Roberto. (2011). “Determinación de los impactos ambientales de tecnologías de tratamiento de aguas residuales a gran escala“ Tesis de Maestría. Instituto Tecnológico de Monterrey, Campus Estado de México.
Medina, Carmen.(2000). De Tenochtitla a Upssala. Universidad de Upssala. Suiza.
Moriarty, James. (1975). “Agricultura de los jardines flotantes en Chinampas prehispánicas”, Carlos Javier González (compilador), Consejo Nacional para la Cultura y las Artes e Instituto Nacional de Antropología e Historia, México.
Mundy, Bárbara. (1998). Mapping the aztec capital: The 1524 Nurnberg Map of Tenochtitlan, its sources and meanings. Imago Mundi. Fordham University.
Noguera Azuza, Eduardo (1970). “Exploraciones estratigráficas en Xochimilco, Tulancingo y Cerro de la Estrella”. En Anales de Antropología, Vol. 7, Instituto de Investigaciones Antropológicas de la Universidad Nacional Autónoma de México. México.
Ortiz Eugenia, Pupareli (2011). “Una mirada al pasado: evolución de las chinampas en la cuenca de México”. Facultad de Filosofía y Letras. Universidad Nacional Autónoma de México. México.
Palerm, A. (1990). “México prehispánico. Ensayos sobre evolución y ecología”. Ciudad de México: Conaculta. México.
Parsons, J. (1991). “Political implications of prehispanic chinampa agriculture in the Valley of Mexico”. In Harvey, H. (ed.) Land and politics in the Valley of Mexico. A two thousand year perspective. Albuquerque: University of New Mexico Press.
Pérez Centeno, Diego (2009). “Modelado del hundimiento de la zona lacustre del Valle de México”. Cita Planos de Evolución Lagos de México. Instituto Politécnico Nacional. México.
PEX, Parque Ecológico de Xochimilco, Asociación Civil. Ciudad de México.
Programa de Sustentabilidad y Gestión de los Servicios Hídricos (PSGSH) 2013 – 2018. Sistema de Aguas de la Ciudad de México – SACMEX (2016). Gaceta Oficial Ciudad de México.
Quiñonez Amézquita, Columba (2005). Chimnampas y Chinamperos: Los horticultores de San Juan Tezompa. Universidad Iberoamericana. Néxico.

Ramírez Guardado, Patricia y otros (2013). "Política Hídrica y Cambio Tecnológico en Tecnologías Aplicadas al Tratamiento de las Aguas Residuales". Journal of Technology Management & Innovation.
Rangel, José Antonio y otros (2012). "Chinampas: alternativa agrohidrológica sustentable". Universidad Bolivariana de Venezuela.
RMA, Revista Mexicana de Agronegocios Número 34. (2014). Sociedad Mexicana de Administración Agropecuaria A.C. México.
Rojas Rabiela, Teresa y Sanders, William T. (1985). "Historia de la agricultura Epoca prehispánica- siglo XVI". Instituto Nacional de Antropología e Historia. México.
Rojas-Rabiela, T. 1991. "Ecological and agricultural changes in the chinampas of Xochimilco-Chalco". In H. R. Harvey (ed.). Land and politics in the Valley of Mexico. A two thousand year perspective. Albuquerque: University of New Mexico Press.
San Miguel Villegas, Ruth Trinidad (2010). "Maestría en Población y Desarrollo: La expansión urbana en suelo de conservación en la delegación Tláhuac, DF. México". Tesis para optar al grado de Maestra en Población y Desarrollo.
Sanders, W.T. (1957). "Tierra y agua: A Study of the ecological factors in the development of Meso-American civilizations". PhD. Dissertation. Harvard University.
Sanders, William T., y otros (1975). "The Basin of Mexico: Ecological Processes in the Evolution of a Civilization". Academic Press New York, San Francisco, London.
Sanders, W. T., J. R. Parsons, and R. S. Sanfley (1979). "The basin of Mexico. Ecological processes in the evolution of a civilization". New York: Academic Press.
Serra Puche, Mari Carmen (1994). "Xochimilco Arqueológico". Patronato del Parque Ecológico de Xochimilco. Ciudad de México.
Stephan-Otto Parrodi, Erwin (1993). "El ahuejote". Patronato del Parque Ecológico de Xochimilco. Ciudad de México.
Stephan-Otto, Erwin (1996). "Sustentabilidad de los parques ecológicos: el caso del Parque Ecológico de Xochimilco". Facultad de Ciencias Políticas y Sociales de la Universidad Nacional Autónoma de México.
Stephan-Otto Parrodi, Erwin y Aurora Zlotnik (1998). "La chinampa: evaluación y sustentabilidad". Patronato del Parque Ecológico de Xochimilco y Universidad Autónoma Metropolitana
SEMARNAT, Secretaría del Medio Ambiente y Recursos Naturales. (2009). Semblanza histórica del agua en México. CONAGUA, Comisión Nacional del Agua. Ciudad de México.
Torres Lima, Pablo Alberto y otros (1990). "Sustentabilidad, viabilidad económica y estrategias sociales del modelo chinampero". UAMX Xochimilco , Ciudad de México.

Urdapilleta Pérez, José Antonio.(2009). "Las obras hidráulicas prehispánicas y coloniales en Tlatelolco". Ciudad de México.
UNESCO, (2012) Reporte sobre el grupo temático Paisajes Culturales de América Latina y el Caribe, Chile.
Villa Salas, Avelino B. y María de los Ángeles Alonso Romero (1995). "Una contribución al conocimiento de los sauces en México". En Ciencia Forestal en México, Vol. 20, Num. 77. México.

2. Treated wastewater supply to the Lacustrine Zone of Xochimilco and Tláhuac

a. Background
b. Treated wastewater supply to the Lacustrine Zone of Xochimilco and Tláhuac from eight wastewater treatment plants (WWTP.)
c. Hydrological Balance of Treated Wastewater supplied by eight WWTP to the lacustrine zone of Xochimilco and Tláhuac
d. Quality of Treated Wastewater.
e. Water Action Plan

a. Background

The supply of treated water to the area of Xochimilco and Tláhuac comes mainly from the treatment plant of Cerro de la Estrella, which has supplied 87 percent of the volume required for the operation of the *chinampería* system from the first half of the past century, beginning its operations in the year 1971. Additionally, the system receives additional supplies from seven local treatment plants (13 per cent); the treated water volumes are jointly supplied to the lacustrine area in blocks (in total volumes) from the aforementioned of this eight sources, and together, these sources of water have made the permanent and continuous operation of the lacustrine area possible for half a century, enabling agricultural production of the chinampa system of Mexico City.

For almost 60 years, SACMEX has operated *the* treatment plants that supply water to the area of Xochimilco and Tláhuac, based on a Plan of Action and specific policies designed to ensure the water supply, which includes an annual budget for its implementation. In addition, this agency has specialized staff at the professional level and operational level.

SACMEX has developed and implements the program for institutional action that incorporates as one of its four lines of action the treatment and reuse of wastewater. This Program of Action, which is known as the *Sustainability*

and Integral Management of Water Services Program, is also identified as *"Water for the Future CDMX Plan".* It represents the official guiding instrument for water policy in Mexico City and is based on the Water Law of the Federal District, LADF, published in May 2003.

Thus, the provision of water to the lacustrine area has been satisfied continuously, on an ongoing basis, for six decades through the provision of treated wastewater from these 8 treatment plants operated by SACMEX, and no reason is foreseen to discontinue this staffing.

Together with the Authority of the World Natural and Cultural Heritage Zone in Xochimilco, Tláhuac and Milpa Alta, as a coordination agency for the various institutions with interest in the area, SACMEX has a permanent commitment towards this Authority to continue supplying the needed volumes of treated wastewater in such a way as to ensure ancestral agricultural practices of food production in the chinampa system.

b. Treated wastewater supply to the Lacustrine Zone of Xochimilco and Tláhuac from eight wastewater treatment plants (WWTP.)

The provision of treated wastewater to the Xochimilco system began nearly 60 years ago in 1958, with the construction and commissioning of the first Wastewater Treatment Plant called "Xochimilco", currently "Coyoacan". Initially, a certain percentage of treated wastewater was provided to supplement the water volumes required; however, the supply of water from different springs and water outcrops started gradually declining as they got diverted for human consumption. This situation created a need to increase the treatment of wastewater to meet the needs of the lacustrine zone.

Thus, in the year 1971, the WWTP "Cerro de la Estrella" came into operation, providing treated wastewater to the area of Xochimilco and Tláhuac through a network of conveyance pipelines of varying diameters that leads to weirs distributed at strategic points throughout the lacustrine area.

Originally this plant was designed with a treatment capacity of 4000 liters per second (lps), using the conventional biological treatment process with activated sludge, and it operated for 37 years. In the period 2007 – 2009, the plant was upgraded to treat a flow of 3000 lps, and reconditioned with a system for nutrient removal (Nitrogen and Phosphate.)

In 1989, the WWTP "San Luis Tlaxialtemalco" came into operation as part of the sanitation works for the area of Xochimilco. The facility receives wastewater from the towns of Santa María Nativitas, Santa Cruz Acalpixca, San Gregorio Atlapulco and San Luis Tlaxialtemalco, all localities that had previously discharged their wastewater into the canals. The commissioning of this plant provided an additional source of treated water for the area of Xochimilco.
Respectively in 1993 and 1994 were built and began operating in Tláhuac municipality the WWTP "San Nicolás Tetelco" and "La Lupita", respectively in 1993 and 1994; these plants receive waste affluent from the towns in which they are located and discharge their treated effluents into the canals of the production area of San Nicolás Tetelco and San Juan Ixtayopan.

In 1997, the WWTP "San Andrés Mixquic" was built and began operations in Tláhuac. Its treatment process initially entailed an advanced primary level, but at the request of agricultural producers, water treatment in 2009 reached the tertiary level. Also in Tláhuac, in 1997, the WWTP "San Pedro Atocpan" was built and put into operation.

In addition, the "San Lorenzo" WWTP was built in 1998 in Tláhuac and its effluents are used in both in the lacustrine zone of San Gregorio Atlapulco and in Xochimilco.

In the year 2000, agricultural producers of San Juan Ixtayopan in Tláhuac benefited with the commissioning of the WWTP "El Llano".

For six decades, the lacustrine area of Xochimilco and Tláhuac has been supplied continuously with treated wastewater, provided by the Government of the City of Mexico through an entity set up specifically to safeguard water resources. It has been in operation since 1933, with subsequent modifications over the following decades in response to new demands posed for the administration of water.

Currently, and since 2003, SACMEX (acronym in Spanish for Mexico City Water System), is the responsible operative agency. Its regulatory framework, also published in 2003 under the Water Law of the (then) Federal District, underpins the Program on Sustainability and Integrated Water Services Management (PSGISH, for its initials in Spanish), commonly referred to as the "Water Plan for the Future CDMX". This is the lead instrument on water policy for the City of Mexico, instrumented by SACMEX.

Water Treatment Plants for Wastewater (8 WWTP)

No.	WWTP	Design Flow (lps)	Comments
1	**Cerro de la Estrella**	**4000** **3000**	Built in 1971 Restored in 2007-2009
2	San Luis Tlaxialtemalco	150	Built in 1989
3	San Nicolás Tetelco	15	Built in 1993
4	La Lupita	15	Built in 1994
5	San Andrés Mixquic	30	Built in 1997
6	San Pedro Atocpan	60	Built in 1997 Restored in 2015
7	San Lorenzo	225	Built in 1998
8	El Llano	250	Built in 2000 Restored in 2012
	Total	**3745**	The first WWTP was built 60 years ago Cerro de la Estrella WWTP starts operations 46 years ago

c. Hydrological Balance of Treated Wastewater supplied by eight WWTP to the Lacustrine Area of Xochimilco and Tláhuac

Total flow design for the eight treatment plants in the area is 3745 liters per second. Of this potential capacity, 2488 lps are processed, thus opening up the possibility of treating an additional 1257 lps. (3745 lps - 2488 lps=1257 lps.)

The current output or flow provided to the lacustrine area of Xochimilco and Tláhuac is 2312 lps, an amount that covers the present demand, with a surplus of 176 lps (2488 lps -2312 lps =176 lps).

The largest volume of treated wastewater emanates from the Cerro de la Estrella WWTP (2150 lps). Additionally, the lacustrine area of Xochimilco and Tláhuac receives treated water from seven local plants with a design flow of 745 lps that are all fed into the lacustrine area.

Therefore, 3745 lps is the total potential available treated-water volume (obtained from adding the Cerro de la Estrella WWTP production of 3000 lps plus 745 lps provided by seven local plants). This amount represents a surplus of 1257 lps in relation to the 2488 lps that are treated, (3745 lps - 2488 lps=1257 lps) and of 176 lps in relation to those required for current operations (2488 -2312 lps=176 lps).

In brief, there is a positive hydric balance concerning the volume of treated water contributed by the eight treatment plants that provide water to the area of Xochimilco and Tláhuac. The water volume that enters into the existing treatment plant system and then leaves to feed the lacustrine area is in equilibrium, leaving an additional surplus volume in reserve with potential of treatment.

These data serve to guarantee the sustainability of water supplies in coming years, as the available volume of treated wastewater will satisfy the demand required by the lacustrine area. On the one hand, the demand created by the operational expenditure of the lacustrine zone is covered with the present flow rate. On the other hand, a significant treatment capacity is kept in reserve related to the plant's design flow rate (capable of treating large volumes of wastewater), as the attached water balance shows. In relation to the inputs of wastewater for treatment, the City of Mexico currently only uses 15 per cent of the wastewater generated, creating a wide offer for reuse.

Hydric Balance for treated wastewater in the lacustrine zone of Xochimilco and Tláhuac

No.	WWTP	Installed Capacity (lps)	Flow Treated (Ft) (lps)	Flow Available (Fa) for Treatment (in lps) (Fa-Ft)	Flow Provided (in lps)
1	**Cerro de la Estrella**	**3000**	**2150***	**850**	**2000**
2	San Luis Tlaxialtemalco	150	65	85	60
3	San Nicolas Tetelco	15	10	5	9
4	La Lupita	15	14	1	13
5	San Andres Mixquic	30	25	5	23
6	San Pedro Atocpan	60	19	41	17
7	San Lorenzo	225	75	150	70
8	El Llano	250	130	120	120
	Total	**3745**	**2488**	**1257**	**2312***

- The Treatment Plant Cerro de la Estrella produces a volume of treated water *of* 2350 lps, of which 9 per cent (200 lps) is destined for use by industry and the green areas of the Delegation Iztapalapa; the remaining 91 per cent, i.e. **2150 lps,** is sent to the lacustrine area of Xochimilco and Tláhuac; 47 per cent of this volume, 1110 lps, goes to Tláhuac and 44 per cent, 1040 lps, is sent to Xochimilco. (See Table Cerro Estrella WWTP expenditure distribution.)
- The water-flow reported for the eight Treatment Plants represents an average estimate.

Summary Balance of Treated Wastewater
Lacustrine Zone Xochimilco and Tláhuac

No.	WWTP	Installed Capacity (Fa) (lps)	Treated Flow (Ft) (lps)	Surplus Flow (lps) (Fa-Ft)	Flow Provided (lps)
1	**Cerro de la Estrella**	**3000**	**2150**	**850**	**2000**
2	Total contribution 7 Local Plants	745	338	407	312
	Total	**3745**	**2488**	**1257**	**2312**

Water demand of the chinampa zone in Xochimilco and Tláhuac is 2.312 lps. Compared to the current provision of 2.488 lps, produced by the 8 treatment plants, only 93 per cent of the water flow of treated water available in the area is being used, leaving a surplus flow of 7 per cent (176 lps). Of the treated water provided, the Treatment Plant of Cerro de la Estrella supplies 87 per cent, i.e., 2000 lps.) The remaining seven local plants jointly contribute the remaining 13 per cent *(*312 lps).

With regard to the installed capacity of the eight treatment plants, they were designed to produce a total flow of 3745 lps, but only 2488 lps are treated at present, leaving a surplus of untreated water of 1257 lps. The installed capacity of the Cerro de la Estrella WWTP represents 80 per cent or 3000 lps of the systems joint treatment capacity; the remaining 20 per cent, 745 lps, is divided among the seven local plants.

The Treatment Plant Cerro de la Estrella provides the lacustrine area of Xochimilco and Tláhuac with 87 per cent of the treated wastewater volume it requires. The seven local treatment plants provide the remaining 13 per cent. The group of eight plants supplying treated water to the lake area are currently operating below treatment capacity, i.e., 57 per cent, and would thus be able to provide an additional 43 per cent of their installed capacity (flow potential).

This means a reserve or water surplus of 1257 lps exists that could still be treated and made available for incorporation into the lacustrine area. The flow treated at present satisfies current spending requirements for the lacustrine area of Xochimilco and Tláhuac, with a 7 per cent surplus (2488 lps - 2312 lps) = 176 lps.)

It should be noted that, in addition, the lacustrine area receives storm-water contributions during the rainy season, from June to August, a period during which the isohyets (rainfall spatial distribution graphs) for the area of Xochimilco and Tláhuac show an annual average rainfall of between 900 and 1000 mm, a volume of water that is directly incorporated into the lacustrine system.

Taking advantage of these high rainfall volumes, SACMEX is implementing a program in the municipalities of Xochimilco and Tláhuac known as "Water Harvest". It consists of building rainwater infiltration wells for the purpose of inducing the recharge of rainwater in the hilly areas of these municipalities, where the majority of surface runoff and geological formations that enable water infiltration to the subsoil are concentrated. These wells help to improve the availability of water in the area and help reduce the overexploitation of the aquifer.

d. Quality of Treated Wastewater

Wastewater is treated in the Cerro de la Estrella plant to tertiary level, using a modified biological process with activated sludge, sand and gravel filtration, and chlorine disinfection.

These volumes of treated wastewater comply with the quality requirements established by the Official Mexican Standard NOM-003-SEMARNAT-1997, which determines the maximum permissible levels of contaminants in treated wastewater for public service reuse. The Standard defines treated water as those effluents that have been made suitable for public reuse and specific purposes by means of individual or combined physical, chemical, biological, or other types of treatment processes.

The official standard in question has two sections:

1. The first section establishes parameters for reuse in services where people enter in direct contact with treated water (activities where the public is exposed directly to or enters into physical contact with treated water, such as: resourcing of lakes and artificial recreational canals for boat tours, rowing, canoeing and water-skiing; decorative fountains, car washing, irrigation of public parks and gardens. The lacustrine area of Xochimilco and Tláhuac falls into this classification.
2. The second section applies to water for reuse in services to the public with indirect or occasional contact (earmarked for activities where the general

public is exposed indirectly or by incidental physical contact and restricted access, either by physical barriers or surveillance personnel. The following applications are considered: irrigation of gardens and medians on motorways; medians along city avenues; ornamental fountains, golf courses, water supply for fire hydrants, non-recreational artificial lakes, hydaulic safety barriers, and cemeteries.

