Original Research Article

PRODUCTIVE VOCATION IN SEASONAL MAIZE IN CALPAN, PUEBLA, MEXICO

Abstract

The objective of the study was to analyze and diagnose the productive specialization of the municipality of Calpan, for which the Location Coefficient (LC), proposed by Boisier (1980), was calculated. The unit of analysis was the Economically Active Population (EAP) occupied by sector of the economy. Twelve semi-structured interviews with key informants in the municipality were also conducted. A questionnaire was applied to a representative sample of 110 producers involved in planting seasonal maize. The results indicate that there is a productive specialization according to the EAP in Mexico promoted towards the secondary and tertiary sectors of the economy. The municipality of Calpan specializes in the agricultural sector. It should be noted that the agricultural specialization in maize represents the support food of the families, which is the reason for the persistence in its cultivation. It is also important to highlight the coexistence of agricultural systems such as the family orchard and the management of maize and livestock. The relationship between the two is important to improve nutrition.

Key words: productive specialization, economically active population, maize.

INTRODUCTION

Since 1980, the agricultural sector in Mexico has been in crisis [1] due to the implementation of neoliberal economic policies focused on competitiveness [2] through productive specialization as the main factor of economic growth [3]. Specialization stimulates economic growth by increasing labor productivity and obtaining increasing returns from areas and goods that offer the best technology or sales in international markets [4]. However, productive specialization linked to economic growth generated economic instability in less industrialized countries with the agricultural production model

based on comparative advantages, by prioritizing profitable crops for the market, generating the need to buy staple foods, such as corn in Mexico [5].

Food dependence on basic grains in Mexico has a long history [6], and this situation undermines national security by solving shortages through imports [7].

In view of this situation, various multilateral organizations at the global and regional levels are urging countries to strengthen their native (traditional) agriculture, which is basic for feeding their people, to avoid possible food shortages, social and political destabilization [8].

In Mexico's case, it is necessary to reflect on the agricultural specialization model promoted as a policy through the green revolution and industrialization for small producers [9], which, according to Gerbeau and Avallone [10], has favored the deterioration of natural resources.

The previous situation generates the possibility of directing efforts towards a new development model based on agricultural specialization derived from traditional knowledge that has proven capable of increasing the production of basic grains [11], through agroecological practices with the concomitant conservation of natural resources [12, 13] and consequently increasing the production of basic grains that favors food security and family autonomy [14].

Therefore, the objective of this work was to analyze and diagnose the productive specialization of the municipality of Calpan, Puebla, Mexico.

MATERIALS AND METHODS

Study area

Calpan is located between parallels 19° 03' and 19° 09' of NL and meridians 98° 23' and 98° 35' of WL between 2 200 and 3 200 m altitude and a surface area of 67 km2 (INEGI, 2015), (Figure 1). The research is framed as a case study [15], quantitative and qualitative research techniques were combined.

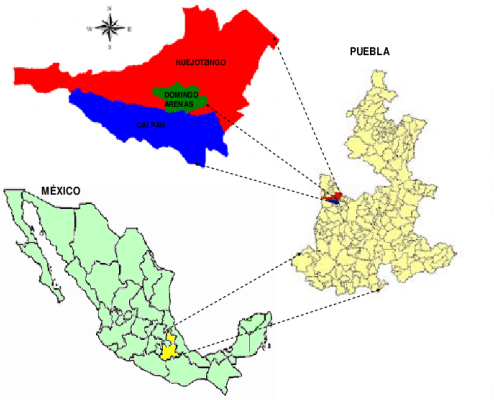

Figure 1. Geographic Location of Calpan, Puebla-Mexico

Relief and Soil

It is located in the Neovolcanic Axis, and the dominant relief is volcanic Sierra (97%) and alluvial plain with hill (3%). The dominant soils are Arenosol (86%) and Andosol (1%). The main activity is seasonal agriculture (71%), forest (16%) and urban area (13%) [16]. There are intermittent and permanent streams coming from the foothills of Iztaccihuatl [17].

Research techniques

The quantitative techniques in the research were based on the review of secondary sources and the application of an in-depth survey to seasonal corn producing families. The information obtained was complemented with qualitative methods such as on-site observation of reality, and semi-structured interviews were conducted with key informants in the municipality.

