

## THE ORIGIN AND SHAPING OF A FLORICULTURAL REGION IN ESTADO DE MEXICO

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### ABSTRACT

In some countries, flower cultivation is a tradition which is carried out as a business and for ornamental purposes. In México, this activity began when it was introduced by the families of Japanese migrants and in specific the Matsumoto family, who looked for places with the right conditions for floriculture. They found the appropriate location for the development of this activity the municipality of Villa Guerrero in Estado de México. Thus, such work began under the standards and work patterns intrinsic to the Japanese culture. To conduct this analysis, the territorial process is analyzed by using the classification model of monitored land use to know its qualities and characteristics. The results provide reference to a constant process which affects the rest of the activities performed in the municipalities adjacent to Villa Guerrero, Tenancingo and Coatepec Harinas. The land dedicated to floriculture either in the open or in greenhouses has pushed forward rapidly, to the point of making up a floricultural production area of regional and global levels.

**Keywords:** Floriculture, region, soil, territory and production.

### 1. INTRODUCTION

There are countries with a long floricultural tradition in the world, such as the Netherlands, the United States, Canada, Japan and recently some Latin American countries such as Colombia,

Ecuador and México, which also take part in the cultivation of flowers in order to be competitive in the international market.

Globally speaking, the development of this activity has been steady, however, globalization of the economy has influenced the ways of producing and marketing services and goods, in this sense flower production was developed and marketed locally or in the regional markets, leading to the world market being ignored by the producers engaged in this activity.

In spite of that, the impact of the decisions of countries with consolidated economies and of world influence were some of the reasons for the search of new spaces for flower cultivation. In the case of México, considered a resource rich country due to the diversity of climates that can be found within its territory, the variety and characteristics of its soil, the existence of considerable water sources and rainfall, are elements that promote the development of agricultural activity, including the cultivation of different varieties of flowers.

Evidence of this is that the Mesoamerican cultures cultivated different types of flowers that were used as decoration in their religious celebrations, a recurrent situation throughout the different stages of México's history. In this regard the aim of the activity is different if you want to cultivate for traditional purposes and another is to produce for commercial purposes.

Floriculture in México but especially in the south of Estado de México, has its origins in the Japanese floricultural vocation where resident families initiated the cultivation in places with appropriate climates and therefore with favorable conditions for the development of the activity. However, the environment that was conducive to the development of the activity was first found in Villa Guerrero, the place of origin and expansion of floriculture within the state.

In this specific case of floriculture that takes place in some municipalities in the south of Estado de México, it is related to the activity focused on the cultivation of plants and flowers intended for decorative use and for local, regional, national and international marketing.

According to Orozco (2007) floriculture in México spread out between 1980 and 1990, in addition to the fact that during this period the cultivated land area grew from 3,000 to 13,000 hectares, resulting in effort being put forth into the consolidation of the export platform. While Chauvet and Massieu (1996) give reference that the value of production was significant for the states of Estado de México and Morelos. García et al. (1999) reports that during the period of 1990-1998, the production of exportation grade flowers accounted for 10 percent of the 8,416 hectares of flowers and plants grown in the country. And generated an average income of 20.3 million dollars annually.

COMEXFLOR (2017) indicates that 90 percent of the production comes from 5 of the 32 states that make up México, these states are Baja California and Sinaloa with 3.8 percent each, Puebla with 5.2 percent, Morelos with 5.4 percent and Estado de México with 73.7 percent of the total production, noting that such production takes place on an area of 4,945 hectares that represent 30 percent of the total area used for the cultivation of flowers.