TREATMENT PLANTS THAT CONTRIBUTE TO THE ZONES OF XOCHIMILCO AND TLÁHUAC			
WWTP	**TREATMENT PROCESS**	**DESIGN FLOW DISCHARGE (lps)**	**OPERATING DISCHARGE Treated Flow (lps)**
1. CERRO DE LA ESTRELLA	Tertiary w/ filtration and chlorine disinfection	3000	2350* 2150*
2. SAN LUIS TLAXIALTEMALCO	Tertiary w/ filtration and chlorine disinfection	150	65
3. TETELCO	Secondary Activated sludge w/ sludge treatment	15	10
4. LA LUPITA	Secondary Activated sludge w/ sludge treatment	15	14
5. MIXQUIC	Tertiary w/ filtration and chlorine disinfection	30	25
6. SAN PEDRO ATOCPAN	Tertiary w/ filtration and chlorine disinfection	60	19
7. SAN LORENZO	Tertiary w/ filtration and chlorine disinfection	225	75
8. EL LLANO	Tertiary w/ filtration and chlorine disinfection	250	130
Total		**3745**	**2688* 2488**

Minus 200 lps of the operating expenses destined *to* the Iztapalapa Delegation (See Table Cerro de la Estrella WWTP Expenditure Distribution

The type of water treatment facilities managed by SACMEX is based on the removal of organic matter using an activated sludge process or any of its modifications.

An operations prototype schema for a WWTP operated by SACMEX in the area of Xochimilco and Tláhuac, is structured as follows:

- **Receiving canal**: The site receives, quantifies and distributes the wastewater to be treated; residual water inflow quality is measured here.
- **Primary sedimentation tank**: These containers allow for the separation of solids or suspended particles from wastewater. As the specific weight of these materials is greater than that of water, separation takes place by gravity and the low rates of flow in these tanks. This Unitary Operation is expected to remove up to 30 per cent of residual water contaminants.
- **Anoxic cells or Bio-selectors**: Once the residual water has proceeded through primary sedimentation, it is poured into bio-selectors, i.e., tanks where it is combined with a mixed culture of micro-organisms derived from re-circulated sludge; mixing is performed by hyperboloid agitators that put microorganisms in contact with water in the primary sedimenter. The anoxic tanks promote the formation of microorganism colonies with good sedimentation characteristics, while also eliminating nitrogen and phosphorus.
- **Biological reactors or Aerators**: The mixture of residual water and microorganisms goes into a biological reactor tank where, by means of pressurized air injection to the bottom part, metered through membrane diffusers, the diffusion of oxygen from the air into the interior of the colonies of microorganisms is promoted, and agitation keeps these colonies in a flocculent suspension. In this tank, the mixture receives the name "mixed liquor" and the colony of microorganisms is called an "activated sludge". The mixed liquor of this tank is poured into a clarifier or secondary sedimentation tank.
- **Secondary Sedimentation Tank**: The colonies of microorganisms have a specific weight higher than that of water, therefore the effect of gravity separates these colonies. As the attraction forces between particles are sufficient to hinder their separation or sedimentation, particles tend to stay in relatively fixed positions, developing a solid-liquid interface. For this reason, this type of tank is larger than the primary settler tanks. The water from the top of these tanks is poured out and is now considered as secondary level treated wastewater. At this point, it complies with current legislation; however, it will be subject to a further phase of treatment.

The Aerator-Secondary Sedimentation tank (reactor-separator), removes approximately 65 per cent of the wastewater pollutants, measured as BOD.

- **Sand Filters**: Water derived from secondary settlement tanks is passed through a filtration area. Filters are of the atmospheric type, slow, with a downward flow, and sand is used as the primary means of solid retention. Filter operation consists of two stages: filtration and backwash. During filtration, particulate matter that can color or cause odor in treated water is removed.
- **Disinfection**: Water that has been through the filtration process is then passed to the chlorine application unit where the selective destruction of disease causing microorganisms is carried out. Although microorganisms were preferentially separated in the secondary sedimenter or recovered in the filters, some remain after these operations and it becomes necessary to rid the treated wastewater of them.
- **Pumping**: Finally, the treated and disinfected water is passed to a pumping sump where, by means of pumps and pipelines, it is sent to different treated wastewater users.

According to water quality reports derived from laboratory tests, and prepared at the WWTP, pollutant removal is greater than 90 per cent and fully complies with the Official Mexican Standard NOM-003-SEMARNAT, which "establishes the maximum permissible levels of contaminants for treated wastewater to be re-used for Public Services".

Application of Norm 003

The implementation of the Official Mexican Standard NOM-003-SEMARNAT-1997, which establishes maximum permissible levels of contaminants in treated wastewater for reuse by the public, is intended to protect the health of the population and preserve the environment, and is mandatory for public entities responsible for the treatment and reuse of wastewater.

To ensure water quality control, SACMEX operates the Central Laboratory for Quality Control of Water, built in 1982. The laboratory has the facilities and specialized equipment needed to analyze the physical, chemical and biological parameters that define the quality of drinking water, waste water and treated wastewater. The laboratory analyzes 50 thousand samples annually, evaluating more than 70 parameters of physical, chemical and bacteriological nature.

The WWTPs managed by SACMEX comply with water quality criteria established for direct contact, as shown in the following table:

PLANTAS DE TRATAMIENTO	DBO (mg/l)		SST (mg/l)		COOLIFORMES FECALES (col/100 ml)		G Y A (gr/ml)		HUEVO DE HELMINTO
	INF.	EFL	INF	EFL	INF	EFL	INF	EFL	EFL
CERRO DE LA ESTRELLA	50	5	100	< 15	2.20 E+07	1.10 E+02	21.3	< 5	< E 1
SAN LUIS TLAXIALTEMALCO	99	3	43	< 15	4.20 E+07	1.70 E+02	10	< 5	< E 1
SAN PEDRO ATOCPAN	272	1	92	< 15	4.10 E+07	3.00 E+01	< 5	< 5	< E 1
SAN LORENZO	60	7	38	< 15	1.30 E+02	1.40 E+02	< 5	< 5	< E 1
MIXQUIC	158	13	70	< 15	3.00 E07	3.40 E+01	< 5	< 5	< E 1
TETELCO	125	3	167	< 15	5.90 E+07	2.80 E+02	25	< 5	<E 1
LA LUPITA	173	4	185	< 15	2.7 E+07	1.10 E+02	99.2	< 5	< E 1
EL LLANO	518	13	105	< 15	2.50 E+08	5.00 E+01	85.5	< 5	< E 1

These values can be compared with reference values shown for maximum permissible levels of contaminants (in treated wastewater) of the Official Mexican Norm NOM-SEMARNAT 003 – 1997.

Type of reuse	Monthly average				
	Fecal Coliform NMP/100 ml	Helminth eggs (h/l)	Fats and Oils mg/l	BOD5 mg/l	TSS mg/l
Services to the public with direct contact	240	≤ 1	15	20	20
Services to the public with indirect or occasional contact	1.000	≤ 5	15	30	30

Official Mexican Norm NOM-003-SEMARNAT-1997
Maximum admissible contaminant levels

The values reported for the WWTP effluent, show that:

1. Values for fecal coliforms indicate that treated water presents good disinfection quality and will not generate microbiological contamination problems in the canals of Xochimilco; visitors and workers can use the treated wastewater without any health problems.

2. Helminth eggs are used as an indicator to measure for parasite cysts and eggs that may be present in the wastewater and represent a health treat to humans, plants or animals. The values found in the treated water discharged into the canals fall within standard code.

3. Grease and oils in treated water discharged into the canals are present in concentrations that do not create a problem for species inhabiting different depths in the canals during the exchange or transfer of oxygen and other nutrients.

4. The presence of organic matter, determined by BOD, was removed to values below norm specification; and therefore, Dissolved Oxygen DO in the water body will not decline as a result of it being consumed during organic matter degradation by microorganism activity. This promotes aerobic conditions, without unpleasant odor problems, that contribute to the preservation of aquatic life. The content of organic matter, as established BOD, constitutes an important parameter for treated wastewater.

5. Likewise, Total Suspended Solids show acceptable concentrations in compliance with the standard.

   The aforementioned data establish that treated wastewater delivered by the WWTPs administered by SACMEX is of an excellent quality for the maintenance and conservation of the lacustrine area of Xochimilco and Tláhuac, complying with parameters established by the Official Mexican Standard.

Nutrients in treated wastewater

Levels of Dissolved Oxygen (DO) in water are affected by the growth of algae (phytoplankton) and weeds (macrophytes) that proliferate in media with nutrient availability (nitrogen and phosphorus), sunlight and a liquid environment. Higher nutrient concentrations result in higher levels of algae and weed production. If this growth is not controlled, the proliferation of algae and weeds can have serious effects on DO concentrations.

Under moderate nutrient presence, photosynthesis and respiration tend to balance out, so that the overall impact is lessened.

Because the activated sludge process used to purify wastewater at the WWTP "Cerro de la Estrella" only oxidized organic matter, without nutrient removal, in 2009 this process was modified with another that would reduce

nitrogen and phosphorus concentrations to levels that would allow to control the excessive growth of weeds and algae. This is a real problem in the canals, as vegetation hinders navigation and the use of water. The presence of nutrients is reduced through nitrification and denitrification processes. However, nutrients are not removed in their entirety, since it only reduces its presence in the treated water that is discharged to the channels.

Water quality data for the WWTP "Cerro de la Estrella" during the last quarter of 2016 are shown below (the data for this WWTP were chosen as the plant provides the largest volume of treated wastewater to the target area):

No.	Parameter	mg/L		
		In-flow	Out-flow	Standard or Criterion
1	Ammoniacal nitrogen	20	1.5	5*
2	Nitrate nitrogen	0,113	2.16	4*
3	Total phosphates	5.50	5.65	30*

Source: * SACM criterium ,1999

1. There is a significant reduction in the concentration of Ammoniacal Nitrogen. Ammoniacal Nitrogen and Organic Nitrogen are converted at the WWTP by oxidation into nitrates.
2. Note the presence in the effluent of Nitrates Nitrogen (an oxidized from of nitrogen).
3. The outflow of the WWTP shows a slight increase in the concentration of phosphates.

The above table also indicates that nutrients are not removed in their entirety, leaving a residual fraction for agricultural activities in the area and taking into account that water is not the only the source of nutrients. According to the *Guide for the efficient management of plant nutrition* (FAO, 1999,) they may also be taken from soil reserves, organic sources, atmospheric nitrogen deposition, wind and rain.

There is a slight increase in the concentration *of* phosphate in the plant's outflow. It should be borne in mind that the decline in the availability of

one of the nutrients acts as a limiting factor to algae and weed development, which is favorable to canal conservation objectives; in turn, the residual concentration of these nutrients favors agricultural practices (there is no need to supply additional nutrients through chemical fertilizers).

It is worth noting that during the eight years that the wastewater treatment system has been operating with an anoxic bio-selector, the input of nutrients to the lacustrine area has not been affected and the high productivity of the *chinampería* soils having been preserved.

e. Water Action Plan

In agreement with the Water Law of the Federal District, (2003), the guiding instrument of Mexico City's water policy is the Program known as the **Sustainability and Management of Water Services Program** (the PSGSH, for its initials in Spanish) and also called **"Plan CDMX Water for the Future".** It was recently updated in October 2016.

The PSGSH extends over a 10-year horizon, covering the period from 2015 to 2024. It aims to ensure the provision of drinking water, drainage and sewage systems for the inhabitants of the City of Mexico, and also to promote the treatment and reuse of wastewater in sufficient quantity and good quality through an efficient use of operational resources allocated to Mexico City's water system.

SUSTAINABILITY AND MANAGEMENT OF WATER SERVICES PROGRAM			
A. PROVISION OF WATER SERVIC	**B. INTEGRATED WATER RESOURCES MANAGEMENT**	**C. INFRASTRUCTURE CONSTRUCTION AND MAINTENANCE**	**D. INSTITUTIONAL STRENGTHENIN G**
A1 Customer attention and commercial optimization 1. Customer service and technical suppot 2. Social communications and institutional benchmarking	**B1 Strategies for sustainable use of water** 1. Promote a water culture 2. Project development for aquifer preservation	**C1 Infrastructure construction** 1. Drinking water system 2. Drainage system 3. Treatment and reuse system 4. Environment	**D1 Administration finances and legal services** 1.Human resources training 2. Material resources administration 3. Financial system strengthening 4. Investment

3. Comercial system strengthening 4. Water management in block			programing
A2 Hydraulic system operation 1. Service provision 2. Analysis systems upgrading and supervisory control 3. Continuing sectorization for water control 4. Water quality surveilance 5. Attention to hydraulic emergencies	**B2 Environmental management of water resources** 1. Conservation of ecological balance for the valley of Mexico 2. Rainfall harvest	**C2 infrastructure maintenance** 1. Drinking water system 2. Drainage system 3. Treatment and reuse system 4. Environment 5. Maintenance of hidric system supplementary infrastructure	**D2 Organization and quality certification** 1. Process administration and quality certification 2. Information system upgrading

The Sustainability and Management of Water Services Program, is structured on the basis of four strategic axis:

A. Provision of water services
B. Integrated water resources management
C. Infrastructure construction and maintenance
D. Institutional strengthening

The total budget for Water Service Sustainability and Management is 157 thousand 438 million pesos for the period 2015-2024, scheduled on a yearly basis (PSGSH, SACMEX, 2016.) It should be noted that this budget represents a projection of investment for a ten-year programmatic timeframe, with an annual authorization, which is incorporated into SACMEX Annual Operating Budget of (the POA, for its initials in Spanish,) with appropriate adjustments once authorized for the year in question.

Sustainability Program and Management of Water Services Budget

A. HIDRAULIC SERVICE PROVISION	B. INTEGRATED WATER RESOURCE MANAGEMENT				C. CONSTRUCTION AND INFRASTRUCTURE MAINTENENCE				D. INSTITUTIONAL STRENGTHENING		
	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	TOTAL
A.. HIDRAULIC SERVICE PROVISION	7,540	7,643	7,661	7,714	8,494	8,447	8,513	8,468	8,477	8,530	81,485
A.1 Customer attention and commercial optimization	3,283	3,327	3,322	3,353	4,186	4,133	4,121	4,150	4,156	4,201	38,234
A.2 Hydraulic system operation	4,257	4,315	4,338	4,361	4,308	4,314	4,392	4,318	4,320	4,328	43,251
B. INTEGRATED WATER RESOURCE MANAGEMENT	640	452	467	497	704	701	707	755	887	1,008	6,819
B.1 Strategies for sustainable use of water	376	184	189	221	427	427	429	487	618	733	4,090
B.2 Environmental management of water resources	264	268	278	277	277	274	278	268	269	275	2,729
C. CONSTRUCTION AND INFRASTRUCTURE MAINTENENCE	2,740	5,023	6,215	5,929	4,713	4,894	3,650	3,434	3,788	4,150	44,534
C.1 Infrastructure construction	983	2,908	3,451	3,371	2,391	2,304	1,272	1,232	1,364	1,620	20,898
C.2 Infrastructure maintenance	1,756	2,114	2,764	2,558	2,322	2,590	2,377	2,201	2,424	2,531	23,636
D. INSTITUTIONAL STRENGTHENING	663	891	1,423	2,031	2,605	3,144	3,500	3,423	3,460	3,471	24,610
D.1 Administration, finances and legal services	643	871	1,403	2,011	2,565	3,104	3,460	3,371	3,380	3,391	24,198
D.2 Organization and quality certification	20	20	20	20	40	40	40	52	80	80	412
*Numbers may not add due to rounding											

The **Axis C** on **Infrastructure Construction and Maintenance** attends two lines of action:

1. Infrastructure Construction
2. Infrastructure Maintenance

For the period 2015-2024, the total operation budget for **Axis C. Construction and Maintenance of Infrastructure** amounted to 44 thousand 534 million Mexican pesos (MXP), distributed into 20 thousand 898 million MXP for Infrastructure Construction and 23 thousand 636 million MXP for Infrastructure Maintenance.

Line 2. Infrastructure Maintenance incorporates the **Treatment and Wastewater Reuse System,** with aims to to ensure the use of treated water for applications that do not require drinking quality. The system is in charge of treatment plant operation in Mexico City, including the eight WWTP that provide treated wastewater to the lacustrine area of Xochimilco and Tláhuac, thus enabling the agricultural production in the chinampas system .

	C.1 INFRASTRUCTURE CONSTRUCTION	C.2 INFRASTRUCTURE MAINTENANCE
OBJECTIVE	Expand infrastructure coverage, with cost reduction and increased quality of said infrastructure.	Maintain infrastructure in optimal operation conditions, seeking to reduce the risk of failure in the hidraulic systems.
LINES FOR ACTION	C.1.1 Drinking water system C.1.2 Sewer (drainage) system C.1.3 Treatment and reuse system C.1.4 Environment	C.2.1 Drinking water system C.2.2 Sewer (drainage) system C.2.3 Treatment and reuse system C.2.4 Environment C.2.5 Hidraulic system supplementary infrastructure maintenance

Axis C. Infrastructure Construction and Maintenance

C.2 Infrastructure Maintenance

C.2.3 Treatment and reuse system

The city's wastewater treatment and reuse system will be strengthened.

One of the goals of the PSGSH is to increase wastewater treatment capacity to augment the volume of available treated water and promote the replacement of first time use water for treated water.

The total budget allocated in the Sustainability and Management of Water Services Program for the period 2015-2024 for the Water Treatment and

Reuse system is *circa* three thousand million Mexican pesos (2, 997 million MXP).

Treatment and Reuse	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	TOTAL
TRATAMIENTO Y REÚSO	97	293	310	324	256	265	252	281	401	517	2,997

Of the total assignment to Axis C, as shown in the attached table, the **System for Treatment and Reuse of Wastewater for the City of Mexico** includes 4 specific lines of action:

- **Optimize wastewater capacity**
- **Ensure use of treated water for uses that do not require drinking quality**
- Treatment of metropolitan wastewater
- Recharge the aquifer with treated wastewater

Described in the first two specific lines of action "**Optimize sewage treatment capacity of the city"** and "**Ensure the use of treated water in uses that do not require drinking-quality standards"**, are actions related to the operation of the eight treatment plants that supply treated wastewater to the lagoons and canals in the area of Xochimilco and Tláhuac, which in turn feed the *chinampería* zone. The total budget destined to comply with these two lines of action is one thousand 310 MXP, distributed as shown in the attached table.

Staff Assigned

SACMEX has more than 11.000 employees and professional staff; 78 per cent of staff serves in an operations capacity, 11 per cent is allocated to the technical area, and the rest is dedicated to administrative activities.