***In situ* observation of reality**

The work began with field trips, in an action to take in the reality in its real and existing dimension, i.e. at a scale of 1:1 [18]. The aim was to appropriate the reality [19] in order to obtain first-hand information on the socio-productive processes in the municipality [20].

Calculation of the Specialization Coefficient

To identify the agricultural productive vocation and demonstrate the territories with specialization in seasonal agriculture, the location coefficient (LC) proposed by Boisier [20] was calculated. This coefficient allows the identification of spatial concentration or dispersion patterns of a sectoral activity, i.e., it compares the percentage participation of a region in a particular sector with the percentage participation of the same region. The

unit of analysis was the Economically Active Population (EAP) employed by sector of the economy.

The calculation of LC is obtained with the following mathematical expression:

$$LC = \frac{\mathrm{Vij}}{\sum_{i=1}^{n} \mathrm{Vij}} + \frac{\sum_{j=1}^{m} \mathrm{Vij}}{\sum_{i=1}^{n} \mathrm{Vij} \sum_{j=1}^{m} \mathrm{Vij}}$$

LC = location coefficient, Vij = total economically active population of sector i in the state or municipality j., i = 1, 2,..., (primary, secondary or tertiary sector of the economy), j = 1,2,..., (States of the Mexican Republic), n = number of sectors of the economy, m = number of municipalities and states.

$\sum_{i=1}^{n}$ Vij = total de población económicamente activa en el Municipio

$\sum^{m}$ Vij = total de población económicamente activa del sector i en el Estado.

$\sum_{i=1}^{n} V_{ij} \sum_{i=1}^{m} V_{ij}$ = total de población económicamente activa en el estado.

LC = location coefficient, Vij = total economically active population of sector i in the state or municipality j., i = 1, 2,..., (primary, secondary or tertiary sector of the economy), j = 1,2,..., (States of the Mexican Republic), n = number of sectors of the economy, m = number of municipalities and states.

The values will be compared with the following values and ranges:

(a) if LC= 1, it means that the relative importance of the economic sector i in state j is identical to that of this sector in the country or in the Municipality depending on the case of analysis.

b) if LC < 1, it indicates that in the state j, the relative importance of sector i is lower than in the municipality. If this or the previous case were to occur, there would be no productive specialization in that sector of the state in sector i;

c) if LC > 1, it indicates that sector i is more important in the state j than at the municipal level. Therefore, it can be concluded that LC > 1 shows that the state j is specialized in economic sector i.

Questionnaire design and application

The questionnaire included 130 questions related to economic activities as well as agricultural production techniques and practices, income, demographic, social and cultural aspects.

Sample calculation

The simple random sampling formula was used to determine the sample size [21].

$$n = \frac{Z^2_{\alpha/2}\, S_n^{\,2}}{d^2 + Z^2_{\alpha/2}\, S_n^{\,2}}$$

Where:

n= Sample size. 547 benefited families from “PROAGRO Productivo” in the municipality of Calpan, d=.14 (Precision), $Z_{\square/2}$= 1.95 (Reliability 95%), S_n^2= .25

Simple random sampling was applied with proportional distribution of the municipal sample according to the number of producers in the communities (334 San Andrés Calpan, 146 San Lucas Atzala, 62 San Mateo Ozolco and 5 Pueblo Nuevo). The sampling frame was the beneficiaries of “PROAGRO Productivo[1]” and the selection of the sampling units was done randomly one by one and without replacement. The sample size was 110 families with the following distribution: San Andrés Calpan 42, San Lucas Atzala 36, San Mateo Ozolco 27 and Pueblo Nuevo 5.

Semi-structured interviews

Twelve semi-structured interviews were conducted with key informants (municipal president, ejidal commissioner, agricultural producers) and included guiding questions on economic, social, cultural and agricultural production aspects.

Producer typology

To demonstrate the agricultural specialization in corn, the families interviewed were classified into F1 and F2, according to economic activity. The F1s, in addition to planting corn, carry out other economic activities in the primary sector; and the F2s, in addition to planting corn, carry out other activities in the secondary and tertiary sectors of the economy. This typology compared the families and allowed us to know the particularities of the productive specialization, as well as to show the advantages of having an agricultural specialization in corn in the municipality.

RESULTS AND DISCUSSION

Reviews of secondary sources allowed us to identify the economically active population and agricultural production data.