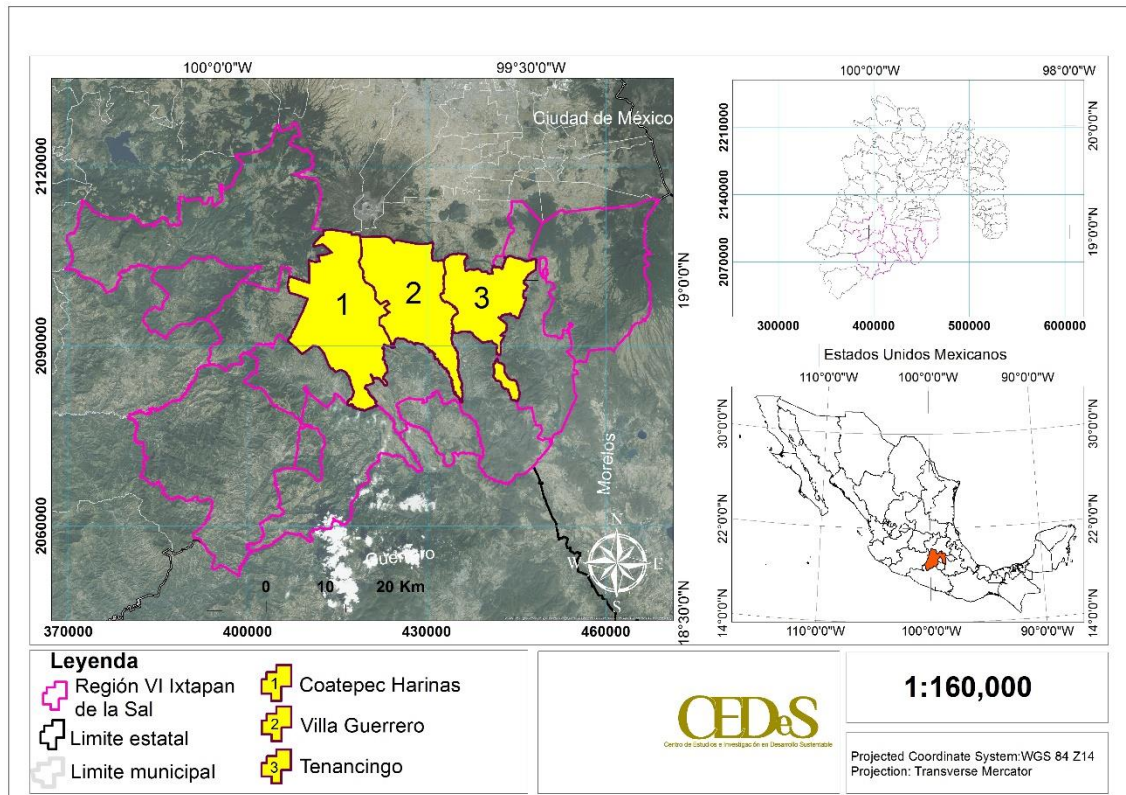
The relevance of Estado de México in respect to flower production makes it part of the Rural Development District of Coatepec Harinas (DDRCH), said district comprises the municipalities of Villa Guerrero, Coatepec Harinas, Tenancingo, Zumpahuacán, Ixtapan de la Sal, Tonatico, Malinalco, Ocuilan, Texcaltitlán, Almoloya de Alquisiras, Sultepec and Zacualpan, which in the case of the Coatlan River sub-basin and the municipalities located in it, would be included in the DDRCH, which according to Orozco (2007) has 9,772.2 hectares cultivated with flowers, which made up 88 percent of the total area cultivated with ornamental flowers and generated 84 percent of the value of the state floricultural sector's production.

The hypothesis from which the current article starts is that the origin of the floricultural activity in the region was brought about by the Japanese undertaking the search for ideal conditions of the environment. In this sense, the initial cultivation in the state of Morelos did not have such characteristics as those found in the municipalities of Villa Guerrero, Tenancingo and Coatepec Harinas, which indicate the adphological knowledge of the Japanese, thus initiating one of the most prolific activities in the south of Estado de México.

## **2. METHODOLOGY**

The study was conducted in Villa Guerrero, Tenancingo and Coatepec Harinas, municipalities belonging to region VI, south of Estado de México. This area is adjacent to the north with the municipalities of Valle de Bravo, Amanalco, Zinacantepec, Tenango del Valle, Texcalyacac and Tianguistenco; to the east with the state of Morelos; to the south with the state of Guerrero; and to the west with the municipalities of Amatepec, Tejupilco and Zacazonapan of Estado de México, as shown in Figure 1. This covers an estimated area of 3,655,98 square kilometers (km<sup>2</sup>), equivalent to 16.26 percent of the total state territory.

Figure 1: Location of municipalities in the region VI south, Estado de México.



Source: Compiled from INEGI, 2016.

Region VI South has altitudes ranging from 800 meters (m) to 3900 m. Most of the territory (66 percent) is between 1500 and 2500 meters above sea level (mamsl). According to García (1998), the most representative climate is the semi-warm sub-humid group C, because it has an average annual temperature higher than 18 degrees celsius (°C), a temperature lower than 18°C in the coldest month, in the warmest month higher than 22°C. Precipitation in the driest month is less than 40 millimeters (mm); summer rainfall has a seasonal rainfall index (P / T) between 43.2 and 55, and a winter rainfall percentage from 5 percent to 10.2 percent per year.

For this approach, research was carried out concerning historical phases, in order to know the origin of the floricultural activity in the municipality of Villa Guerrero, while the field work allowed to identify the municipalities with the greatest floricultural activity in the region.

For the territorial analysis the method of classification of supervised land use was applied through specialized cartography which allowed for the interpretation of resources in the area that

makes up these three municipalities. Their characteristics also became known, and with that the area with greenhouses and its growth in the period of 1996-2016 was identified.

The method that was developed consisted of the handling of satellite images of Landsat 8, with spatial resolution of 30m, February 2016, bands 5, 4 and 3 and satellite images of Landsat 5, with spatial resolution of 30m, February 1996, bands 4, 3 and 2, specialized software was used to classify the land use of the region using the satellite datasheet to select the best spectral signatures to identify bodies of water, dense forest, mixed forest, agriculture, human settlements, greenhouses and grasslands.

The result of the treatment of the images was a raster file that kept the satellite resolution. This format was converted into a vector file to perform a cleaning procedure and verification of the first classification. Finally, the edition of the mapping was developed based on the analysis sought.

### **3. RESULTS AND DISCUSSION**

#### **Villa Guerrero: Origin of the floricultural activity**

The composition and production expansion of the municipality of Villa Guerrero is structured around cultivation, at first of peach, avocado and flowers. The initial precedent of commercial production in this area was that of the tomato, which allowed the inhabitants of the municipality to generate prosperity reporting that the volume and marketing of the product was in the order of 12 trucks per week. Subsequently, there was a decrease in production due to the explosion of the Parícutín volcano, whose ashes, negatively affected the cultivation areas. Another version for the decrease and loss of crops was the lack of interest of producers to continue producing tomato, as there is no evidence to claim that volcanic ash was the cause of crop loss (Castro, 2003).