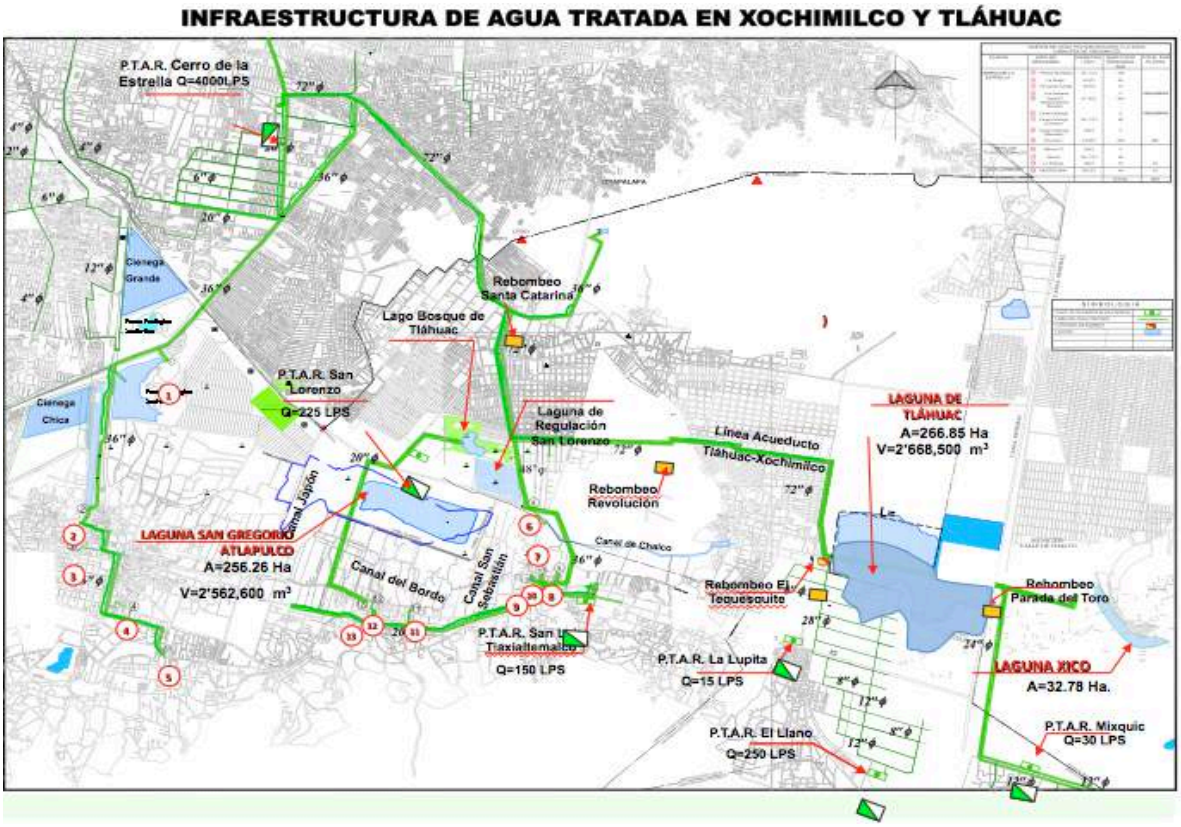
Its organizational structure incorporates a General Director, a General Administrative Director, 3 Executive Directorates, 16 Area Directorates, 41 Sub-Directorates, and 113 Departmental Units.

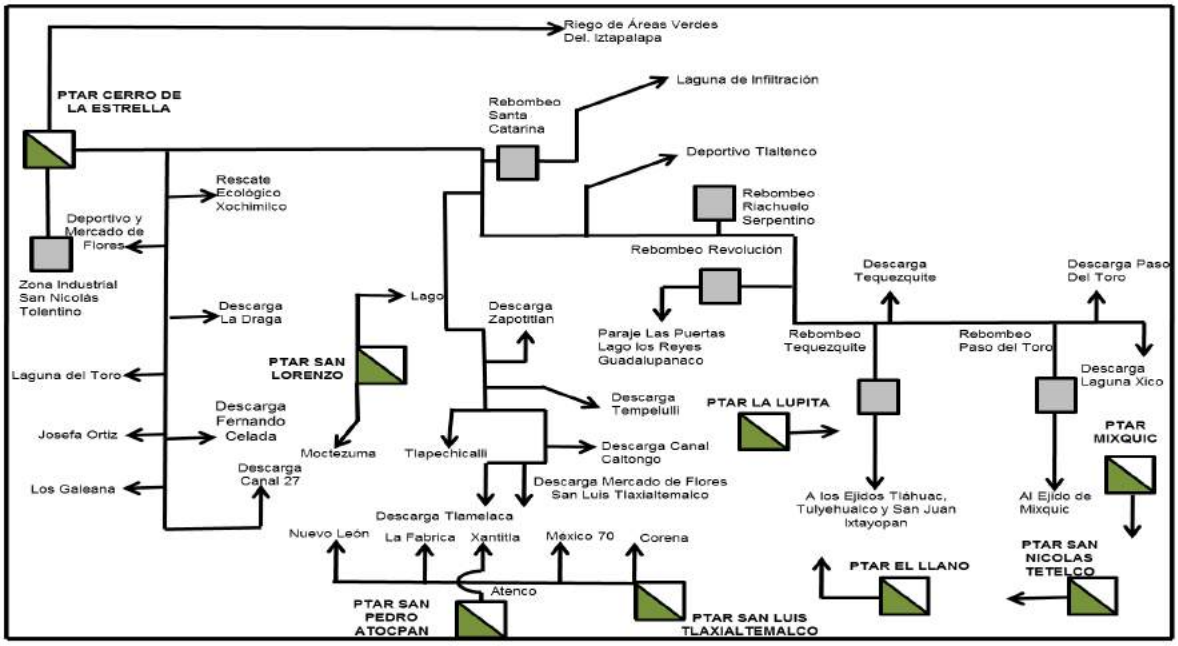
To operate the Treatment and Reuse of Wastewater program for the city of Mexico, which is run 365 days a year, 24 hours a day, SACMEX relies on a staff of 504 persons; 30 per cent are skilled professionals, including 150 engineers, in different specialties: hydrological, civil, chemical, mechanical and industrial engineers and hydro-biologists.

The remaining 70 per cent are technical and operational staff in charge of operations at the treatment plants, including maintenance and monitoring activities in three shifts, including holidays; laboratory technicians are in charge of sampling, analysis and interpretation of results from treated water processing and quality controls in the plants.

An engineer has been appointed as Head of Office in charge of coordinating activities at the WWTP Cerro de la Estrella. He manages a trained team, staffed by resident engineers, technicians and operators in charge of maintenance and operations, and specialized in distribution lines and leak repair. Additionally, there are shift supervisors, maintenance crews, administrative staff, laboratory staff and drivers. In all, nearly 100 people work at this plant.

Treated water Infrastructure in Xochimilco and Tláhuac





SPENDING DISTRIBUTION FOR DIFFERENT FLOW RATES PROVIDED BY THE WWTP CERRO DE LA ESTRELLA	
DISCHARGE SITE/DELEGATION (**Municipality**)	CURRENT SPENDING **2350 lps**
IZTAPALAPA DELEGATION	
SAN NICOLAS TOLENTINO INDUSTRIAL ZONE	150
IRRIGATION OF GREEN AREAS AND AVAILABILITY FOR OTHER USERS	50
SUBTOTAL	**200 (9 per cent)**
TLÁHUAC DELEGATION (Municipality)	
RE-PUMPING STATION SANTA CATARINA	50
PARAJE TEMPILULLI	50
EJIDO ZAPOTITLAN	20
RE-PUMPING STATION REVOLUCIÓN	50
RE-PUMPING STATION RIACHUELO SERPENTINO	0
RE-PUMPING STATION TEQUEZQUITE	330
TEQUEZQUITE DISCHARGE (SAN PEDRO TLAHUAC)	20
RE-PUMPING STATION PASO DEL TORO	480
PASO DEL TORO DISCHARGE	10
LAGUNA XICO	100
SUBTOTAL	**1110 (47 per cent)**
XOCHIMILCO DELEGATION (Municipality)	
ECOLOGICAL RESCUE FOR XOCHIMILCO	150
RE-PUMPING STATION CUEMANCO	50
LA DRAGA DISCHARGE	50
FERNANDO CELADA DOCK DISCHARGE	60
CANAL 27 DOCK DISCHARGE	300
CALTONGO CANAL DISCHARGE	200
SAN LUIS TLAXIALTEMALCO MARKET DISCHARGE	30
TLAMELACA DOCK DISCHARGE	200
SUBTOTAL	**1040 (44 per cent)**

The Treatment Plant Cerro de la Estrella produces a flow of treated water of 2350 lps, of which 9 per cent (200 lps) is used for industry and green areas, and the remaining 91 per cent is sent to the lacustrine area of Xochimilco and Tláhuac, i.e. **2150 lps**. Of this volume, 47 per cent (1110 lps) go to Tláhuac and 44 per cent (1040 lps) to Xochimilco.

CDMX
CIUDAD DE MÉXICO

"Año del Centenario de la Promulgación de la Constitución Política de los Estados Unidos Mexicanos"

Ciudad de México, viernes, 19 de mayo de 2017

Oficio Número: GCDMX-SEDEMA-SACMEX-DG-DEPC-DT-SP-UDPPT-**1030252/2017**
Asunto: **ABASTECIMIENTO DE AGUA RESIDUAL TRATADA A LA ZONA LACUSTRE**

C. ERASTO ENSASTIGA SANTIAGO
COORDINADOR GENERAL DE LA AUTORIDAD
DE LA ZONA PATRIMONIO MUNDIAL NATURAL Y CULTURAL
DE LA HUMANIDAD EN XOCHIMILCO, TLÁHUAC Y MILPA ALTA.
P R E S E N T E

En relación al abastecimiento de agua residual tratada, que este Órgano Desconcentrado realiza a la Zona Lacustre de Xochimilco, Tláhuac y Milpa Alta, hago de su conocimiento lo siguiente:

El Sistema de Agua de la Ciudad de México ha suministrado en forma permanente durante seis décadas la demanda de agua residual tratada para las unidades de riego y llenado de canales de la zona chinampera y lacustre del sur de la Ciudad de México, mediante la aportación de la planta de tratamiento denominada Cerro de la Estrella y 7 plantas adicionales localizadas en la zona lacustre que son propiedad del Gobierno de la Ciudad y operadas por este Órgano Desconcentrado.

Cabe señalar, que los volúmenes de agua tratada que se suministran en bloque de las diferentes fuentes en su conjunto, permiten cubrir en forma continua la demanda para satisfacer los diferentes usos requeridos, riego agrícola tecnificado, floricultura, fruticultura, conservación de niveles para la navegación en canales de zonas agrícolas y turísticas, haciendo posible la producción dentro del sistema chinampero de la Ciudad.

Por lo anterior, dada la relevancia a nivel internacional que representa la Zona Patrimonio Mundial Natural y Cultural de la Humanidad en Xochimilco, Tláhuac y Milpa Alta, así como para la Ciudad de México el abastecimiento para la zona lacustre señalada, continuará siendo suministrado en bloque por este Órgano Desconcentrado.

A T E N T A M E N T E
EL DIRECTOR GENERAL

ING. RAMÓN AGUIRRE DÍAZ

Copias:
Ing. Alejandro Martínez Pérez- Director Ejecutivo de Operación- SACMEX
Ing. Mauricio Jaime Hernández García- Director Técnico- SACMEX
Ing. Marco Antonio Reyes Zermeño- Subdirección de Proyectos- SACMEX
Ing. Arturo Alberto Morga Cruz-J.U.D. de Proyectos de Plantas de Tratamiento- SACMEX
Archivo de la Dirección General

GOBIERNO DEL DISTRITO FEDERAL
Autoridad de la Zona Patrimonio Mundial Natural y Cultural de la Humanidad en Xochimilco, Tláhuac y Milpa Alta
19 MAY 2017
RECIBIDO
Hora: 13:20 Recibió

SACMEX

Sistema de Aguas de la Ciudad de México
Dirección General
Dirección Ejecutiva de Planeación y Construcción
Dirección Técnica
Subdirección de Proyectos
Unidad Departamental de Proyectos de Plantas de Tratamiento

Nezahualcóyotl No.109, 3°. Piso,
Col. Centro, Deleg. Cuauhtémoc C.P. 6080
Tel. 5130 4444 Ext. 1319 y 1320

México City, May 19, 2017

C. ERASTO ENSASTIGA SANTIAGO
GENERAL COORDINATOR OF THE AUTHORITY
OF NATURAL AND CULTURAL WORLD HERITAGE ZONE IN XOCHIMILCO, TLÁHUAC AND MILPA ALTA.
PRESENT

With respect to the supply of treated wastewater that this Decentralized Entity (*órgano desconcentrado*) provides to the Lacustrine Zone of Xochimilco, Tlahuac and Milpa Alta, be advised of the following:

Mexico City's Water System (*Sistema de Aguas de la Ciudad de México*, SACMEX) has, for six decades, permanently provided the treated wastewater required for the irrigation and canal-filling units of southern Mexico City's chinampa and lacustrine zones. This has been carried out by contributing the *Cerro de la Estrella* treatment plant and seven additional local plants located in the lacustrine zone that are owned by the City Government and operated by this Decentralized Entity.

It should be noted that the treated water volumes are jointly supplied to the lacustrine area in blocks (in total volumes) from the aforementioned different sources, and that they allow for the continued fulfillment of the water demand to satisfy the zones' different needs: technified agricultural irrigation, floriculture, fruit cultivation, conservation of water-levels for navigation in agricultural and touristic canals, enabling production within the City's chinampa system.

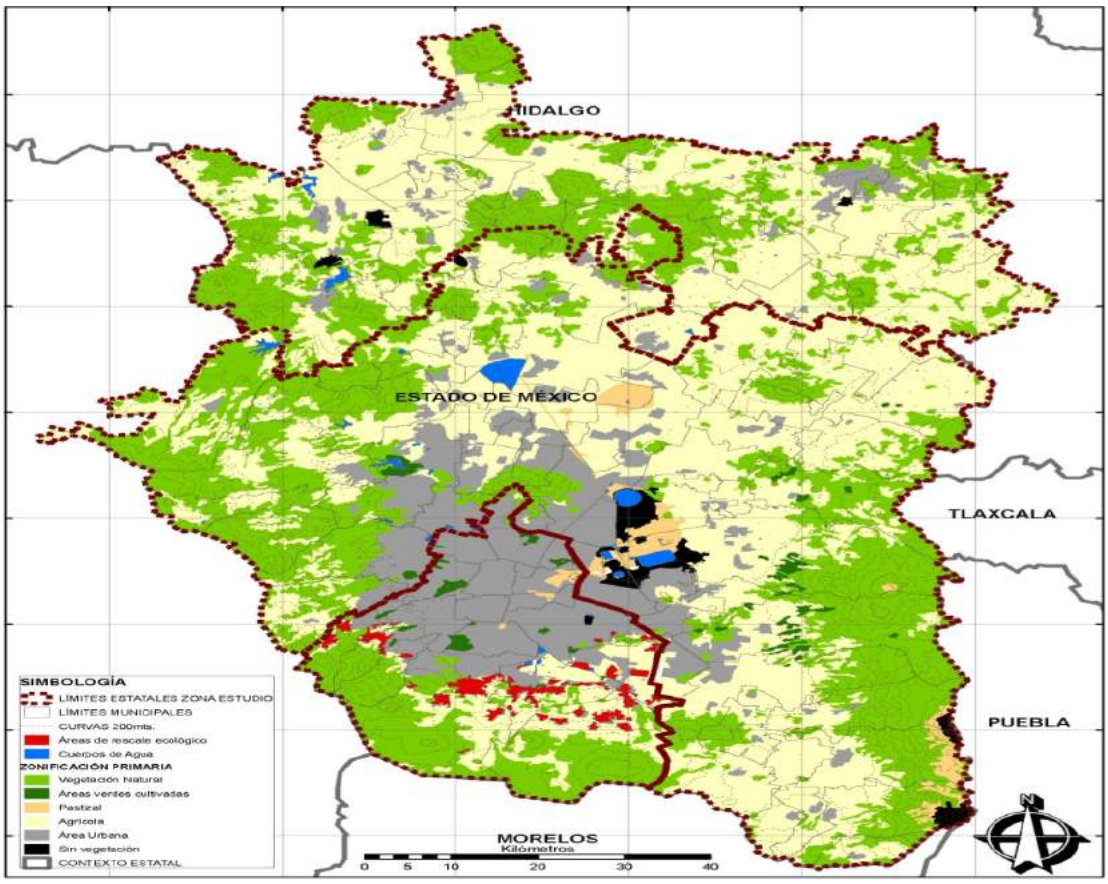
For these reasons, given the international relevance of the Natural and Cultural World Heritage Zone in Xochimilco, Tlahuac and Milpa Alta, and due to its importance for Mexico City, water-supply for the said lacustrine zone will continue to be provided in blocks by this Decentralized Entity.

General Director
Mexico City's Water System (SACMEX)
ING. RAMÓN AGUIRRE DÍAZ

ANNEX 1. MAP OF GEOGRAPHIC LOCATION OF MEXICO IN NORTH AMERICA

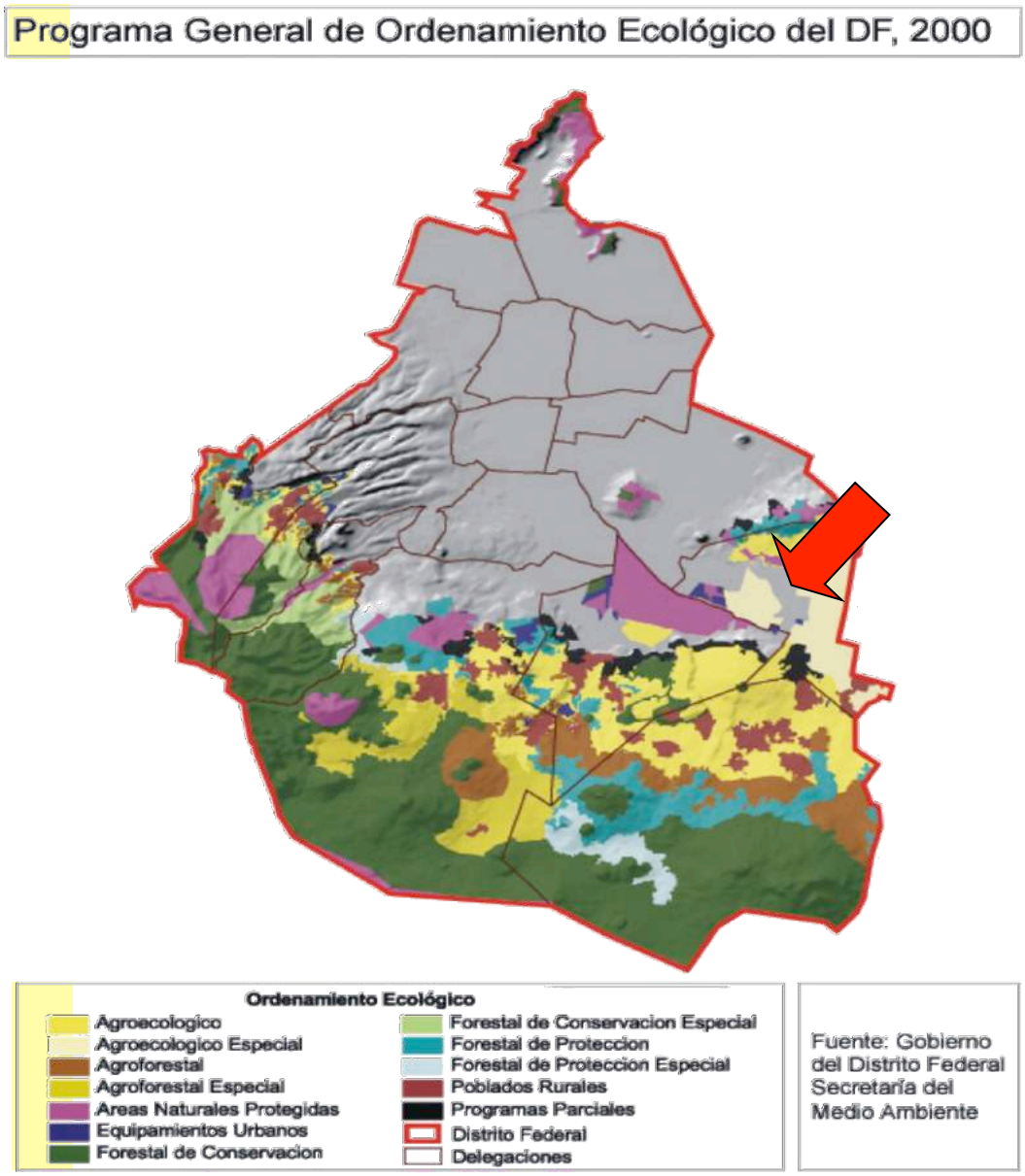
Mexico is located in North America, on the boundary with the United States and Guatemala and Belize. It has a surface of 2 millions km². It consists of 31 States or Provinces, most Federal District or city of Mexico(1 500 km²) , which is its capital. It has a population of 122 million people. Metropolitan area, i.e. Mexico City and adjoining States, concentrated 20 million, 8 million are located in its capital.