In agricultural production, the area planted with corn, represents 67% of the total species and contributes 46% of the total production value (Table 1).

Corn is followed by gladiolus, beans, spinach, cauliflower, peas, green chili and onions, which together account for 40% of the total. Even though corn has been the most sown crop, it has presented important variations over time, such as the 16% decrease in 2015 [17]. This reflects the low profitability of agricultural activity.

The transformation of the crop structure does not imply the complete change and replacement of the old structure oriented to maize production; rather, crops are interwoven and changes in agricultural activities over time reflect the importance of marginal populations, such as Calpan, to improve household food security due to recurrent environmental challenges and the political and logistical capacity of governments [22].

Table 1. Agricultural production, planted area, yield and value of production in the municipality of Calpan, 2015.

Agricultural production	Surface (Ha)	Production (Ton)	Value (thousands of ($)
Corn *(Zea mays* L*)*	2,258.60	4,916.81	24,711.38
Bean *(Phaseolus vulgaris* L*)*	368.20	341.25	2,771.99
Mexican Hawthorn *(Crataegus mexicana* Moc.	87.30	612.10	831.01
Spinach *(Spinacia oleracea* L*)*	82.50	1,100.25	4,327.00
Green bean *(Vicia faba* L)	74.70	717.72	1,457.93
Pear *(Pyrus communis* L*)*	73.80	301.00	891.67
Pea *(Pisum sativum* L)	63.70	381.15	2,606.72
Fodder Oats *(Avena sativa* L)	62.60	988.93	776.31
Apple *(Malus domestica* Borkh.)	48.50	284.66	896.39
Cilantro *(Coriandrum sativum* L)	42.00	414.00	850.66
Barley *(Hordeum vulgare* L)	37.60	688.51	262.44
Green Alfalfa *(Medicago sativa* L)	37.00	2,904.50	925.87
Onion *(Allium cepa* L)	31.50	421.94	3,428.12
Green Chile *(Capsicum annuum* L)	30.50	237.20	2,127.88
Cauliflower *(Brassica oleracea* var. Botrytis L)	20.50	611.93	2,043.85
Plum *(Prunus domestica* L)	19.20	128.99	601.96
Cabbage *(Brassica oleracea* var. Capitata (L.)	15.50	356.50	684.48
Gladiolus *(Gladiolus* sp L.)	9.10	7,492.00	2,622.20
Peach *(Prunus pérsica* (L.) Stokes)	7.50	42.10	263.21
Brussels sprouts *(Brassica oleracea* L. var.	5.50	112.75	296.53
Vetch (Janamargo o Veza) *(Vicia sativa* L)	5.50	83.00	56.02
Green Tomato *(Physalis philadelphica* Lam)	4.10	22.02	72.67
Pumpkin *(Cucurbita pepo* L)	2.50	37.00	266.40
TOTAL	3,398.10		53,964.48

Source: Prepared by the authors based on data available from SIAP, 2020.

Productive specialization in agriculture, as in the case of corn in Calpan, generates conditions of food stability and allows improving crop practices, as well as increasing production, yield and quality [23]. Several studies cite that regional productive specialization is combined with crop diversification, but the planting of seasonal maize for self-subsistence is preserved, as in this case, in addition to the mobility of one or more family members to work in a non-agricultural work [24, 25].

In the case of livestock, cattle production is the highest in the municipality, followed by swine and poultry (Table 2).

Table 2. Livestock production by species, price, production value and weight in the municipality of Calpan, 2015.

Livestock Production	Production	Price (pesos per	Production Value

	(tons)	Kilogram)	(thousands of pesos)
On foot:			
Bovine *(Bovinae)*	143	18.36	2,632
Swine *(Sus scrofa domestica)*	88	23.66	2,080
Ovine *(Ovis aries)*	26	25.40	673
Goat *(Capra aegagrus hircus)*	6	20.00	112
Chicken *(Gallus domesticus)*	46	21.87	995
Turkey *(Meleagris gallopavo)*	6	41.26	257
Canal:			
Bovine *(Bovinae)*	84	38.02	3,211
Swine *(Sus scrofa domestica)*	68	36.37	2,475
Ovine *(Ovis aries)*	14	50.00	715
Goat *(Capra aegagrus hircus)*	3	42.97	127
Chicken *(Gallus domesticus)*	38	27.38	1,040
Turkey *(Meleagris gallopavo)*	5	60.18	284

Source: Prepared by the authors based on data available from SIAP, 2020.