A third version is one that comes from the collective memory of the people of Villa Guerrero, saying that such a decrease was caused by the change of crop, from tomato to avocado, which was introduced by a couple of North American migrants (The Johnson family) who also founded the ranch La Frambuayana (Castro, 2003)

The new crop adapted to the climatic conditions of the municipality, which encouraged rapid acceptance by producers and yielded up to 10 more truckloads<sup>1</sup> per week, which were transported to the La Merced market in México City every week on Thursday. The peach was another important crop, whose production and market price became a nodal activity in the

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<sup>1</sup> The transportation of tomato and avocado to the market of La Merced was done through vehicles owned by Samuel González, where Laureano Ortega, a native of Villa Guerrero, then bought and offered the goods.

previously mentioned municipality, to such a degree that in some peach groves up to 60 workers were employed.

This trend was interrupted by a very aggressive pest that not only damaged the avocado crops, but also the peach ones. These events led producers to look for new crops according to the physical-geographical characteristics of the area, reason why the cultivation of flowers was established as one of the basic and fundamental tasks of the neighboring municipalities around Villa Guerrero, as was the case of the town of Santa Anita in the municipality of Tenancingo, whose flower production was carried out in pots, which were then offered at the local market on Thursdays and Sundays in Tenancingo. Despite this effort, the production was not relevant enough for the producers and the market there, reason why it was moved to Villa Guerrero, considered the best place in the southern region of Estado de México for this activity.

It was in this municipality between 1950 and 1960, that the cultivation of flowers began to take off, activity which became very appealing to several Japanese families such as the Matsumoto, Muriyama, Simishu, Nagamini, Yamagushi, Yukota, Kawabata, Sato, Hito, Ushio, among others. The culture and discipline of these migrant families managed to change the activity from orchards to floriculture, initially in rented spaces, and given the results, the Matsumoto family began acquiring properties such as Rancho Colorado, owned by former governor Wenceslao Labra, for the cultivation of roses, gladiolous and carnations (Fenner and Gebauer, 1992).

In concordance, the Association of Flower Growers of Villa Guerrero (Asflorvi), indicates that during the year of 1952 a group of Japanese residents in México City found in that municipality the ideal conditions for the cultivation in the open of carnations. The group of Asians was made up of the Moriyama, Imuta, Nagamini, Kudo, Kinto, Sato, Ushio, Kano, Horiuchi, Yamaguchi and Kawabata families (DIF Villa Guerrero, 2016). In this regard, the floricultural activity in Estado de México has its origin in Villa Guerrero with the work done by the Japanese migrants, where the participation of the local labor force was more than relevant, mainly in those tasks that demanded greater physical effort (El Universal, 2012).

Thus, in certain places such as the Rancho Colorado owned by the Matsumoto family, an average of 20 people worked as laborers, while in the communities of Santa María, San José and San Miguel, belonging to the municipality of Villa Guerrero, the workers totaled around 100. The tasks were done in shifts of eight hours a day, Monday through Friday, while the last work day, Saturday, the time was reduced by half, while at the same time receiving a higher salary than that offered for other jobs done in the area, what was locally attractive for the production of carnations, delphiniums and daisies.

The diversification of flower cultivation caused the Matsumoto family to be considered as the ones who monopolized the production of flowers, both in the region and throughout the country; their products were shipped to México City for marketing, passing through Toluca, by using the shipping services offered by the Corona Roja transport line. By making three runs, the merchandise arrived at the flower shops for retail sale, a situation that allowed the controlling of the flower production chain, which by the end of the 1950's had displaced all the other activities that were practiced in the municipality (such as avocado and peach growing) (Castro, 2003).

The knowledge developed by the Japanese created an alternative for the local workers to establish their own spaces to cultivate, but the limitation was the availability of vegetative material, since it was an input of difficult access given its high cost. This resulted in the extraction (theft) of cuttings from the Asians' cultivation areas. This way the growing of flowers began to expand due to the incipient participation of the local producers of Villa Guerrero, which also contributed in giving some strength to the local economy, but it also accelerated the displacement of the avocado and peach crops.

Likewise, the competition began to grow so that the incipient local producers saw their aspirations curtailed as this situation represented the marketing of the product and the opposition of the associations of flower producers that were at the points of purchase in the capital of the country, which were not willing to let this type of producers divide the market of flowers.

Faced with this situation, the producers of Villa Guerrero began to group together to form an association that would achieve representation and assist in both offering the product and obtaining fair prices for the quality of the flowers. Castro (2003) states that the first association was made up of small flower growers from different localities, which allowed for the creation of the Villa Guerrero Floricultural Association, considered a solid organization with great influence in the purchase and introduction of new varieties such as the carnation that came from the United States.

In this context, there was a diversification of varieties, expanding the lands dedicated to the cultivation of flowers and ornamental plants. This kind of productive organization caused great competition with the Japanese producers, a situation that resulted in their gradual displacement, to the extent that in the second half of the sixties, the Japanese abandoned Villa Guerrero. From there, such activity has been in constant expansion towards other neighboring municipalities that have not only adopted flower growing, but has also intensified to the point of becoming one of the most significant regions in the development of this activity at the state and national level.