ANNEX 2. MAP OF METROPOLITAN AREA OF MEXICO CITY AND NEIGHBORING STATES.



Valley of Mexico Bassin with the 5 originating Lakes

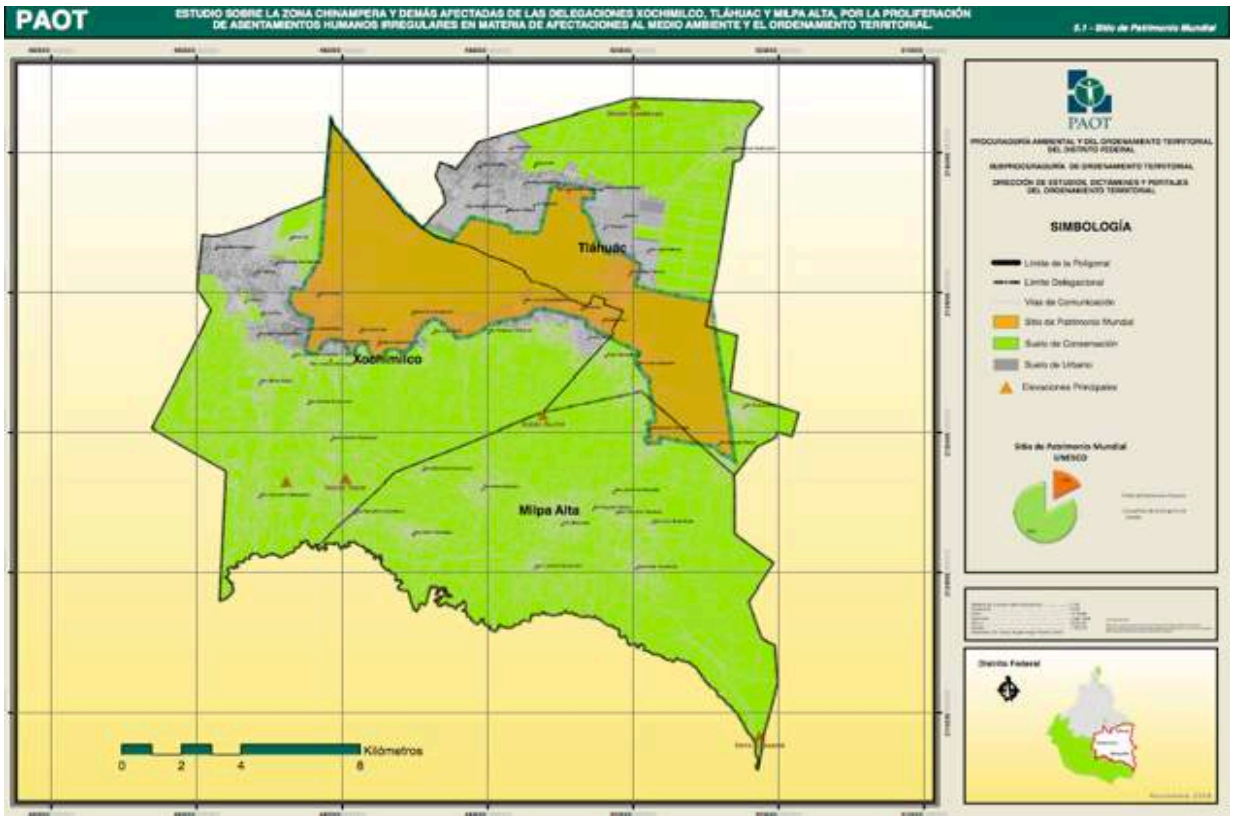
ANNEX 3. MAP OF THE CHINAMPA AGRICULTURAL SYSTEM IN THE CONTEXT OF THE ECOLOGICAL FRAMEWORK OF MEXICO CITY



Note:
Map of Mexico City: is made up of 16 delegations or municipalities.
Is classified in urban soil (9 municipalities) and in conservation soil (7 municipalities) in addition 36 rural villages that date of the time pre-Hispanic
Grey area: urban land
Colours area: conservation soil
Red arrow: Natural and Cultural World Heritage Zone in Xochimilco, Tláhuac and Milpa Alta, Mexico City.

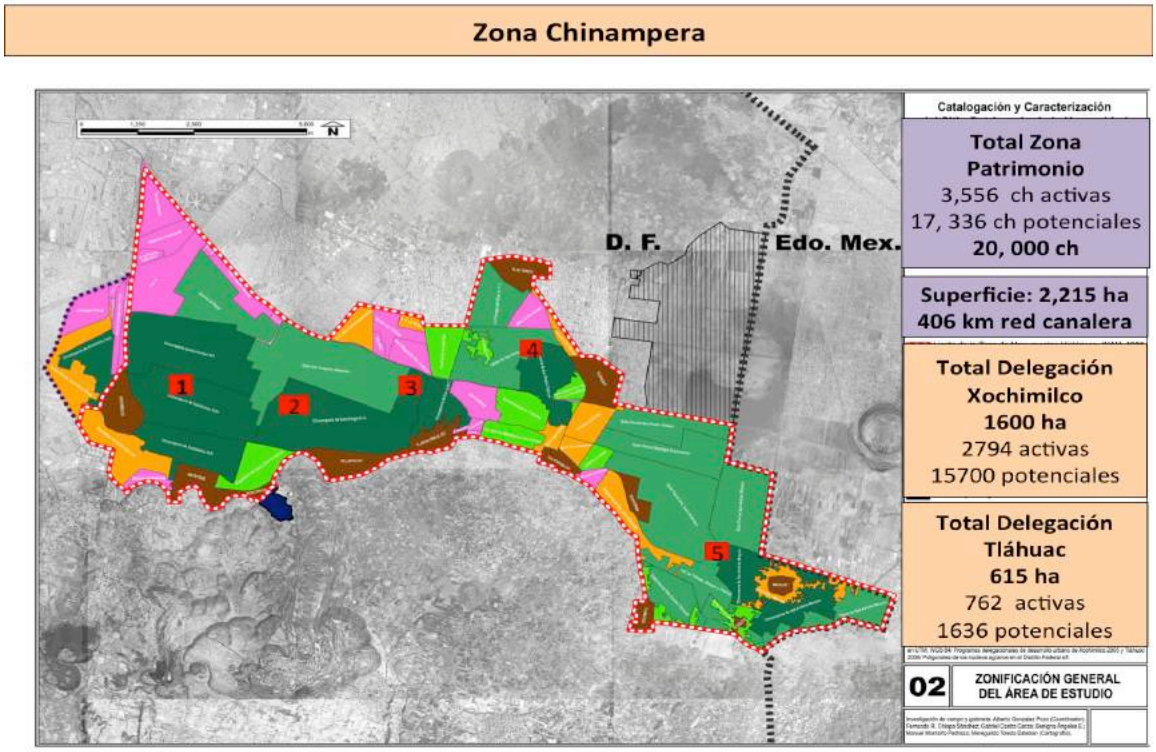
ANNEX 4. MAP OF HERITAGE ZONE IN THE CONTEXT OF THE THREE MUNICIPALITIES

Natural and Cultural World Heritage Zone in Xochimilco, Tláhuac and Milpa Alta, Mexico City.
Surface 7,534 ha



The heritage area has 7,534 ha, comprises 30% of Xochimilco Municipality (3,866 has), 40% of Tlahuac Municipality (3,589 has) and 109 ha in Milpa Alta Municipality.

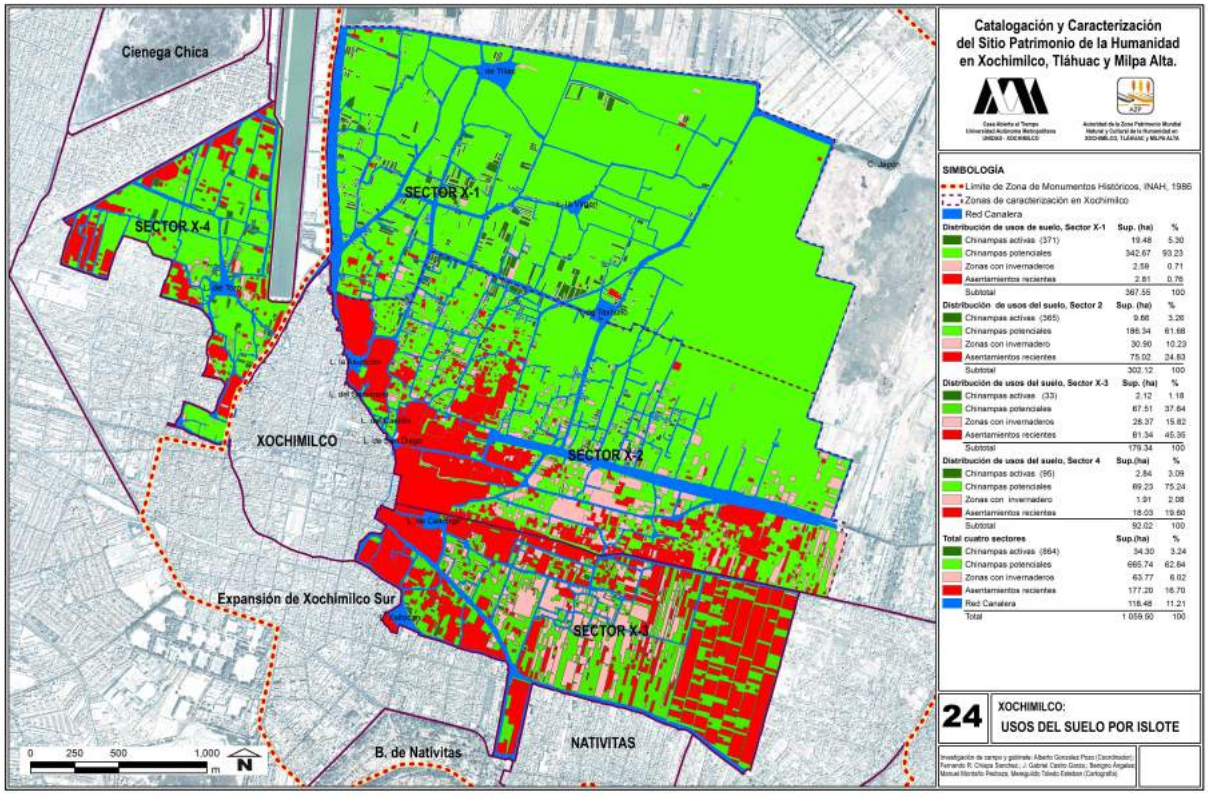
ANNEX 5. MAP OF THE GIAHS SITE PROPOSED WITH ITS FIVE ZONES



Chinampas Zones		***Sectors or rural landscapes***	***Surface area (ha)***	***Numbers of chinampas***		
				Active	*Potential*	*Totals*
Xochimilco	1	18	1,059	864	15,000	15,864
San Gregorio Atlapulco	2	23	484	1,530	530	2,060
San Luis laxialtemalco	3	16	103	430	170	600
San Pedro Tláhuac	4	9	165	474	666	1,140
San Andrés Mixquic	5	10	404	288	970	1,258
Total		**76**	**2,215**	**3,586**	**17,336**	**20,922**

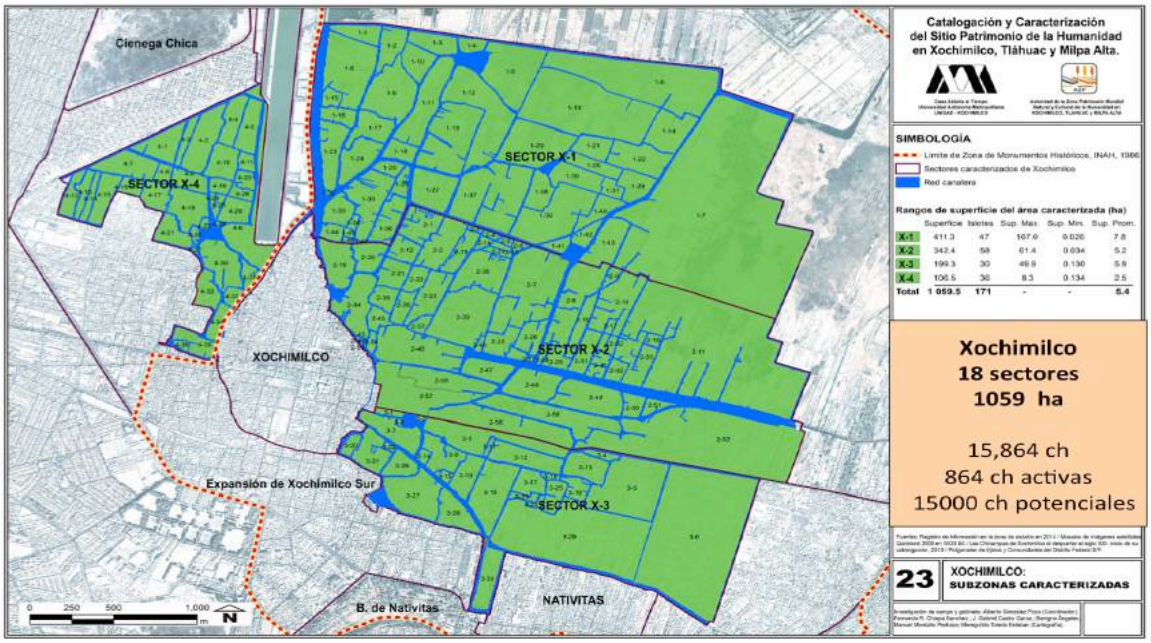
The GIAHS site proposed corresponds to the chinampa agricultural system consisting of five Chinampas areas. Occupies an area of 2,215 has equivalent to 30% of the total surface of the Heritage Zone. The chinampa system is distributed in five Chinampa zones localized in two municipalities. Three chinampa areas belonging to Xochimilco municipality (1,2,3) occupy 74% of the surface of chinmapa system (1,646 ha) and are part of the Natural Protected Area which also has the designation of Ramsar Site as a International Importance Wetland. The two pertaining municipality of Tlahuac (4,5), occupy the remaining 26% (569 has)