The percentage of participation by species activity is distributed by 46% bovine, 27% swine, 9% ovine and 17% in poultry. The contribution of bovine livestock decreased 3% compared to 2016 and ovine, in the same period increased 2% [26].

Consequently, there are two scenarios, one that reflects the crisis of traditional productive activity and the other, which has given rise to the emergence of new rural actors [27] with the modification of the reproduction strategies of peasant domestic units (PDU), as indicated by Sacco [28] when referring to the diversification of activities of families that practice seasonal agriculture and combine various activities (agricultural and non-agricultural) within or outside their PDU. In this regard, Arrieta Bolaños [29] adds that pluriactivity can be a reaction strategy to a situation of risk, vulnerability or adaptation and, according to Cirilo [30], it tends to be followed by a social process of commoditization. Pluriactivity can be an effective survival strategy to improve the income of rural households [31], even when they have reduced their agricultural income and their dependence on agriculture is lower [14]; in addition, pluriactivity can cause the producer, by temporarily or permanently abandoning or neglecting planting, to reduce his specialization in crop management [32].

The growth of the tertiary and secondary sectors has caused people engaged in the primary sector to participate in these sectors to supplement their income [33].

Agricultural specialization in the cultivation of corn in the municipality of Calpan.

The general characteristics of the families in the localities of the study municipality are presented in Table 3.

Table 3. Families, maize yield, hectares planted and size of the family orchard of families in the municipality of Calpan, Puebla-Mexico.

Municipality	Number of Families	Average yield (Kg Ha^{-1})	Planted Hectares	Family orchard size (m^2) (MTS)
San Andrés Calpan	42	2488	3.05	420
San Lucas Atzala	36	2406	2.20	355
San Mateo Ozolco	27	2412	2.71	450
Pueblo Nuevo	5	2440	2.40	354
Promedio Municipal		2436	2.59	

Source: Own elaboration based on data from the 2020 survey.

The average family is composed of 5.9 inhabitants, and the level of schooling is 4.7 years. The average area dedicated to planting corn is 2.59 ha and they obtain an average yield of 2,441 kg ha^{-1}. With these values, 434 kg of corn are available per person.The low yield of corn crops is associated with the origin of the dominant soils, sandy soils, which are characterized by a low capacity to retain water and store nutrients [22,16], however, they offer ease for rooting and harvesting root and tuber crops, or some timber species [22], but the permanent development of annual crops, such as corn, requires inputs that are generally not economically justifiable.

In the municipality of Calpan, government support (Prospera, pro-agro-productive, etc.) is a constant for families. However, the availability of resources for small producers in the agricultural sector is minimal [34]. In addition, Lavinas [35] and Villagómez [36] point out that rural assistance programs do not work and do not fulfill their objectives.

The peculiarities underpin the premise that specialization cannot be general, as it recognizes the particular characteristics of producers.

When calculating the LC per area planted with corn with respect to the municipalities of the State of Puebla, Calpan showed a specialization of 1.07 in corn. Considering the land and its limiting factors, as well as the genetic potential of the crop, management is ultimately the determining factor in production. In this regard, Gudiño [37], points out that

certain territories suffer changes in their morphology due to the influence of the internationalization of the economy, and others are excluded or marginalized. In terms of municipalities specialized in the primary sector and in another sector, whether secondary or tertiary, 11% of the economy was represented. Agricultural activity was outstanding as an employer of the EAP in the municipalities. Calpan is specialized only in the primary sector of the economy (2.57 CL).

The activities additional to maize cultivation in the primary sector (F1) and the families that carry out these activities in the secondary and/or tertiary sector (F2) are presented in Table 4.

Table 4. Agricultural characteristics according to the typology of the families in the localities of the municipality of Calpan, Puebla-Mexico.