Thus, during the autumn-winter and spring-summer agricultural cycle of 2014, the municipality of Villa Guerrero had an area sown on irrigation mode of 2,154 hectares, whose production value

was 1,016,898.62 million pesos (SIAP, 2017). In this regard and in order to give momentum to the floricultural activity, the producers, the associations of floriculturists and the different orders of government have recently promoted the development of floriculture trying to emulate the success of other countries with a floricultural vocation as is the case of Colombia.

Several municipalities of floricultural tradition such as Villa Guerrero, Coatepec Harinas, Zumpahuacán, Tenancingo and Malinalco have benefited from the operation of this project. About 80 percent of the flowers that are exported are produced within this group of municipalities, that is why it is known as a floricultural corridor, which makes up for 46.5 percent of the ornamental horticulture surface of the country, mainly of species such as chrysanthemum, carnation, rose, liliun, gerbera and statice (SEDAGRO, 2014).

#### **4. REGIONAL EXPANSION OF FLORICULTURE**

The agricultural activity developed in Villa Guerrero from the Japanese enterprise influenced the process of expansion of neighboring towns and municipalities, so that in the south of Estado de México the largest extension of land in México intended for the cultivation of cut flowers is currently located. The so-called floricultural region includes the agricultural district of Coatepec Harinas and includes the municipalities of Villa Guerrero, Coatepec Harinas, Tenancingo, Zumpahuacán, Ixtapan de la Sal, Tonático, Malinalco, Ocuilan, Texcaltitlán, Almoloya de Alquisiras, Sultepec and Zacualpan.

The forming of this region is the result of a historical process initiated by the Japanese and adopted by the local population, which led to the substitution of the tomato, peach and avocado crops for flowers and ornamental plants. This is how the floriculture activity in this region allowed for the foundation to be laid down to establish an articulated production environment on a global scale (Miranda and Macri, 2014).

According to Rubio (2002) the second phase has its beginnings in the fifties and the two following decades where the increasing integration and subordination of agriculture to industry begins, which represented a significant role attributed to the agricultural sector as a supplier of cheap inputs to the industrial sector, in which traditional crops such as corn, sugarcane, legumes and vegetables became more important. In this way the agriculture that developed in the south of Estado de México, fulfilled the requirements of the previous development model from the supplying of raw materials, coupled with the process of industrialization of agriculture that demanded the use of improved seeds, fertilizers, pesticides and other inputs.

Given this background, there was a boom in floriculture, where the activity was favored by the trade liberalization in favor of large producers at the expense of farmer subsistence economies. This dynamic was reflected in:



- The production of flowers in the region represents 38 percent of the national area.
- Production makes up about 80 percent of the total volume of flowers produced in México.
- There are about 24.3 million gross, 14.3 million pots and 5.3 million bunches, which is equivalent to 3,676 million stems produced, with a value of 3,046 million pesos.

Unlike Villa Guerrero, in the beginning the municipality of Tenancingo had a vocation for the development of floriculture, mainly for the local market. As new production techniques were adopted, it led to the establishment of companies committed to flower growing, such as the case of Flores de Tenancingo, Villa Flor and Flores Selectas with an area of five hectares each. (Castro, 2003).

Starting from 1974 the floriculture companies arrived in the municipality of Tenancingo, particularly the town of Francisco Zarco, which contributed to its continuous and accelerated growth. One of the most important companies was the Union of Flower Growers "Los Morales", founded in 2008, under the auspices of the Government of Estado de México and the Secretary of Agriculture, Livestock, Rural Development, Fishing and Food (SAGARPA) with the mission of using the best production techniques used in floriculture, in addition to the company's vision of supplying the local and regional market's demand (Xotla and Ruiz, 2012). The union currently has 60 varieties on the market, meeting the demand for roses, with red being the most sought after with 70 percent; white with 15 percent; pink with 10 percent and yellow with 5 percent.

One of the factors that favored the spread of this activity to other municipalities was the densification of communication channels by the federal government, which allowed these companies to contribute 70 percent of the production for export, thus ensuring not only profit but also its continuity. The importance of Tenancingo for the region is based on the fact that it serves as the most important point of sale both for the local and regional settings, explained by a production capacity that exceeds 5 billion pesos, while recording an average annual growth rate of 13.79 percent in the last nine years, going from 39,338 tons in 2005 to about 95 thousand tons in 2010.