ANNEX 6. CHINAMPAS ZONE IN XOCHIMILCO 1

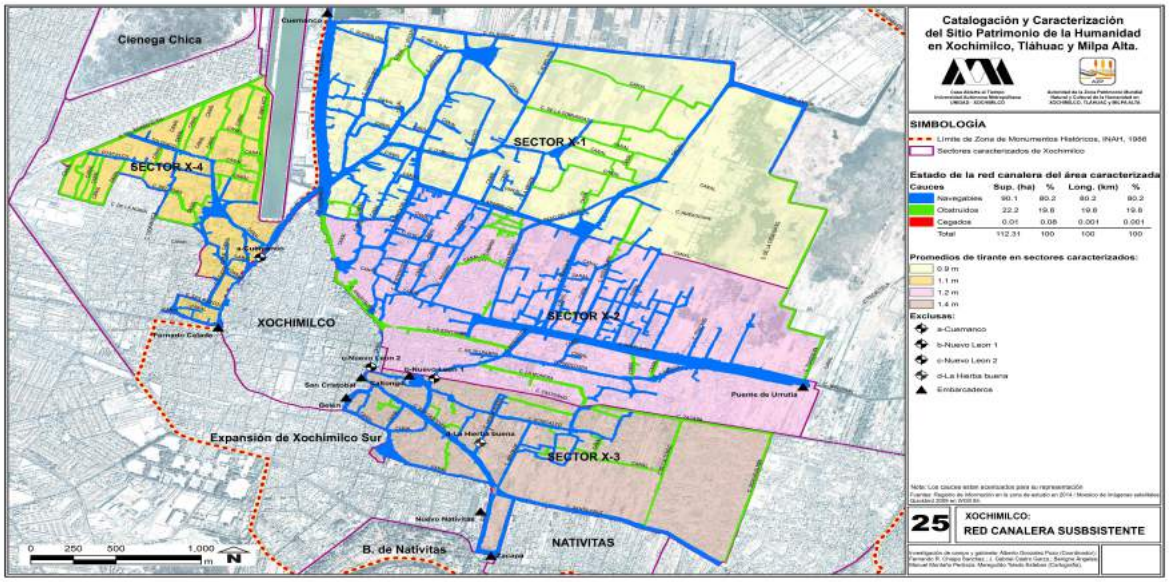


Traditional crops

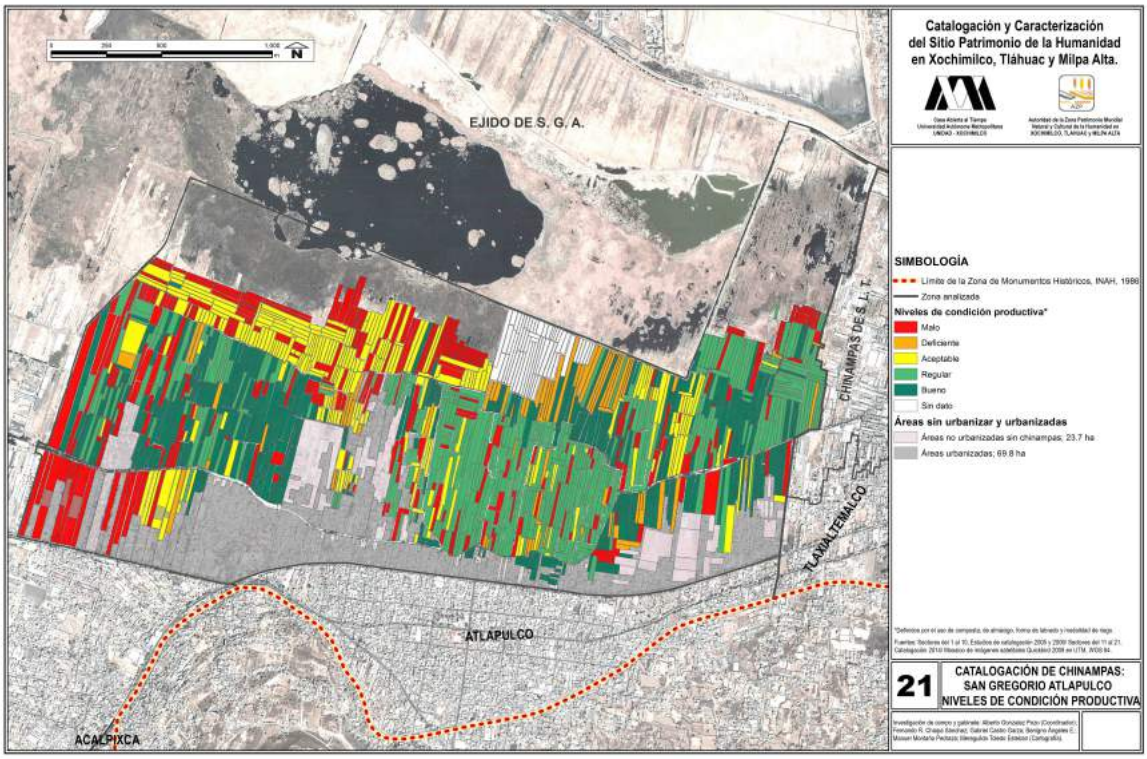
Zona Chinampera Xochimilco

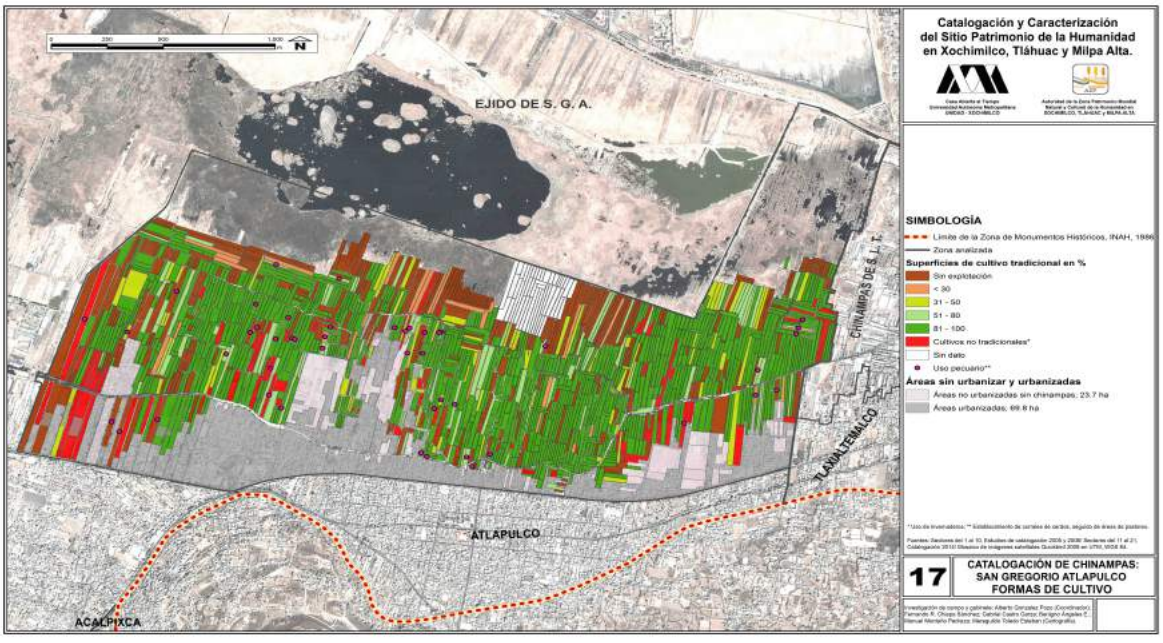


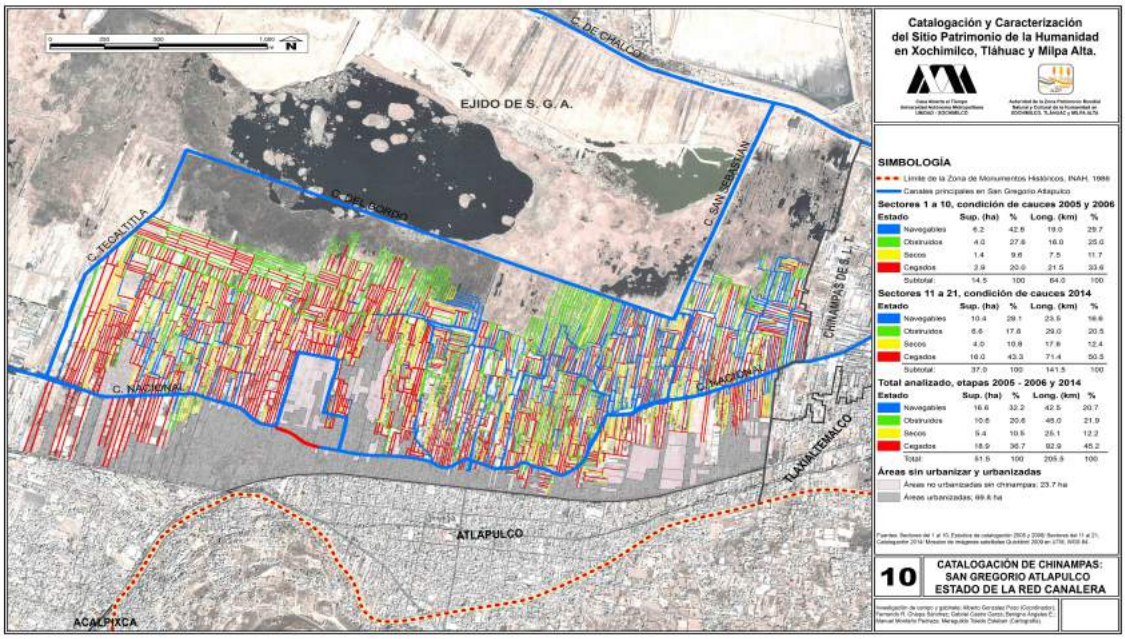
Water Channels Network in Xochimilco



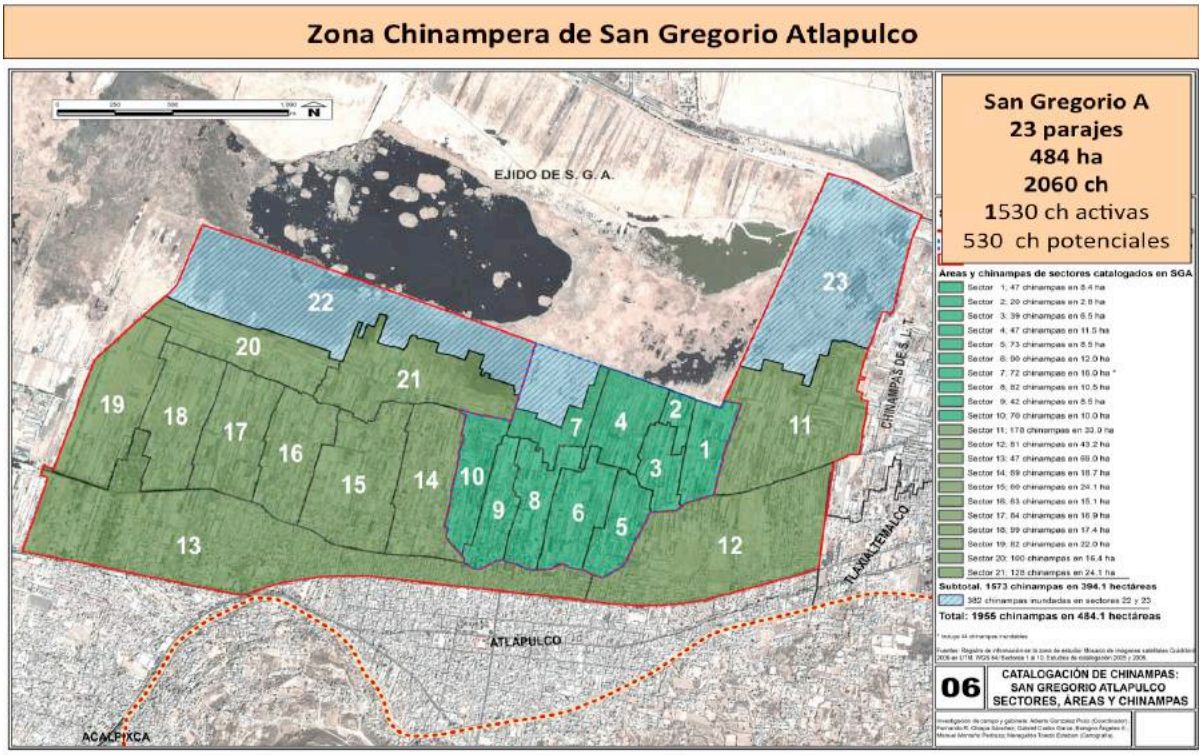
ANNEX 7. CHINAMPAS ZONE IN SAN GREGORIO ATLAPULCO. 2





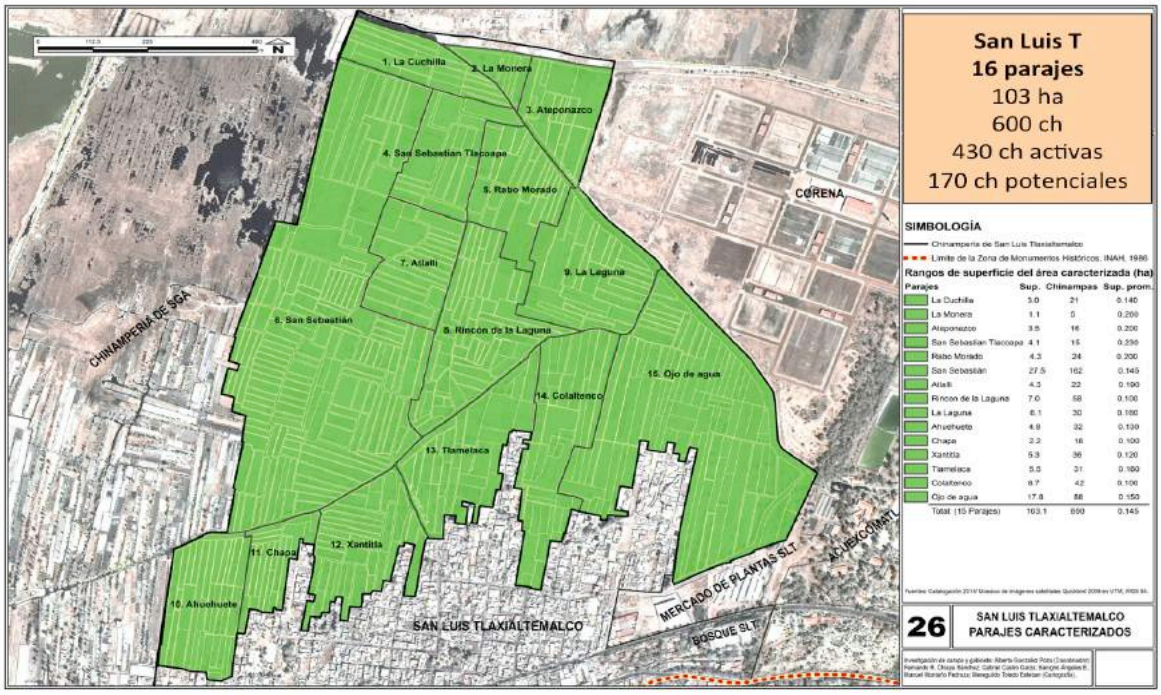


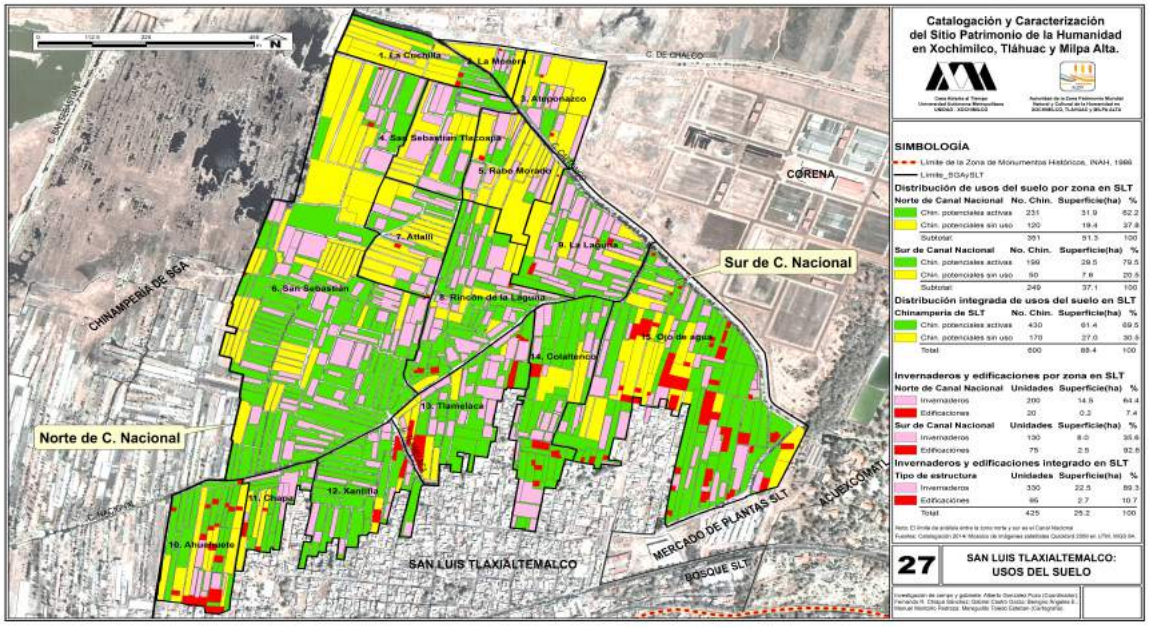
Water Channels Network in San Gregorio Atlapulco



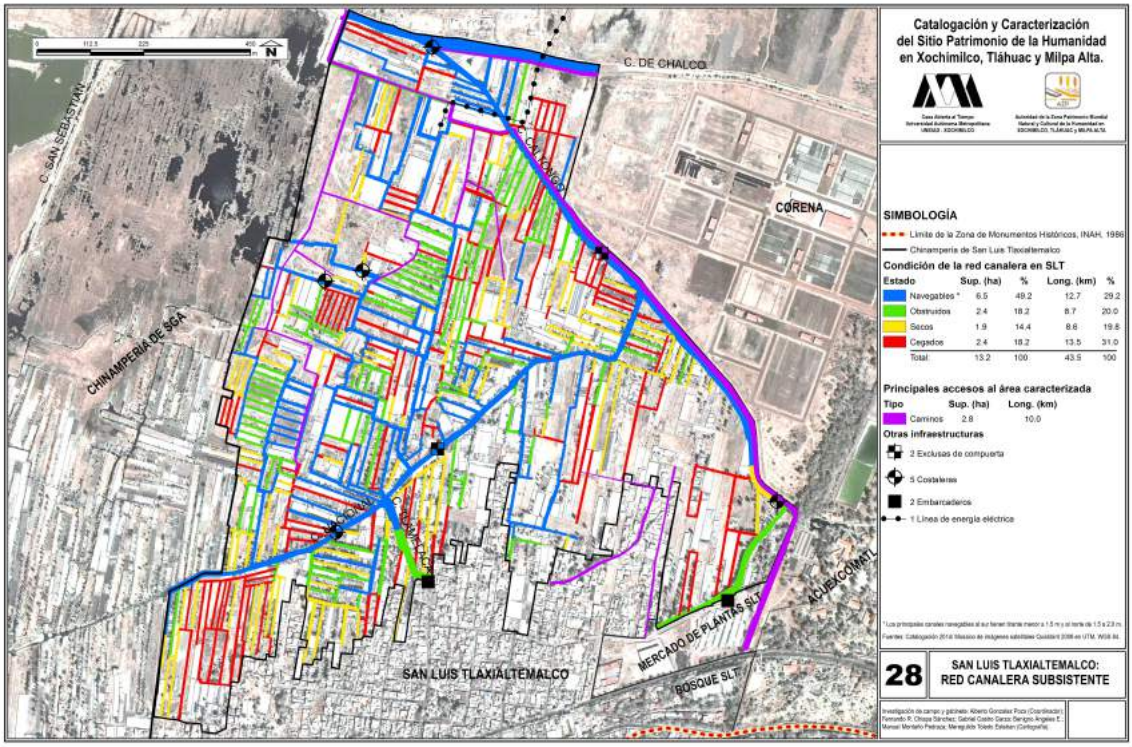
ANNEX 8. CHINAMPAS ZONE IN SAN LUIS TLAXIALTEMALCO.