Location		Families (F1)	Families (F2)
Calpan	Families	27	15
	Corn yield (Kg/Ha)	2679	2143
	Monetary income in Mexican pesos ($)	25,801	42,376
	Corn planted hectares (Ha)	1.9	3.7
	Family orchard size (m^2)	510	256
	Vegetable frequency of plants	524	112
	Average heads of older livestock	114	17
	Average heads of younger livestock	658	139
San Lucas Atzala	Families	24	12
	Corn yield (Kg/Ha)	2554	2112
	Monetary income in Mexican pesos ($)	28,600	34,675
	Corn planted hectares (Ha)	2	2.5
	Family orchard size (m^2)	353	320
	Vegetable frequency of plants	440	84
	Average heads of older livestock	124	20
	Average heads of younger livestock	220	196
San Mateo Ozolco	Families	19	8
	Corn yield (Kg/Ha)	2542	2106
	Monetary income in Mexican pesos ($)	28,573	38,693
	Corn planted hectares (Ha)	1.8	3.1
	Family orchard size (m^2)	494	347
	Vegetable frequency of plants	359	58
	Average heads of older livestock	64	10
	Average heads of younger livestock	534	104
Pueblo Nuevo	Families	3	2
	Corn yield (Kg/Ha)	2600	2200
	Monetary income in Mexican pesos ($)	30,533	36,000

	Corn planted hectares (Ha)	1.7	3
	Family orchard size (m^2)	450	420
	Vegetable frequency of plants	39	15
	Average heads of older livestock	13	5
	Average heads of younger livestock	43	6
	Total number of families	73	37
	Corn yield (Kg Ha^{-1})	2593	2140
	Monetary income in Mexican pesos ($)	28,376	37,936
Promedio	Corn planted hectares (Ha)	1.85	3.07
Municipal	Family orchard size (m^2)	451	335
	Vegetable frequency of plants	340	67.25
	Average heads of older livestock	159	27.5
	Average heads of younger livestock	238	87.5

Source: Own elaboration based on data from the 2020 survey.

In summary, the F1 families have more members, and in addition, the age of the producer is higher, they are primarily engaged in agricultural activities. In contrast to the F2 families, most of whom indicated that they are engaged in other activities unrelated to agriculture.

F1 families obtain 17.4 % more corn yield compared to F2 families. This reflects the farmers' specialization in maize cultivation, even though the planting area of F1 farmers is 40% less. In this regard, Nadal and Wise [31], point out that family members who are engaged in other unrelated activities generate interruption of maize planting for prolonged periods and this action probably hinders the transmission of traditional knowledge, and consequently may reduce the ability in the proper management of maize cultivation.

A producer specialized in the management of his crop is empowered to innovate, generate or adapt knowledge and technologies to increase the income of rural families [32].

The case studies will show that the perception of food security will be higher in the PDU, that only carry out agricultural activities and are specialized in the management of their agricultural resources.

In this respect, there is also an average increase in the vegetable frequency of plants, and in the number of older and younger livestock units.

It is possible to affirm from the data found, that a productive specialization in the primary sector does not mean that there is a specialty in the management of resources related to agriculture, specifically in the management of corn and home orchards.

Specific maize cultivation practices in Calpan

Productive specialization in maize was evident for families engaged in agriculture-related activities (F1 families) (Table 5).

Table 5. Agricultural practices in the management of maize according to the typology of the families in the localities of the municipality of Calpan, Puebla-Mexico.

	Families 1	Families 2
Native seed selection (%)	100	40
Planting date (month)	March-April	April-May
Use of manure (kg ha^{-1})	2.196	.834
Crop association (%)	98	43
Associated hectares (Ha)	100	57.5
Association with leguminous plants (%)	92	25
Crop rotation (%)	88	17
Soil conservation (%)	79	47
Plant density	70,125	56,353
First cultivation work (%)	100	100
Second cultivation work (%)	100	100
Third cultivation work (%)	100	0

Source: Own elaboration based on data from the 2020 survey.

Some agricultural practices of Families 1, such as the use of native seeds, manure application, association of species in the crop as leguminous plants, crop rotation and soil conservation, induce interaction between soil microorganisms that promote nitrogen fixation, such as bacteria of the genus *Rhizobium* [38] or endomycorrhizal fungi present in the soil, that favor the transport of phosphorus, other nutrients and water to the host plant, whether corn or leguminous plants [39]. These practices increase yield per hectare by promoting agroecological interactions that improve the productivity of the scarce resources used for the agroecological management of maize [40].