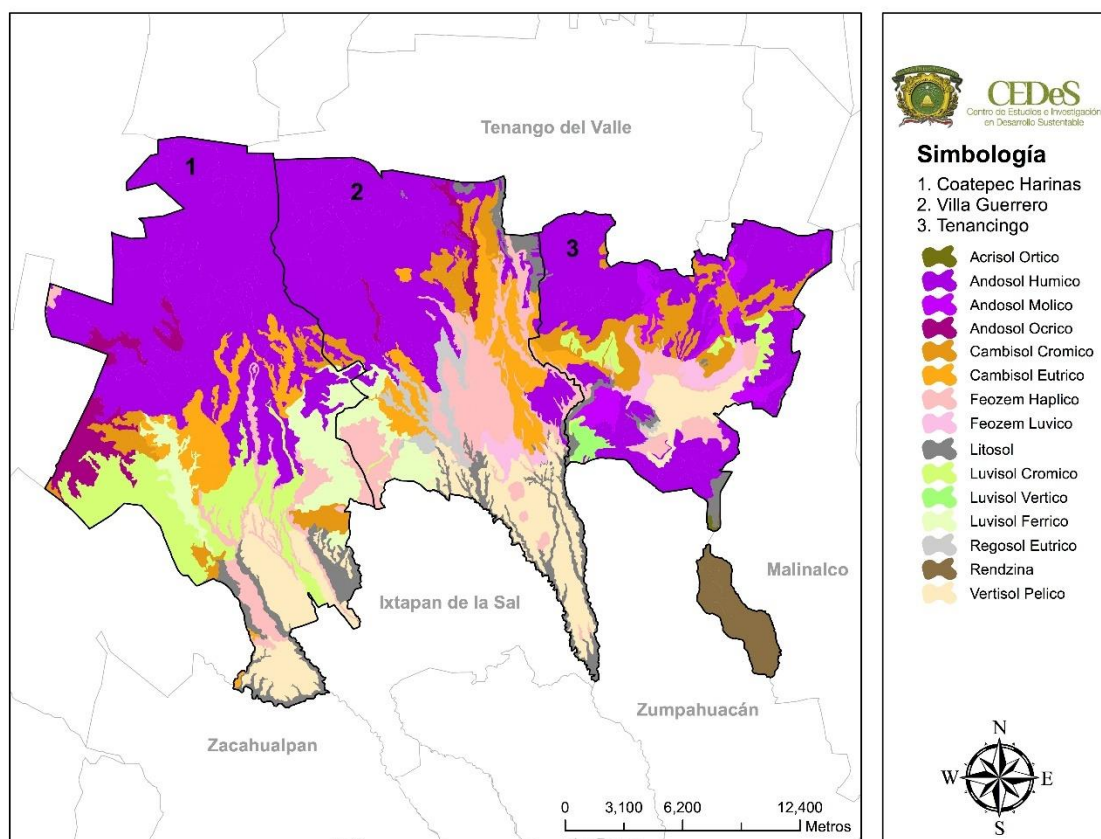
#### **4.1 Land use and transformation within the region.**

Understanding a territory from the multi and transdisciplinary study converges in explaining the activities and social relationships that the human being develops in a specific geographic, political, cultural, economic and environmental space, since these infer the configuration, modification, planning and management of it. (Carrillo, 2016).

For Pecqueur (2009) the term territory refers to "constructed socio-economic entities " so that the actors' ownership becomes a birth certificate of sorts, this implies that the points of view from a

single perspective are surpassed, to make the concept broader. The territory of Villa Guerrero where the floricultural activity of the region originated, is located between the municipalities of Coatepec Harinas and Tenancingo, as can be seen in Figure 2. This geographic location reflects its importance as a central point for its continuity from the municipality of Tenancingo and its expansion towards Coatepec Harinas.

**Figure 2: Edaphological characteristics of the municipalities of the region VI South, Estado de México.**

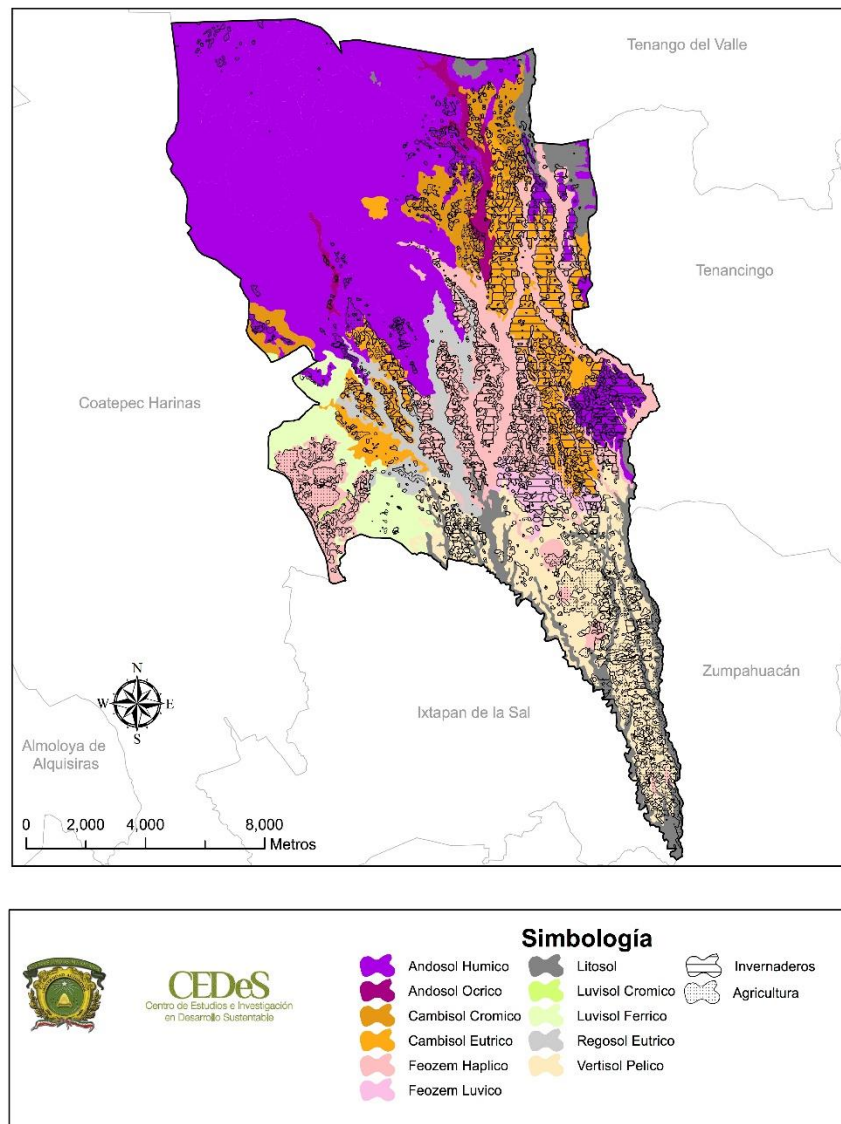


Source: Carrillo et al. (2017).