Zona Chinampera de San Luis Tlaxialtemalco



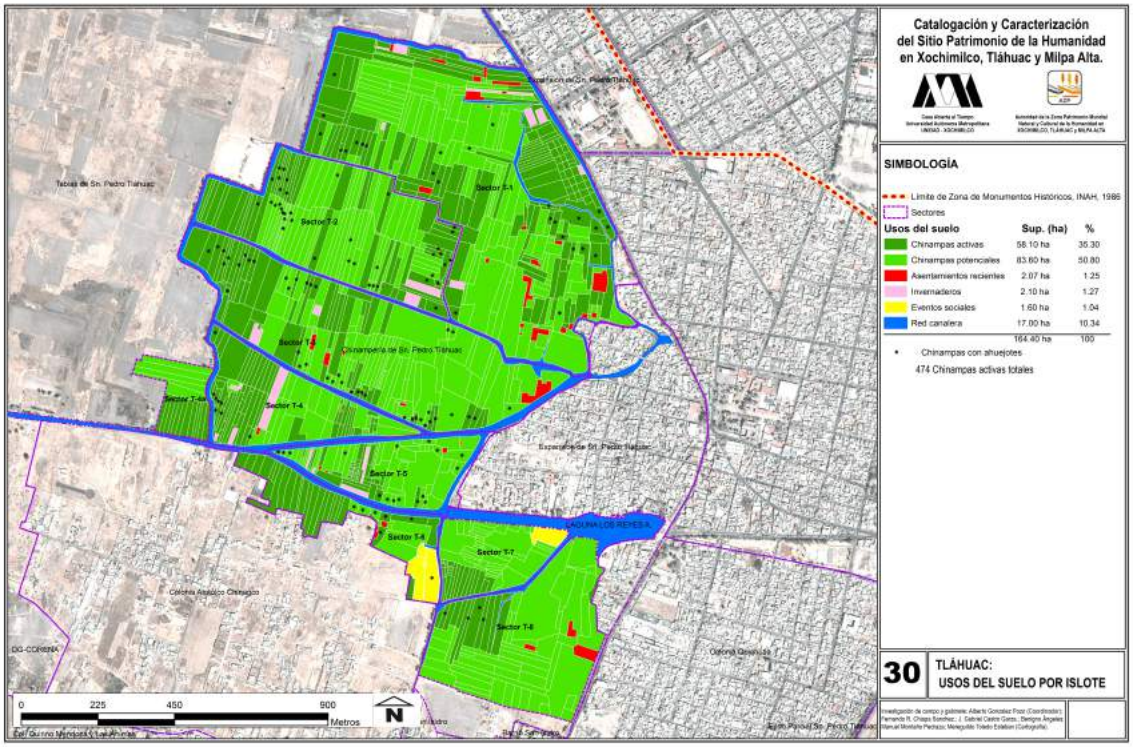


Water Channels Network in San Luis Tlaxialtemalco



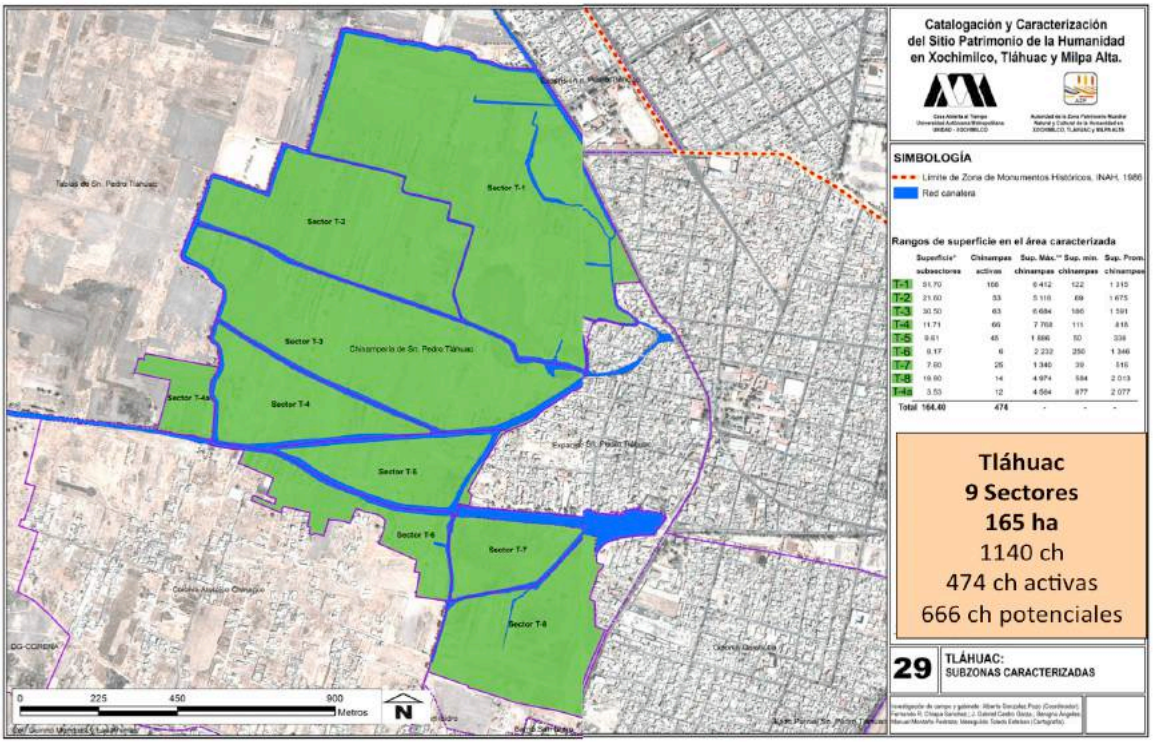
Traditional crops

ANNEX 9. CHINAMPAS ZONE IN SAN PEDRO TLÁHUAC 4

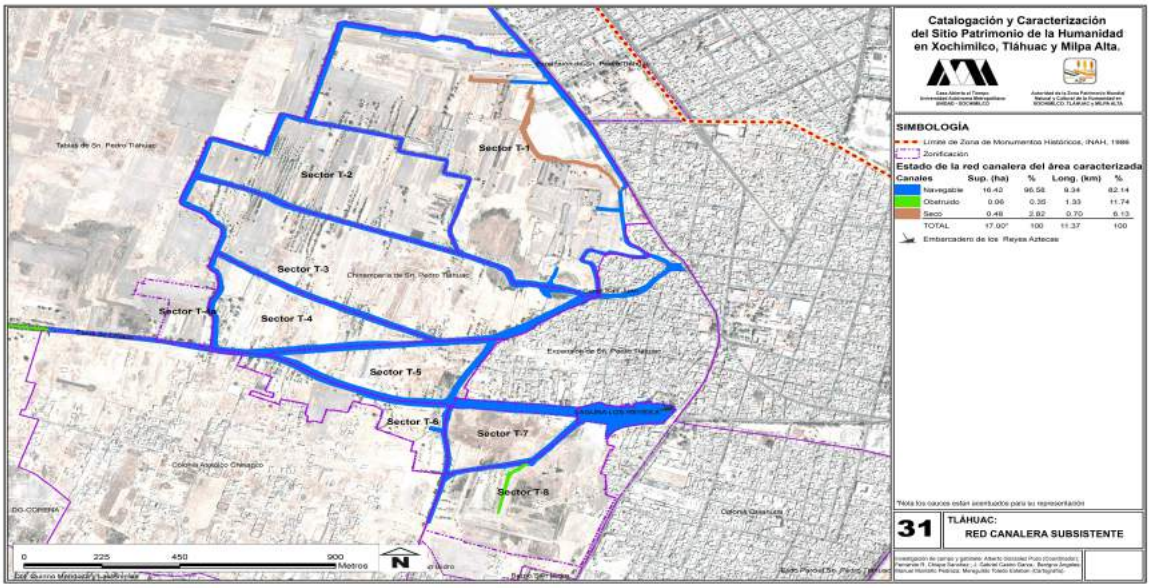


Traditional crops

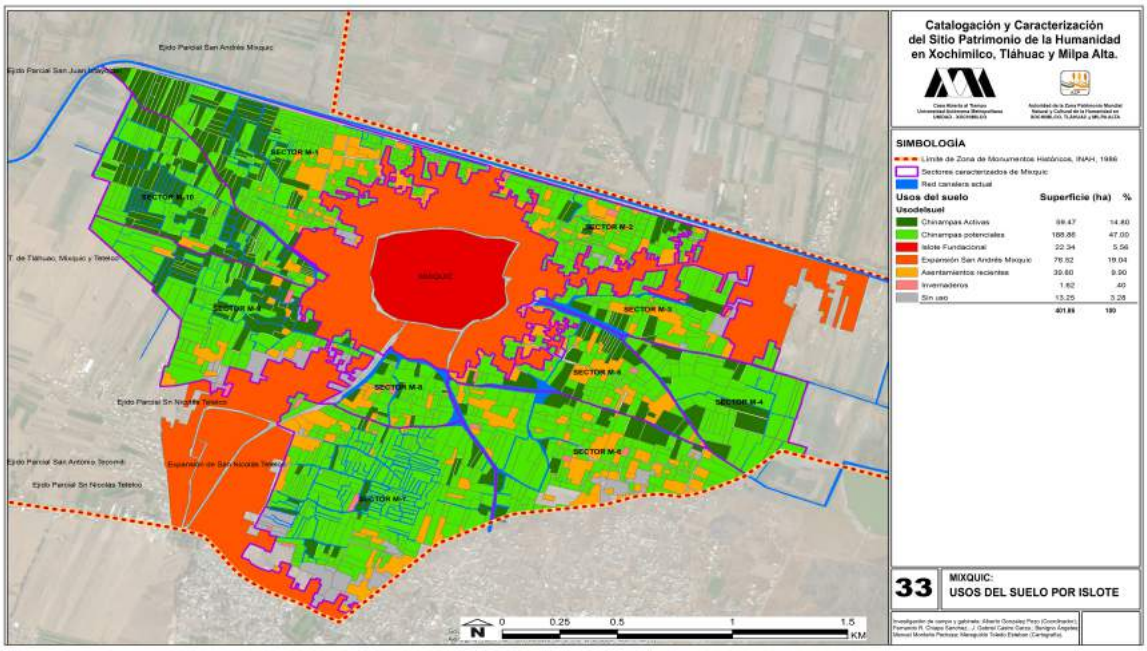
Zona Chinampera de Tláhuac



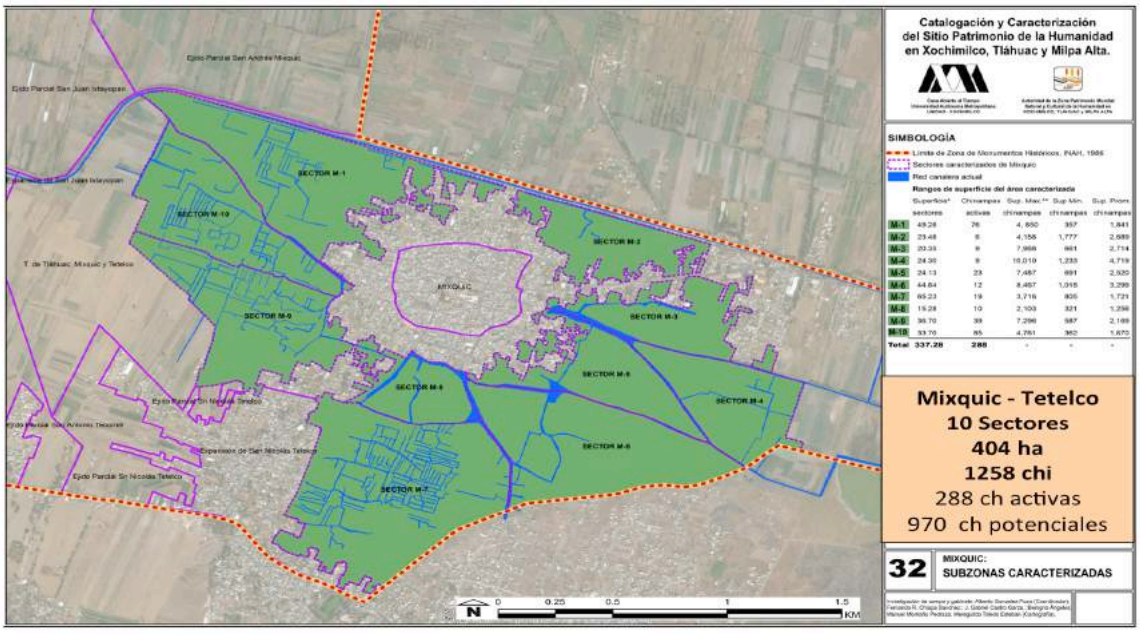
Water Channels Network in San Pedro Tláhuac



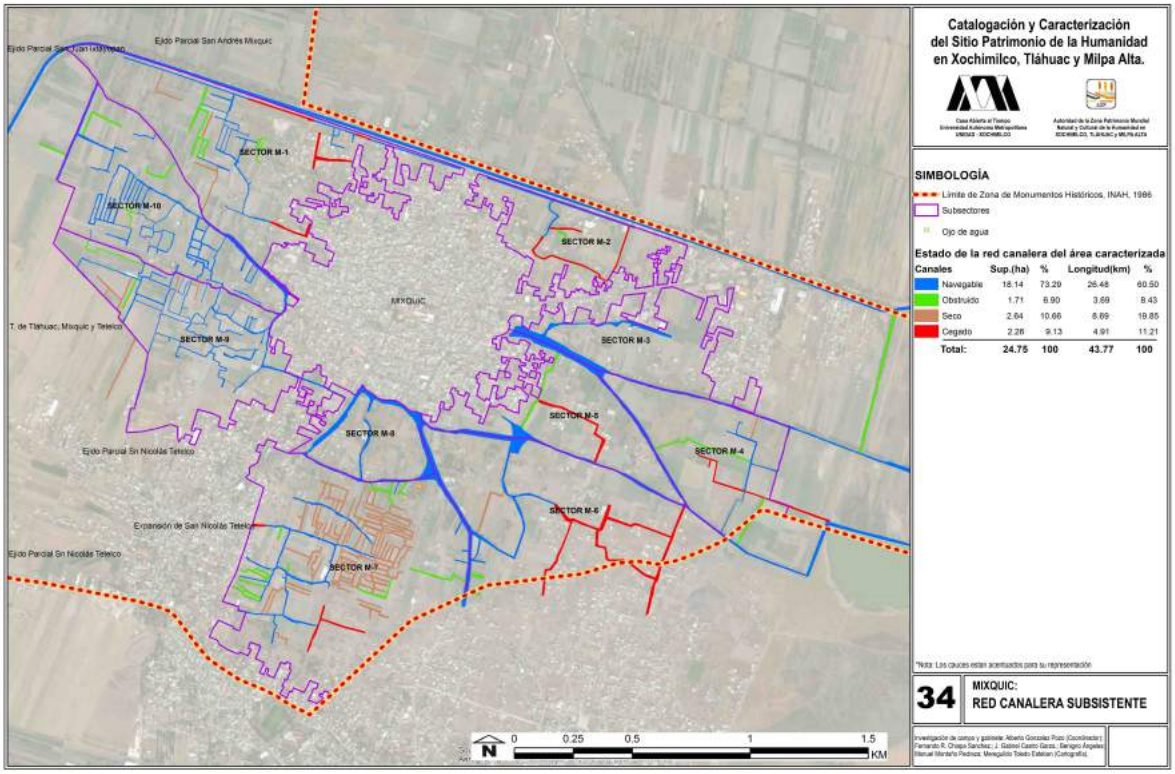
ANNEX 10. CHINAMPAS ZONE IN SAN ANDRÉS MIXQUIC



Zona Chinampera Mixquic - Tetelco

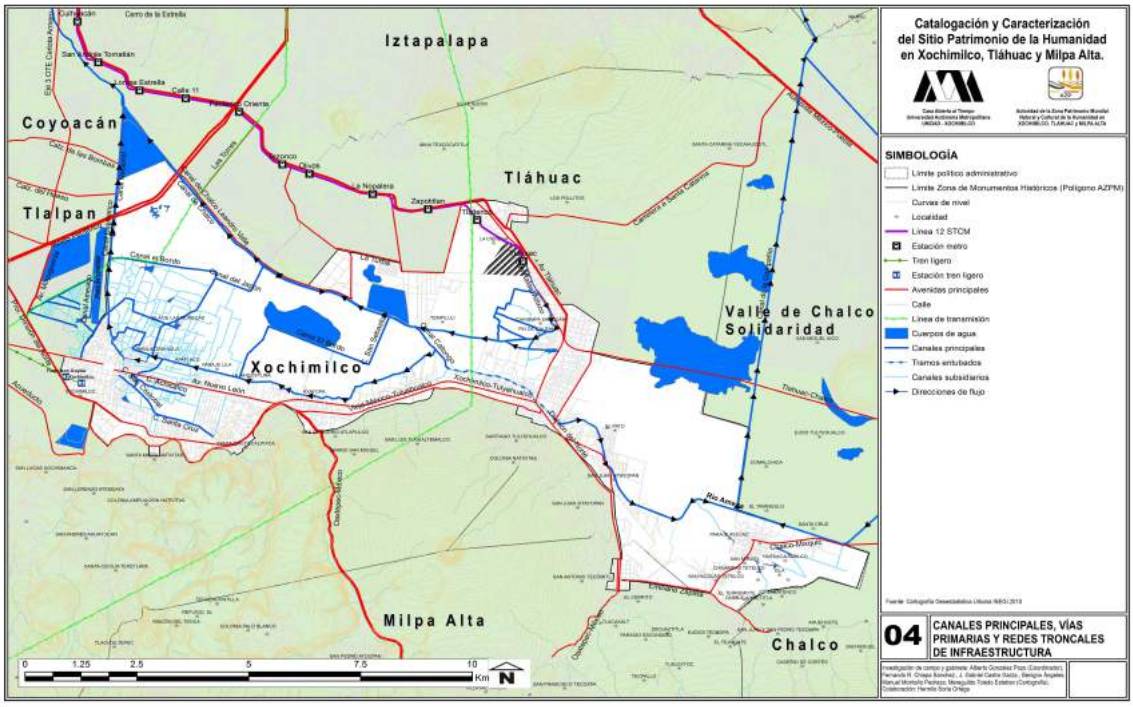


Water Channels Network in San Andrés Mixquic



Traditional crops

ANNEX 11. ACCESSIBILITY TO THE SITE AND WATER NETWORK.

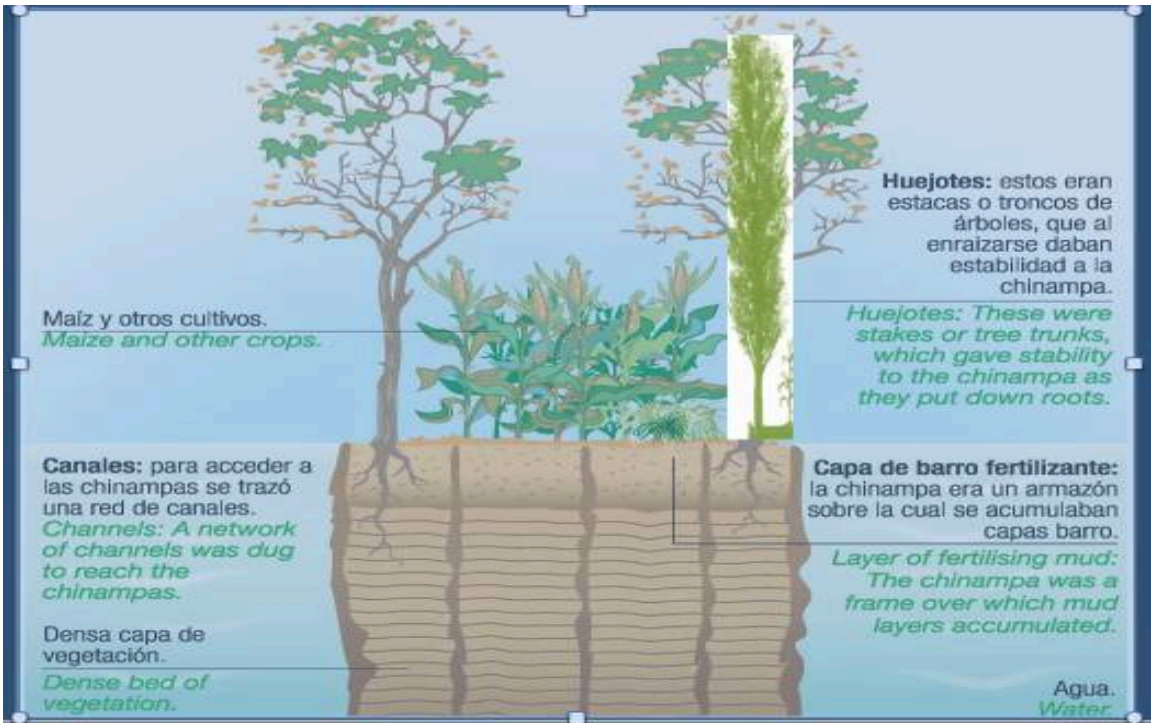


The water channel network retains an extension of 406 kilometers. Is composed by the main channels with wide top to 6 meters, delimited by ahuejotes, usually of use tourist. And the fine channel network formed by acalotes (channels between 3 and 6 meters section) and apantles (narrow channels, like ditches, between 2 and 3 m wide) directly linked with the chinampas activity and the transport of products from the chinampas. All the water in the lacustrine area (blue) is treated water level tertiary, coming from the plant's treatment of Cerro de la Estrella belonging to the Mexico City Government.