Particularly in San Andrés Calpan, Pueblo Nuevo and San Lucas Atzala, corn growers associated the corn crop with fruit trees, such as pomegranate *(Punica granatum* L),

walnut (*Juglans regia L*), apple (*Malus domestica Borkh*.), bean *(Phaseolus vulgaris* L.), pumpkin (*Cucúrbita máxima* Duchesne) and fava bean (*Vicia faba* L).

In the crop rotations and species associations (or polycultures) case, the presence of pests and diseases decreases, both in the root system and in the aerial part of the maize plant, and this is expressed in increased crop efficiency [41].

The application of manure to Calpan sandy soils favors the increase of organic matter, nutrients such as N and P [38], in addition to improving soil structure with the increase of organic matter, which consequently retains more usable moisture for the crop [42, 43].

Peasant knowledge in the management of resources applied in agricultural production arises from experience and practice, fundamental characteristics of the older population (59 years on average of heads of maize-producing households) in the study municipality [44, 45, 46].

The interviewees indicated that the preference to use native corn seed starts with the selection immediately after harvest (97%), and 98% of the producers do it based on the size of the corncob and that it does not show signs of disease, in addition to considering the corncob to be thin and in some cases (33%) the number of rows of grain. Flores [47] found in his research that the number of rows per corncob correlates with yield. The preference for the native seed is due to its flavor, which is appreciated in the preparation of tortillas.

CONCLUSIONS

The municipality of Calpan presents productive specialization in the primary sector (agriculture) and a tendency towards secondary and tertiary sectors. The specialization is not general as it recognizes activities of other sectors of the economy. The corn crop persists because it is the food sustenance of the families in coexistence with home orchards, association of corn with leguminous plants, bovine and ovine raising.

References :

1.- Ortega, O. D., & Jiménez, Z. I. (2017). AGRICULTURAL POLICY OF MEXICO AND CHINA. Journal of Research in Science and Management, 3(4), 33-51.

2.- De Alcántara, C. H. (2014). Essay on the obstacles to rural development in Mexico. Retrospective and prospective. Contempt, (25), 79-100. Retrieved on August 10, 2023, from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1607-050X2007000300004&lng=es&tlng=es.

3.- Klinger, B., Hausmann, R., & Lawrence, R. (2016). Examining Benefit.

4.- Ocegueda Hernández, J. M., Castillo Ponce, R. A., & Varela Llamas, R. (2009). Regional growth in Mexico: Specialization and key sectors. Developmental Problems, 40(159), 61-84.

5.- González Chávez, H., & Macías Macías, A. (2007). Food vulnerability and agri-food policy in Mexico. Contempt, (25), 47-78.

6.- Rubio, B. (2016). The dominion of hunger. Crisis of hegemony and food (Mexico: Universidad Autónoma Chapingo/College of Postgraduates/University of Zacatecas/Juan Pablos Editor, 2014), 270 pp. Mexican Journal of Sociology, 78(2), 317-321.

7.- Rosset, P. M., & Torres, M. E. M. (2016). Agroecology, territory, re-peasantization and social movements Agroecology, territory, re-peasantization and social movements. Social studies. Journal of Contemporary Food and Regional Development, 25(47), 273-299.

8.- FAO. (2012). The State of World Agriculture and Food. Food & Agriculture Org.

9.- Guareschi, M. (2017). Challenges and challenges from the paradigm of Food Sovereignty and Agroecology for the Development Cooperation and Rural Development processes. Learning from the Paraguayan context.

10.- Gerbeau, Y. M., & Avallone, G. (2016). Producing cheap food and labor: migrations and agriculture in the capitalist world-ecology. International Relations, (33), 31.

11.- Nicholls, C. I., Altieri, M. A., & Vázquez, L. L. (2017). Agroecology: Principles for the conversion and redesign of agricultural systems. Agroecology, 10(1), 61-72.

12.- Reyes Reyes, J., J.A. Rodríguez Morales, D. Pimienta de la Torre, M.A. Fuentes Pérez, P. Marroquín Morales, A. Merino García, and J.F. Aguirre Medina. 2022. Diversity and tree structure of shade trees associated with Coffea arabica L. in Soconusco, Chiapas. Mexican Journal of Forest Sciences 13 (71):4-27. https://doi: 10.29298/rmcf.v13i71.1191.