The process of regional transformation of the three municipalities (Villa Guerrero, Tenancingo and Coatepec Harinas) is reflected in the knowledge, usage and use that its inhabitants have given this area from the 50's with the arrival of Japanese migrants, who found a vocation for the use of soil and the appropriate climate for agriculture, specifically floriculture. In Figure 3, the characteristics of the soil of the three municipalities can be seen, where the territory's different

types of soil are shown; Andosols, Cambisols, Feozem, Fluvisols, Lithosols, Luvisols, Regosols and Vertisols.

**Figure 3: Edaphology and land use by activity in the municipalities of region VI South, Estado de México.**



Source: Carrillo et al. (2017).

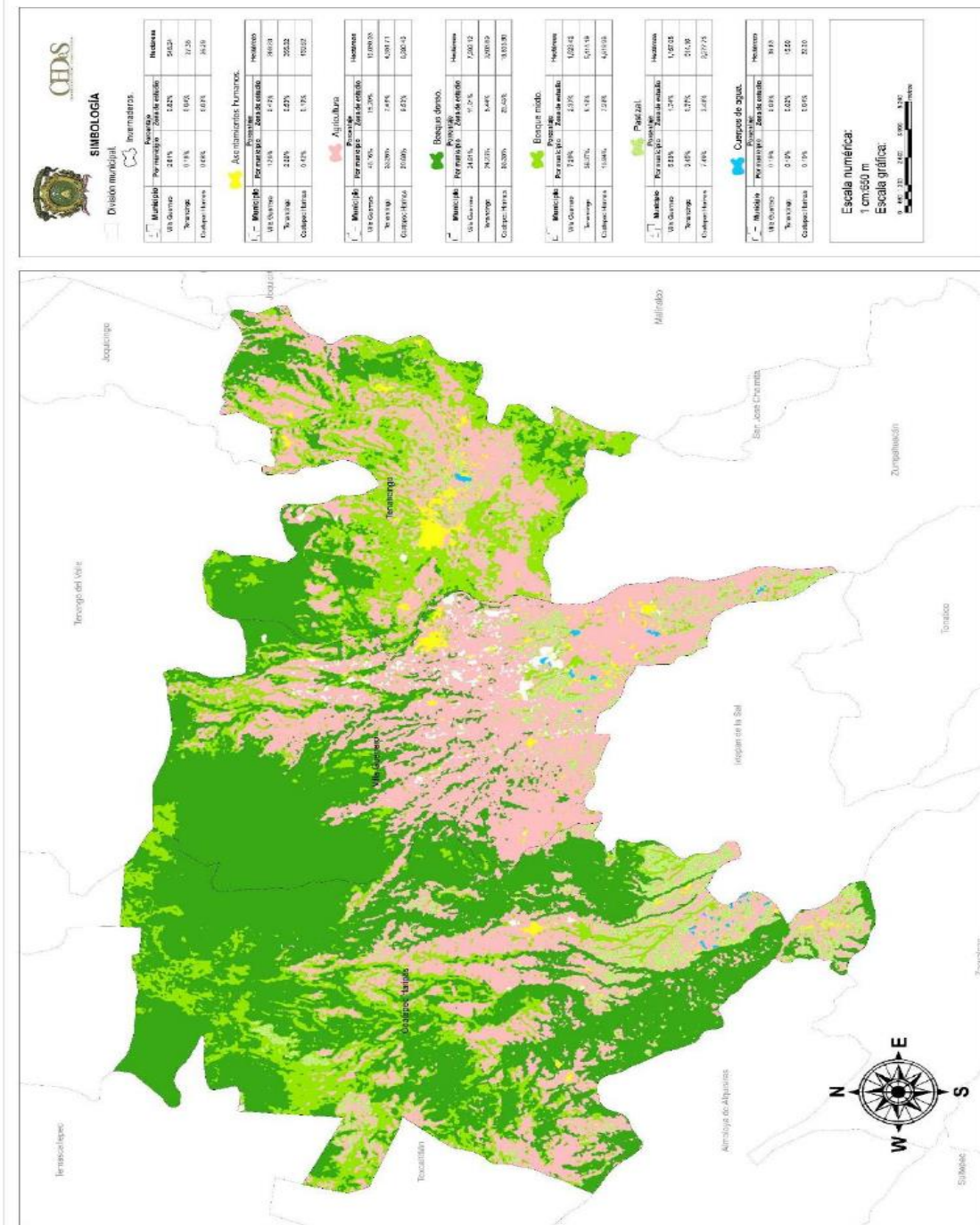
The soil in which agriculture and greenhouse use have predominated is the Cambisol, sub classified as the eutric and chromic types. The second type of soil preferred for these activities is the Andosol, sub classified as the humic and mollic types. Finally, there are the Feozem and the Vertisols, which are used to a lesser extent for these activities.