ANNEX 12. BUILDING A CHINAMPA

To build a chinampa, collected on a gray fabric several layers of soil and mud (taken from the bottom of the Lake). Under the weight of the soil, the whole of sinks to rest at the bottom of the Lake, shallow (the water is between 30 and 50 cm below). To consolidate it, poles and trees at the edge of the plot are planted. Is is of a species of willow native of this part of Mexico, Salix bonplandiana, called Ahuejote in Spanish local.
This sauce is thin and little diffuse, which allows the light to come on the plot. The estate of the Ahuejote keep the edges of the chinampa, surrounded by three or four small channels. These channels are drainage or lane. This system involving the quality of the soil and the contribution in water in a favorable climate allowed the development of a very productive agriculture (4 to 5 crops per year). Using the technique of the chapín or nursery, as seed for seedling selection. Also calls gardens floating, the chinampas is used today for the floriculture and the planting of legumes. A chinampa measures around 1,500 m².

Source: NIP, Note of Identification of the Project, made between the Authority of the Natural and Cultural World Heriatge Zone in Xochimilco, Tláhuac and Milpa Alta, and French Agency of Developmen. (Dr. Ruz Varas Norma, Executive Director of Special Projects at Authority of World Natural and Cultural Heritage Zone. Mexico City 2013)



ANNEX 13. MAIN PLANT SPECIES GROWN IN THE SITE.

Common name	Scientific name
Cultivated native species	
Maíz	*Zea mays*
Frijol	*Phaseolus vulgaris*
Tomate	*Phisalia ixocarpa Brot.*
Jitomate	*Lycopersicum esculentum*
Calabaza	*Cucurbita pepo*
Chía	*Hytis suaveolens PotT*
Quintonil	*Amaranthus hybridus*
Quelite	*Chenopodium macrospermum* Hook. f.
Chilacayote	*Cucurbita fisifolia*
Huauzontle	*Chenopodium nuttaliae Safff*.
Romerito	*Suaeda torreyana* S.Watson
Chayotillo	*Sicyos deppei* G. Don
Lengua de Vaca	*Rumexobtusifolius* L.
Amaranto	*Amaranthus*
Verdolaga	*Portulaca oleracea* L.
Epazote	*Ambrosoides Disphania*
Nochebuena	*Euphorbia pulcherrima*
Cempasúchil	*Tagetes erecta*
Dalia	*Dahlia coccinea*
Alien species cultivated	
Lechuga	*Lactuca sativa*
Espinaca	*Spinacia oleracea*
Col	*Brassica oleracea* var*. Viridis*
Coliflor	*Brassica oleracea* var. *Botrytis*
Brócoli	*Brassica oleracea* var. *Italica*
Cilantro	*Persica odorata*
Perejil	*Petroselinum crispum*
Ornamental species	
Azalea	*Rhododendron obtusum*
Belén	*Impatiens* sp.
Begonia	*Begonia* sp.
Ciclamen	*Cyclamen persicum*
Heliotropo	*Heliotropium arborescens*
Petunia	*Petunia hibrida*

ANNEX 14. SPECIES LISTED UNDER A CONDITION.

Common name	Scientific name	Condition (NOM-059-SEMARNAT-2010)
Amphibians		
Ajolote	*Ambystoma mexicanum*	Endangered
Rana de Tláloc	*Lithobates tlaloci*	Endangered
Rana de Moctezuma	*Lithobates montezumae*	Subject to special protection
Reptiles		
Cincuate	*Pituophis deppei*	Threatened
Víbora de cascabel	*Crotalus molossus*	Subject to special protection
Víbora de cascabel	*Crotalus polystictus*	Subject to special protection
Alicante o escorpión	*Barisia imbricata*	Subject to special protection
Tortuga casquito	*Kinosternon integrum*	Subject to special protection
Birds		
Garza morena	*Ardea herodias*	Subject to special protection
Gavilán pecho rufo	*Accipiter striatus*	Subject to special protection
Avetoro	*Botaurus lentiginosus*	Threatened
Fish		
Mexclapique	*Girardinichthys viviparus*	Endangered

ANNEX 15. ORNITOFAUNA IDENTIFIED ON THE SITE.

FAMILY	SPECIE
Anatidae	*Anas cyanoptera*
	Anas clypeata
	Anas platyrhynchos
	Oxyura jamaicensis
Ardeidae	*Ardea alba*
	*Botaurus lentiginosus**
	Butorides virescens
	Egretta tricolor
	Nycticorax nycticorax
Columbidae	*Columbina inca*
	Columba livia
	Zenaida sp.
Fringillidae	*Pipilo fuscus*
	Carpodacus mexicanus
Haematopodidae	*Himantopus mexicanus*
Hirundinidae	*Hirundo rustica*
Icteridae	*Agelaius phoeniceus*
	Quiscalus mexicanus
	Icterus abeillei
	Icterus galbula
Mimidae	*Toxostoma curvirostre*
Picidae	*Colaptes aureatus*
	Picoides scalaris
Ploceidae	*Passer domesticus*
Psittacidae	*Amazona albifrons*
Rallidae	*Gallinula chloropus*
	Fulica americana
Troglodytidae	*Thryomanes bewickii*
Turdidae	*Turdus rufopalliatus*
Tyranidae	*Tiranus vociferans*
Tytonidae	*Tyto alba*
Vireonidae	*Vermivora ruficapilla*
	Dendroica graciae

ANNEX 16. TREE SPECIES IDENTIFIED ON THE SITE.

Scientific name	Common name	Family	Origen
Salix bonplandiana Kunth.	Ahuejote	Salicaceae	Central Mexico
Salix babylonica L.	Sauce llorón	Salicaceae	Asia
Taxodium mucronatum Ten.	Ahuehuete, Sabino	Taxodiaceae	Mexico, Texas and Guatemala.
Eucalyptus camaldulensis Dehnh.	Eucalipto rojo	Myrtaceae	Australia
Eucalyptus globulus Labill.	Eucalipto, Alcanfor	Myrtaceae	Australia
Casuarina equisetifolia L.	Casuarina	Casuarinaceae	Australia
Fraxinus uhdei Lingelsh.	Fresno	Oleaceae	Mexico
Schinus molle L.	Pirul	Anacardiaceae	Perú
Erythrina americana Mill.	Colorín	Leguminosae	Mexico
Olea europaea L.	Olivo	Oleaceae	Mediterranean
Buddleia cordata H.B.K.	Tepozán	Scrophulariaceae	Mexico
Araucaria heterophylla (Salisb.) Franco.	Araucaria	Araucariaceae	Bolivia
Cupressus lusitánica Mill.	Cedro blanco	Cupressaceae	Mexico
Cupressus macrocarpa Hartw. ex Gord.	Cedro limón	Cupressaceae	United States
Cupressus sempervirens L.	Ciprés italiano	Cupressaceae	Italy
Washingtonia robusta H. Wendl.	Palma abanico.	Arecaceae	Mexico
Phoenix canariensis Hort. Ex Chabaud.	Palmera	Arecaceae	Canary Islands

ANNEX 17. HALOPHILE SPECIES IDENTIFIED ON THE SITE.

Scientific name	Common name	Family	Origen
Amaranthus hybridus	Quintonil	Amaranthaceae	America
Heliotropium curassavicum L.	Hediondilla	Boraginaceae	America
Spergula arvensis L.	Cilantrillo	Caryophyllaceae	Europa
Erigeron longipes D.C.	Chalchuan	Compositae	Mexico
Parthenium bipinnatifidum (Ort.) Rollins	Confitillo	Asteraceae	Mexico
Piqueria trinervia Cav.	Hierba de S. Nicolas	Asteraceae	Mexico
Sanvitalia procumbens Lam.	Ojo de gallo	Asteraceae	Mexico
Senecio vulgaris L.	Lechugilla	Asteraceae	Europe
Sonchus asper (L.) Hill	Lechuguilla	Asteraceae	Africa
Taraxacum officinale G. H. Weber ex Wigg.	Diente de león	Asteraceae	Eurasia
Coronopus didymus (L.) Smith	Mastuerzo	Cruciferae	Unkown
Eruca sativa Mill.	Mostacilla	Cruciferae	Mediterranean
Lepidium sordidum Gray.	Lentejilla	Cruciferae	North America
Chenopodium giganteum D. Don	Quelite gigante	Chenopodiaceae	India and Nepal
Chenopodium macrospermum Hook.	Quelite	Chenopodiaceae	South America
Suaeda torreyana S. Watson	Romerito	Chenopodiaceae	North America
Sicyos deppei G. Don	Chayotillo	Cucurbitaceae	Mexico
Equisetum hyemale L.	Cola de caballo	Equisetaceae	North America
Pennisetum clandestinum Hochst. *ex* Chiov.	Pasto kukuyo	Gramíneae	Africa
Poa annua L	Zacate azul	Gramíneae	Europe
Hordeon jubatum L.	Cola de zorrillo	Gramíneae	North America
Eragrostis obtusiflora (Fourn.) Scribn.	Zacahuixtle	Gramineae	North America

Eragrostis mexicana (Hornem.)Link	Zacate casamiento	Gramineae	Mexico
Hilaria cenchroides Kunth.	Zacate mezquite	Gramineae	Mexico
Cynodon dactylon(L.) Pers.	Pata de gallo	Gramineae	Africa
Dalea foliolosa (Ait.) Barneby	Limoncillo	Leguminosae	Mexico
Melilotus indicus (L.) All.	Meliloto	Leguminosae	Mediterranean
Erodium cicutarium (L.) L'Hér. ex Ait.	Alfilerillo	Geraniaceae	Europe
Marrubium vulgare L.	Marrubio	Labiatae	Europe
Malva nicaeensis All.	Malva	Malvaceae	Asia
Malva parviflora L.	Malva de quesitos	Malvaceae	Europe
Sphaeralcea angustifolia (Cav.) G. Don	Hierba del negro	Malvaceae	Mexico
Oxalis latifolia Kunth	Agritos	Oxalidaceae	Mexico
Argemone ochroleuca Sweet.	Chicalote	Papaveraceae	Mexico.
Phytolacca icosandra L.	Jaboncillo	Phytolaccaceae	Mexico
Plantago major L.	Llantén	Plantaginaceae	Europe
Rumex obtusifolius L.	Lengua de vaca	Polygonaceae	Europe
Portulaca oleracea L.	Verdolaga	Portulacaceae	Mexico
Reseda luteola L.	Vara de colmena	Resedaceae	Europe
Datura stramonium L.	Toloache	Solanaceae	Mexico
Jaltomata procumbens (Cav.) J. L. Gentry	Jaltomate	Solanaceae	America
Nicotiana glauca Graham	Tabaquillo	Solanaceae	South America
Solanum fructu-tecto Cav.	Abrojo	Solanaceae	Mexico
Solanum rostratum Dunal	Duraznillo	Solanaceae	Mexico

ANNEX 18. AQUATIC AND UNDERWATER VEGETATION IDENTIFIED ON THE SITE.

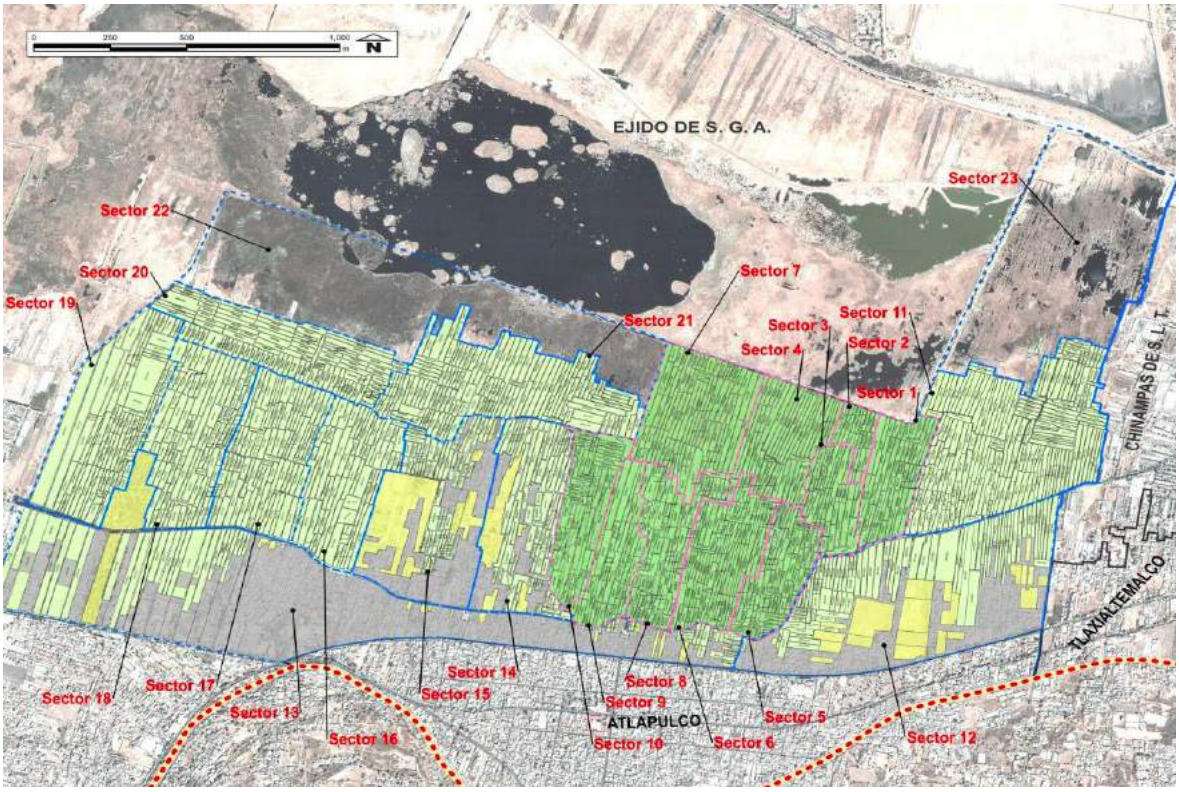
Scientific name	Common name	Family	Origen
FLOATING			
Eichhornia crassipes (Mart.) Solms.	Lirio	Pontederiaceae	South America
Pistia stratiotes L.	Lechuga de agua, lechuguilla	Araceae	Pantropical, Nile River, Africa
Hydromistria laevigata (Humb. et bonpl. ex Willd.) Hunz.	Tepalcate	Hydrocharitaceae	Central America
Lemna minuscula Herter	Chilacascle	Lemnaceae	America,
Lemna gibba L.	Chilacascle	Lemnaceae	Worldwide
Wolffia columbiana Karsten	Lentejilla	Lemnaceae	America
Wolffia brasiliensis Wedd.	Lentejilla	Lemnaceae	America
Azolla caroliniana Willd.	Helecho de agua	Azollaceae	Canada, United States
Azolla filiculoides	Amoyo	Azollaceae	America
SUBMERGED			
Potamogeton pectinatus L.		Potamogetonaceae	Worldwide
Myriophyllum aquaticum	Pinito	Haloragaceae	
Ceratophyllum demersum L.		Ceratophyllaceae	Europe, Africa, Asia, America
ROOTED			
Typha latifolia L.	Tule	Typhaceae	America, Eurasia and Africa
Schoenoplectus americanus (Pers.)	Sacaltule, zacate cuadrado	Cyperaceae	America
Nymphaea mexicana Zucc.	Apapatla	Nymphaeaceae	North America
Hydrocotyle ranunculoides L.f.	Paragüita	Umbelliferae	North America
Polygonum punctatum Ell.	Chililllo	Polygonaceae	America

Ludwigia peploides (HBK.) Raven.	Verdolaga de agua	Onagraceae	Europe and America
Juncus efussus	Junco	Juncaceae	Mediterranean
Cyperus papirus L.	Papiro	Cyperaceae	Egypt
Berula erecta (Huds.)	Berro	Umbelliferae	Asia and North America
Zantedeschia aethiopica (L.) Spreng.	Alcatraz	Araceae	South Africa
Arundo donax L.	Carrizo	Gramíneae	Europe

ANNEX 19. EXAMPLE OF A REHABILITATION PLAN FOR THE RECOVERY OF POTENTIAL CHINAMPAS. CASE STUDY XOCHIMILCO.

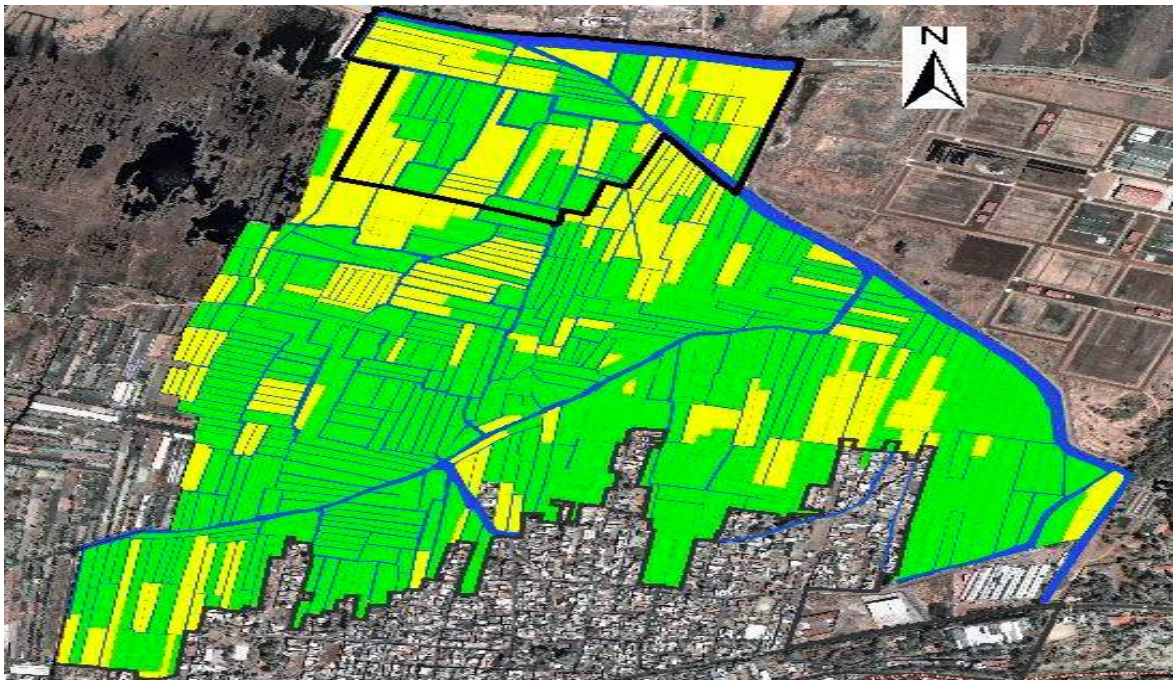
Source: Gonzalez Pozo, 2016.