13.- Baldi, E. (2021) Soil–plant interaction: effects on plant growth and soil biodiversity. Agronomy 2021, 11, 2378. https://doi.org/10.3390/agronomy11122378

14.- Turrent-Fernández, A., Cortés-Flores, J. I., Espinosa-Calderón, A., Turrent-Thompson, C., & Mejía-Andrade, H. (2016). Climate change and some agricultural strategies to strengthen food security in Mexico. Mexican Journal of Agricultural Sciences, 7(7).

15.- Saldaña Contreras, Y., Ruiz Díaz, F. M., Nahuat Arreguín, J. J., Gaona Tamez, L. L., Camacho, C., & Viririana, M. (2017). Knowledge Systematization of the Case Study Method to Research the Family Business.

16.- INEGI, (2010). National Institute of Statistics, Geography and Information (INEGI). Population and Housing Census 2010.

17.- INEGI, (2015). National Institute of Statistics, Geography and Information (INEGI). Cartography of the state of Puebla-Mexico, 2015.

18.- González G, Edelmira. Direct observation is the basis for the study of local space. In: Geoteaching, vol. 10, no. 1, January-June, 2005, pp. 101-105 Universidad de los Andes San Cristobal, Venezuela. Available at: http://www.redalyc.org/articulo.oa?id=36010107

19.- Damián Huato, M. Á., Ramírez Valverde, B., Parra Inzunza, F., Paredes Sánchez, J. A., Gil Muñoz, A., López Olguín, J. F., & Cruz León, A. (2007). Agricultural technology and territory: the case of corn producers in Tlaxcala, Mexico. Geographical investigations, (63), 35-55. Retrieved on August 10, 2023, from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-46112007000200004&lng=es&tlng=es.

20.- Boisier, S. (1980). Regional analysis techniques with limited information. Documents on Projects, Studies and Research ECLAC Headquarters in Santiago (Studies and Research). 212 p. https://hdl.handle.net/11362/33492

21.- Snedecor W.G. and Cochran G.W. (1967). Statistical Methods. Tenth printing, 1984. CECSA. Mexico DF. pp. 625-630.

22.- FAO (Food and Agriculture Organization of the United Nations). 2006. IUSS Working Group WRB. World reference base for soil resources 2006. A framework

for international classification, correlation and communication World Soil Resources Reports No. 103. FAO, Rome. 143 p.

23.- FAO. (2012). Crop yield response to water. (FAO Soil and Drainage Bulletin No. 66). Rome: FAO.

24.- Pinto, L. H. (2017). Food sovereignty, environmental justice and territorial peasant resistance against the metabolic changes of free trade: theoretical and empirical notes from the Mexican experience|| Food Sovereignty, Environmental Justice and Peasant Resistance Agaist Metabolic Changes of Free Trade: Theoretical and Empirical Notes Based on the Mexican Experience. Reason and Word, 20(3_94), 517-542.

25.- De Grammont, H. C. (2010). The evolution of agricultural production in the Mexican countryside: productive concentration, poverty and pluriactivity. Scaffolds, 7(13), 85-117. Retrieved on August 10, 2023, from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1870-00632010000200005&lng=es&tlng=es.

26.- SIAP, 2016. Agri-food and fishing information service, annual production by state agricultural closure 2016.

27.- Echánove, F. and C. Steffen (2005). Agribusiness and Farmers in Mexico: the Importance of Contractual Relations. In The Geographical Journal, 171(2): 166-176.

28.- Sacco dos Anjos, Flávio, & Grossi, Mauro Eduardo Del, & Velleda Caldas, Nádia (2010). Food security from another perspective: analysis of the evolution of the Brazilian population employed in self-consumption activities. Geographic Investigations (Mx), (73),103-118.

29.- Arrieta Bolaños, S. (2015). Article I. Agroecological practices to improve production and food security in home gardens (HC). Agroecological practices to improve production and food security in home gardens in Central Nicaragua. Thesis (Master's Degree in Sustainable Agricultural Systems)--CATIE, Graduate School, Turrialba (Costa Rica). https://repositorio.catie.ac.cr/handle/11554/7212

30.- Cirilo, A. G. (2004). Corn crop yield. Management of density and distance between corn rows. IDIA, 21(6), 128-133.