The world soil baseline of the Food and Agriculture Organization of the United Nations (FAO) in its description, distribution and management of soil groups, is that these develop in ejections or volcanic glass in almost any climate, as well as in materials rich in silicates under acid weathering in humid and perhumid climates, additionally their connotation is of a black soil in volcanic landscapes. He also mentions that many of the Andosol type soils belong to Kuroboku (Japan). This can be the explanation for the knowledge that the Japanese who came to the municipality of Villa Guerrero possessed. In this regard the question posed by Castro (2003) is answered in reference to: how did the Japanese know that the local microclimates were appropriate for this activity? Furthermore, how did they reach a region as isolated as the south of Estado de México?

Thus, the area that these three municipalities make up has undergone a transformation in its use and configuration since the change in the type of agriculture began in the 1950s. In the 70's, flower companies arrived and started a production process in the region that has gradually become established. During the process of creation, growth and adaptation of the companies and flower producers, new production techniques have emerged which have been reflected in the area since the beginning when open fields were first used and by the 1990's when greenhouse construction increased, innovating and optimizing the production of flowers and ornamental plants.

Through the process of territorial analysis using the method of classification of supervised land use for its interpretation, specialized cartography was created that allowed us to analyze the solar use in the studied area. This makes it possible to verify the location and expansion of greenhouses in a twenty year period; 1996-2016. Figure 4 shows the distribution of land use in the three municipalities that make up the floricultural area in 1996. On this year, the largest number of greenhouses was located in the municipality of Villa Guerrero in which there were 546.34 hectares (HA) which represented 2.61 percent of the municipality's territory and 0.82 percent of the regional setting. By 1996 the municipalities of Tenancingo and Coatepec Harinas had a smaller number of hectares used for greenhouses since these were 27.38 and 25.29 HA respectively, which made up 0.18 percent of Tenancingo's territory and only 0.08 percent of Coatepec Harinas's.

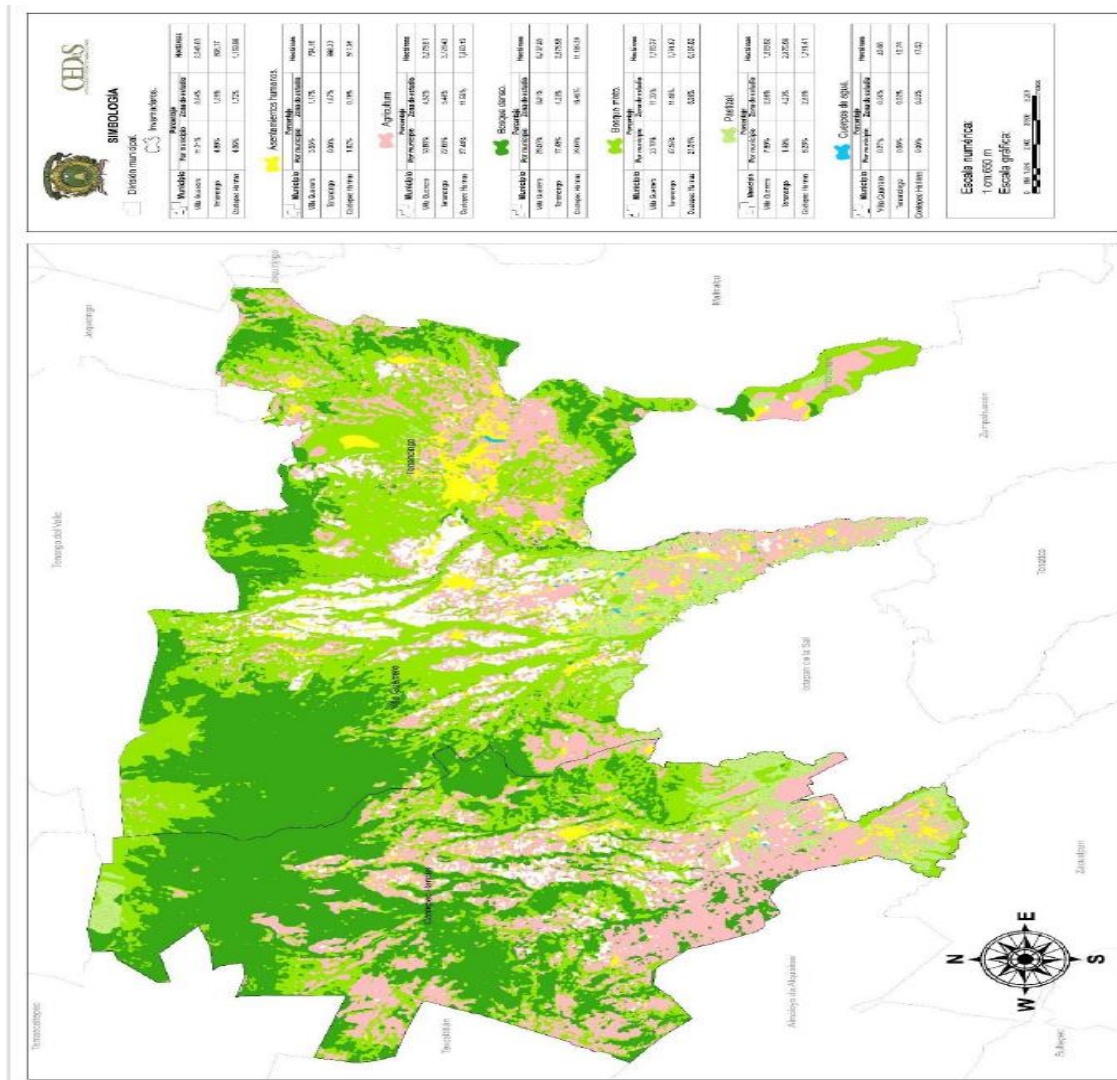
Figure 4: Distribution of land use in the three municipalities belonging to region VI South, Estado de México, 1996.