ANNEX 20. EXAMPLE OF A RESTORATION PLAN TO ENCOURAGE THE PRODUCTION OF ACTIVE CHINAMPAS. CASE STUDY SAN GREGORIO ATLAPULCO.

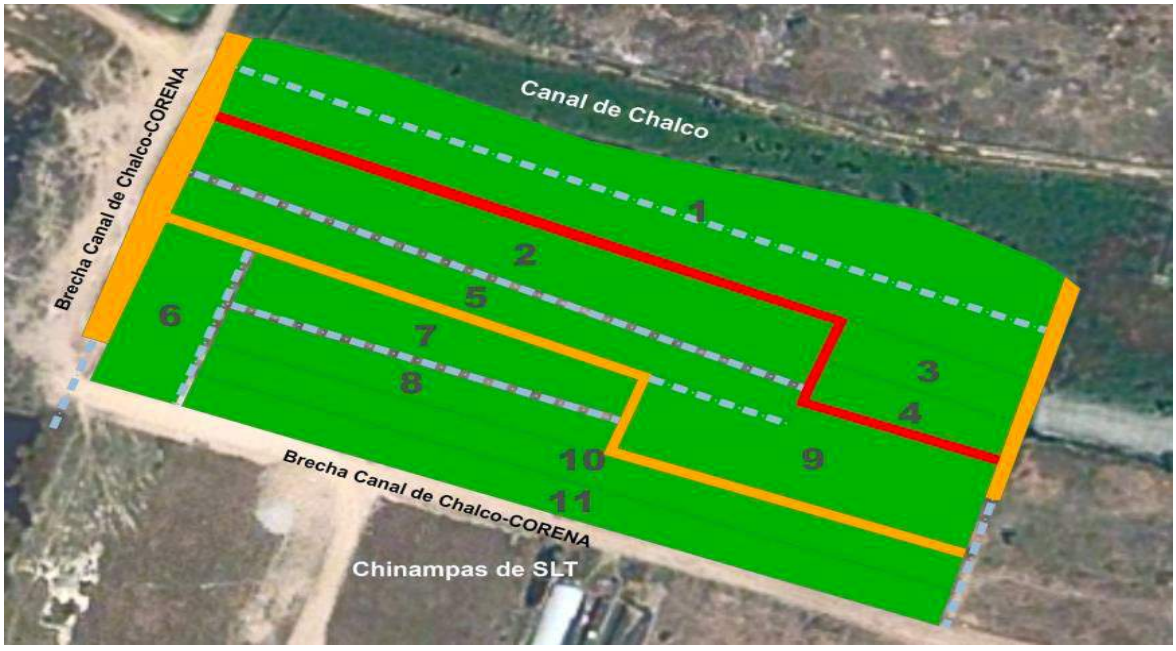


Source: Gonzalez Pozo, 2016.

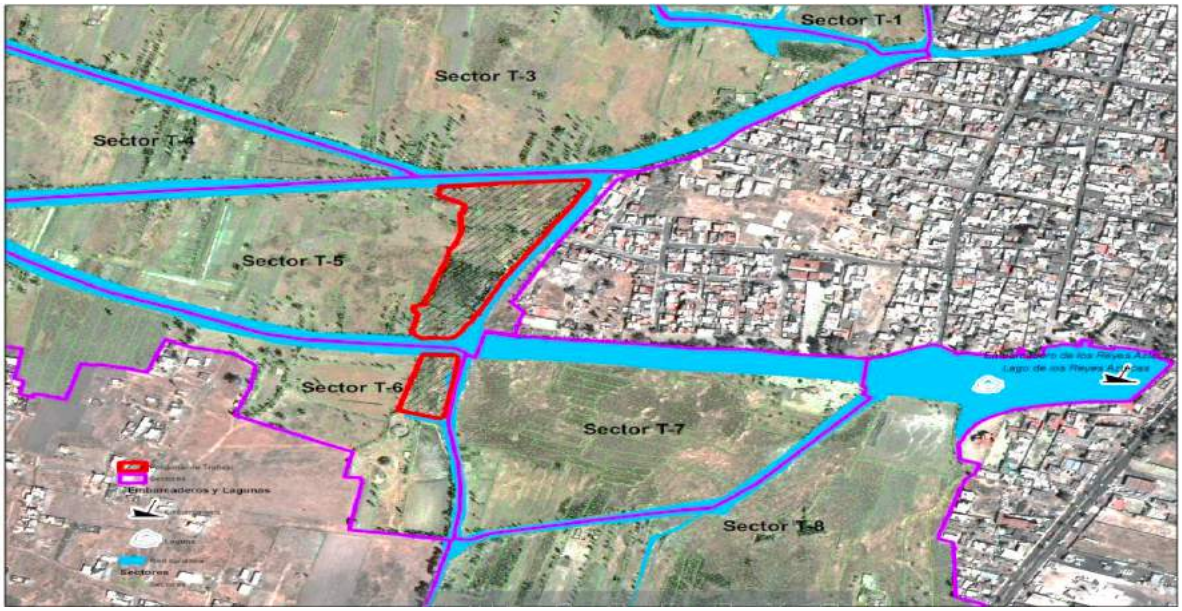
ANNEX 21. EXAMPLE OF A REHABILITATION PLAN FOR THE RECOVERY OF POTENTIAL CHINAMPAS. CASE STUDY SAN LUIS TLAXIALTEMALCO



Source: Gonzalez Pozo, 2016.

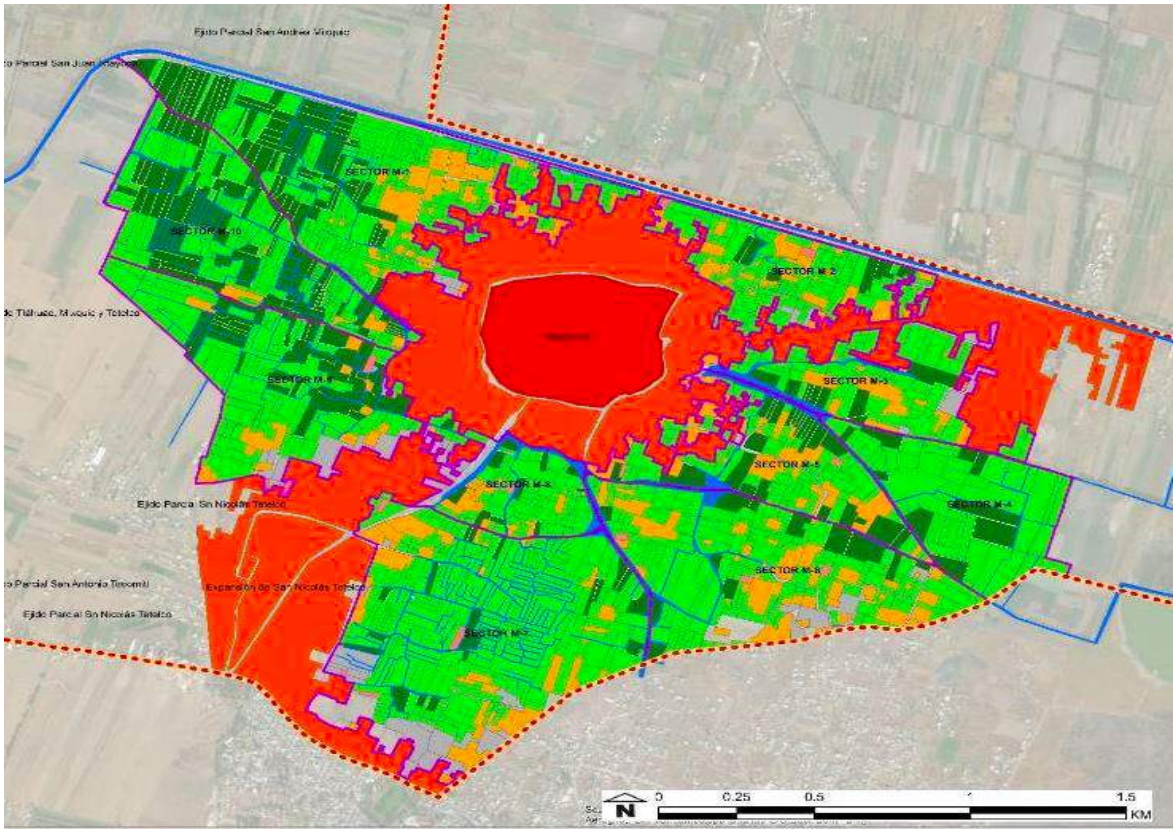


ANNEX 22. EXAMPLE OF A REHABILITATION PLAN FOR THE RECOVERY OF POTENTIAL CHINAMPAS. CASE STUDY OF SAN PEDRO TLÁHUAC.



Source: Gonzalez Pozo, 2016.

ANNEX 23. EXAMPLE OF A RESTORATION PLAN TO ENCOURAGE THE PRODUCTION OF ACTIVE CHINAMPAS. CASE STUDY SAN ANDRÉS MIXQUIC.



Source: Gonzalez Pozo, 2016.

ANNEX 24. DISTRIBUTION OF EXPENDITURE FOR DIFFERENT FLOWS FROM THE CERRO DE LA ESTRELLA TREATMENT PLANT

DISTRIBUTION OF EXPENDITURE FOR DIFFERENT FLOWS FROM THE CERRO DE LA ESTRELLA TREATMENT PLANT	
DISCHARGE/MUNICIPALITY	GASTO ACTUAL **2350lps**
TLÁHUAC MUNICIPALITY	
REBOMBEO SANTA CATARINA (TRABAJA 3 HORAS AL DÍA)	50
PARAJE TEMPILULLI	50
EJIDO ZAPOTITLÁN	20
REBOMBEO REVOLUCIÓN	50
REBOMBEO RIACHUELO SERPENTINO	0
REBOMBEO TEQUEZQUITE	330
DESCARGA TEQUEZQUITE (SAN PEDRO TLÁHUAC)	20
REBOMBEO PASO DEL TORO	480
DESCARGA PASO DEL TORO	10
LAGUNA XICO	100
SUBTOTAL	**1110 (47%)**
XOCHIMILCO MUNICIPALITY	
RESCATE ECOLÓGICO XOCHIMILCO	150
REBOMBEO CUEMANCO	50
DESCARGA LA DRAGA	50
DESCARGA EMBARCADERO FERNANDO CELADA	60
DESCARGA EMBARCADERO CANAL 27	300
DESCARGA CANAL CALTONGO	200
DESCARGA MERCADO DE PLANTAS SAN LUIS TLAXIALTEMALCO	30
DESCARGA EMBARCADERO TLAMELACA	200
SUBTOTAL	**1040 (44%)**

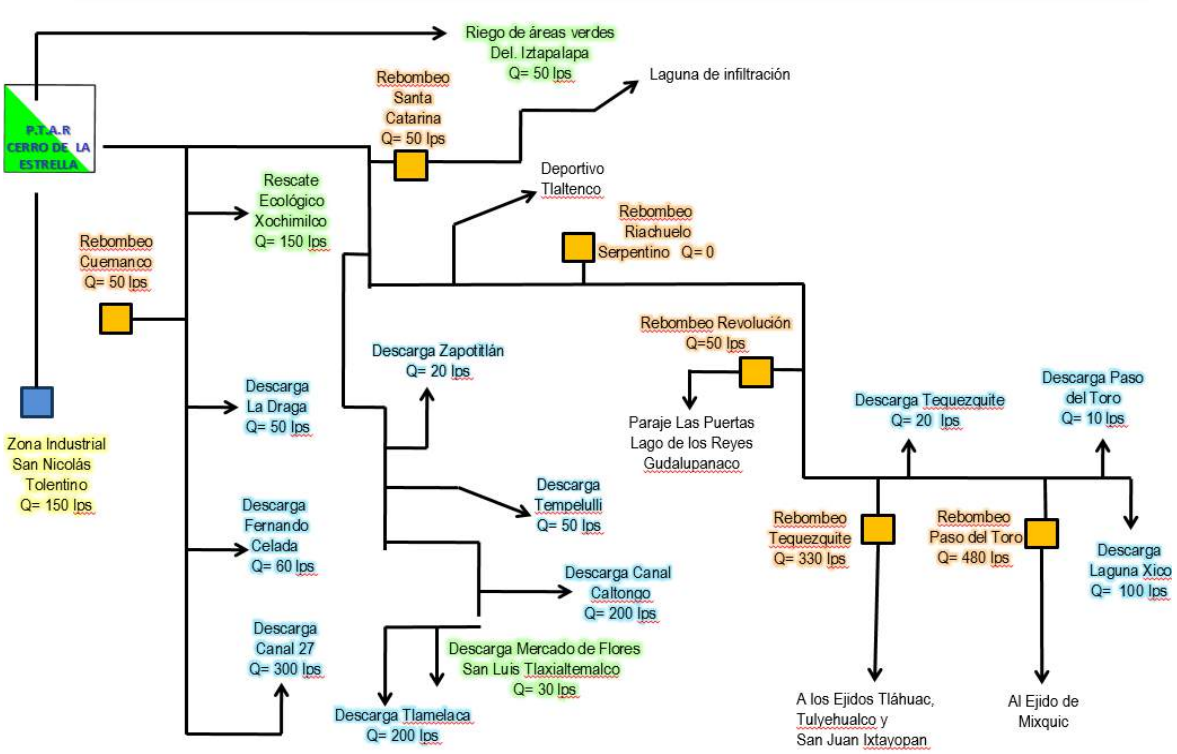
Source: SACMEX (Mexico City Water System) 2014.

ANNEX 25. TREATMENT PLANTS THAT CONTRIBUTE TO THE ZONES OF XOCHIMILCO AND TLÁHUAC			
WWTP	**TREATMENT PROCESS**	**DESIGN FLOW DISCHARGE (lps)**	**OPERATING DISCHARGE Treated Flow (lps)**
9. CERRO DE LA ESTRELLA	Tertiary w/ filtration and chlorine disinfection	3000	2350* 2150*
10. SAN LUIS TLAXIALTEMALCO	Tertiary w/ filtration and chlorine disinfection	150	65
11. TETELCO	Secondary Activated sludge w/ sludge treatment	15	10
12. LA LUPITA	Secondary Activated sludge w/ sludge treatment	15	14
13. MIXQUIC	Tertiary w/ filtration and chlorine disinfection	30	25
14. SAN PEDRO ATOCPAN	Tertiary w/ filtration and chlorine disinfection	60	19
15. SAN LORENZO	Tertiary w/ filtration and chlorine disinfection	225	75
16. EL LLANO	Tertiary w/ filtration and chlorine disinfection	250	130
Total		**3745**	**2688* 2488**

Source: SACMEX (Mexico City Water System) 2016.

TREATMENT PLAN CERRO DE LA ESTRELL

ANNEX 26. DIAGRAM OF DISTRIBUTION OF WASTEWATER TREATED FROM THE PLANT CERRO DE LA ESTRELLA



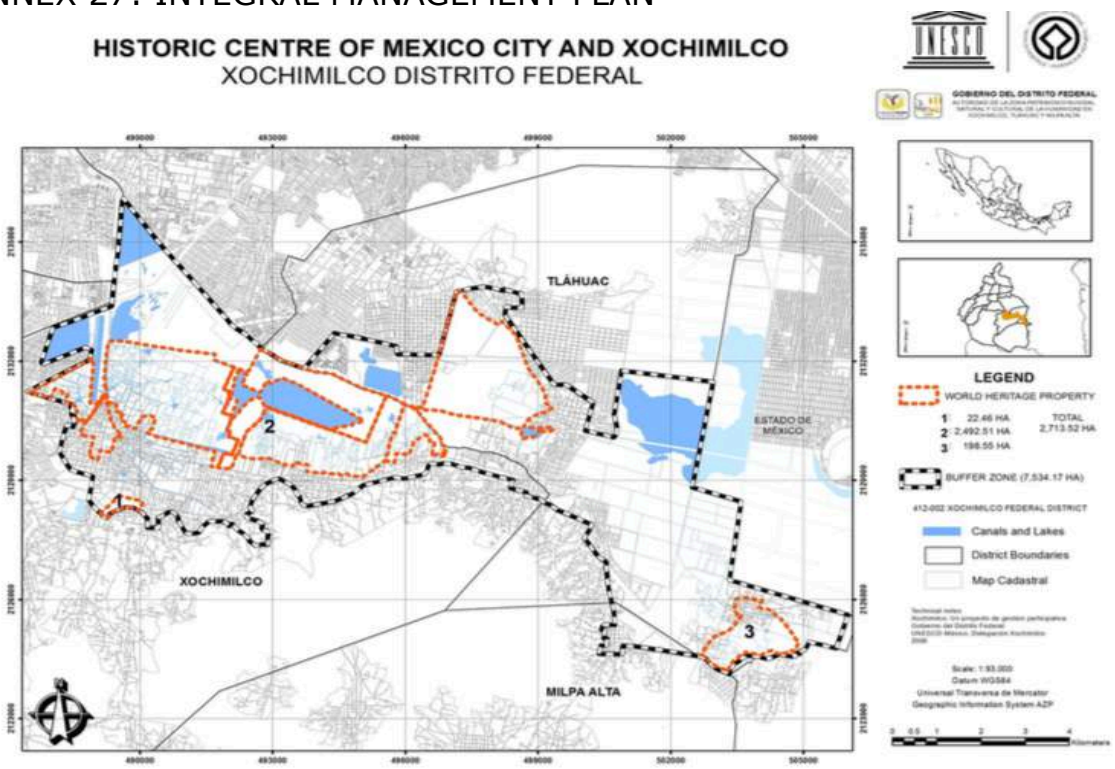
Source: SACMEX (Mexico City Water System) 2014.

Yucatán Lock, Xochimilco

Yucatán Lock, Xochimilco

The Yucatán Lock works as a control system of water levels. It is composed of 4 dump-type gates of 3.0 m stainless steel Wide and 3.5 m. Of height, for the operation of 2 locks located in Canal Nacional, Tlacoapa neighborhood. It was built by the Federal District Government in 2012 and is operated by the Mexico City Water System (SACMEX).

ANNEX 27: INTEGRAL MANAGEMENT PLAN



- - - Core Areas - - - Buffer Areas

The core zones coincide with the surface area of 2,215 ha corresponding to the five zones of agricultural production of chinampas proposed as GIAHS site.