31.- Nadal, Alejandro and Timothy A. Wise (2004). “The Environmental Costs of Agricultural Trade Liberalization of Mexico-U.S. Maize Trade Under NAFTA”, Discussion Paper, No. 4, Working Group on Development and Environment in the Americas, <http://ip.cals.cornell.edu/courses/iard6010/mexico/NadalWise July04.pdf>, Brasilia, pp. 24-26.

32.- Damián, M. A., B. Ramírez, A. Gil, N. Gutiérrez, A. Aragón, R. Mendoza, J. A. Paredes, T. Damián and A. Almazán (2004), Appropriation of agricultural technology. Technical and social characteristics of corn producers in Tlaxcala, Benemérita Universidad Autónoma de Puebla, National Council of Science and Technology-Zaragoza Research System and H. Congress of the State of Tlaxcala, Puebla, Mexico.

33.- De Grammont, H. C. (2016). Towards a fragmented rurality: The deagrarianization of the Mexican countryside. New Society, (262), 1-11. https://nuso.org/articulo/hacia-una-ruralidad-fragmentada-la-desagrarizacion-del-campo-mexicano/

34.- Escalante, R., Catalán, H., & Basurto, S. (2013). Determinants of credit in the Mexican agricultural sector: an analysis using a Probit model. Rural Development Notebooks, 10(71).

35.- Lavinas, l. (2014). Social policies in Latin America in the 21st century: conditional monetary transfer programs. Economic Development, 3-34.

36.- Villagómez, F. A. (2014). Saving for retirement: A reflection for Mexico. The economic quarter, 81(3), 549.

37.- Gudiño, M. E. (2015). Territorial transformations associated with globalization. A theoretical-methodological reflection. Time and Space, (15).

38.- Zuberer, D.A. 2005. Biological dinitrogen fixation: Introductio and Nonsymbiotic. In: Sylvia, M.D., Fuhrmann, J.J., Harte, G.P. and Zuberer, A.D. (Eds). Principles and applications of soil microbiology. Second Edition.Pearson Prentice Hall., New Jersey, USA., p 373-403.

39.- Read, D.J., Perez-Moreno, J. Mycorrhizas and nutrient cycling in ecosystems – a journey towards relevance? New Phytol. 2003, 157, 475-492. https://doi.org/10.1046/j.1469-8137.2003.00704.x

40.-Altieri, M. A., & Nicholls, C. I. (2013). Agroecology and resilience to climate change: principles and methodological considerations. Agroecology, 8(1), 7-20. Recovered from https://revistas.um.es/agroecologia/article/view/182921

41.- Riverol, M. G., & Aguilar, Y. (2015). Alternatives to reduce soil degradation in Cuba and confront climate change. Sowing in Living Land. Agroecology Manual. 185 p. Havana. May, 2015., 121.

42.- Vázquez-Vázquez, C., García-Hernández, J. L., Salazar-Sosa, E., López-Martínez, J. D., Valdez-Cepeda, R. D., Orona-Castillo, I., ... & Preciado-Rangel, P. (2011). Application of solarized manure to the soil and the production of jalapeno pepper (Capsicum annuum L.). Chapingo Magazine. Horticulture Series, 17(SPE. 1), 69-74.

43.- Restrepo, J. M., Gómez, J., & Escobar, R. (2014). Use of organic waste in agriculture.

44.- Riat, P., & Pochettino, M. L. (2015). The remedies of the mountain: validity of local phytotherapeutic knowledge in Los Juríes (Santiago del Estero, Argentina). Latin American and Caribbean Bulletin of Plantas Medicinales and Aromatics, 14(2).

45.- Sarandón, S. J., & Flores, C. C. (2014). Agroecology: theoretical bases for the design and management of sustainable agroecosystems. Teaching books collection. Editorial of the National University of La Plata. Chapter, 5, 131-158.

46.- Castillo-Nonato, J., & Chávez-Mejía, C. (2013). Peasant characterization of the management and use of corn diversity in San Felipe del Progreso, State of Mexico. Agriculture, society and development, 10(1), 26-38. Retrieved on August 10, 2023, from http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1870-54722013000100002&lng=es&tlng=es.

47.- Flores, C., Castillo, R., & Rodriguez, M. (2013). The importance of the services sector in the Mexican economy: a time series analysis. Economic Paradigm, 5(1), 5-27.