Source: Carrillo et al. (2017).

By the year 2016, the land intended for floriculture in greenhouses had increased considerably, which has caused a densification of the greenhouse blot on the map of the area of the three municipalities, as can be seen in Figure 5, although the municipality of Villa Guerrero continues to be the most important with 11.21 percent of its territory and 3.64 percent of the region designated for this purpose, the continuity and expansion of floricultural activity through the use of greenhouses can be seen.

**Figure 5: Distribution of land use in the three municipalities belonging to region VI South, Estado de México, 2016.**



Source: Carrillo et al. (2017).

Table 1 shows the number of hectares and percentages corresponding to the territory of each municipality in a twenty year period. In Villa Guerrero, the number of hectares dedicated to greenhouse use has more than quadrupled, while the municipality of Tenancingo has increased it by more than twenty-nine times, and Coatepec Harinas increased the land destined for this priority activity in the region by more than forty-five times.

**Table 1: Land use for greenhouses in the region VI South, Estado de México, 1996-2016.**

Municipality	Hectares		Percentage			
	Year		By municipality		In relation to the studied area	
	1996	2016	1996	2016	1996	2016
Villa Guerrero	546.34	2,546.63	2.61	11.21	0.82	3.64
Tenancingo	27.38	806.17	0.18	4.89	0.04	1.09
Coatepec Harinas	25.29	1,159.98	0.08	4.06	0.03	1.72

Source: Compiled based on Carrillo et al. (2017).

The continuous and accelerated growth in the change of cultivation in the open for the greenhouse type in the region, allows making a forecast like the one presented in Figure 6, which shapes the land use in the municipalities of Villa Guerrero, Tenancingo and Coatepec Harinas.

## 5. CONCLUSION

The floricultural activity in the southern region of Estado de México has its origins in the interest and cultural skills of some migrants from Japanese families. The search was based on finding places, whose soil characteristics were ideal and had the best conditions for flower growing, since at first Cuernavaca and Temixco, in the state of Morelos, were not considered to be the most suitable for the cultivation of flowers and ornamental plants.

The tour of the Matsumoto family through the southern part of Estado de México took them to the municipality of Villa Guerrero, where they noted a key indicator for the future development of floriculture, that is to say, avocado cultivation was the element that led them to believe that there was suitable and excellent quality soil for flower growing. In addition, the other elements that favored the development and spread of this activity was climate and water, which added to

the human factor have contributed not only to the development, but also to the growth and optimization of the cultivation of flowers and ornamental plants.

Another potential factor that the Japanese migrants noted while in the location of the region in question was that they possessed the edaphological knowledge to identify the nature and composition of the soil in the area. While on their journey they recognized the similarity of the soil in southern Estado de México with that of Japan.

The activity transcends the agricultural limit that the Japanese had established regarding specific times and activities, the latter being learned and mastered by local farmers which gave them the option of becoming independent and carrying out the cultivation on their own, which also allowed for the activity to be performed by the farmers in Villa Guerrero and the neighboring municipalities.

The previously mentioned activity denotes a process of adapting flowers and their varieties to the conditions of the environment not only in the municipality but in the region as well, at the same time this implies a range of knowledge developed by the now producers, who, despite the initial limitations of vegetative materials and considerable extensions of land, had key elements for the initial cultivation; which were water and land combined with micro climates.

These factors allow the development of an activity that is in constant progress, product of the drive of the state and federal administrations who through programs offer the option to finance a certain sector of producers while the rest of them cover their own production process in the open and under conditions of knowledge and local technology or adapting the available materials and resources.

The use of agricultural land that initially produced crops was replaced by floriculture to carry out production for the commercial market, this process of change created a territorial transformation in which infrastructure was developed to promote the construction of greenhouses on farmland. Additionally, in each greenhouse there is at least one human settlement as opposed to the agricultural model where it was not necessary to have an urban type building in it.

However, despite the limitations, the production of flowers and ornamental plants has been emphasized and diversified, while expanding to other municipalities, such as Tenancingo, Ixtapan de la Sal, Coatepec Harinas, Zumpahuacan, Malinalco, Ocuilan, among others. Whose volume, variety and quality, have contributed so that this region is considered one of the most important flower corridors in México and the only one in the state, its international coverage is reflected in the exports made to the United States, Canada, Japan and other countries.



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## **ABBREVIATIONS AND ACRONYMS**

Abbreviation and acronyms should be defined the first time they appear in the text, even after the have already been defined in the abstract. Do not use abbreviations in the title unless they are unavoidable.