Socioeconomic characteristics of sisal producing municipalities in the State of Yucatan, Mexico using Principal Component Analysis

Características socioeconómicas de los municipios productores de sisal en el estado de Yucatán, México utilizando el análisis de componentes principales

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Abstrac

This paper seeks to analyze market trends and foresight of Henequen (Sisal: plant native to Mexico; source of textile fiber, agave and tequila) in the state of Yucatan, build a stratification of producing municipalities using productive characteristics, social shortcomings and infrastructure. To do this, we have used variables obtained from SAGARPA for its initials in Spanish (Secretaria de Agricultura Ganadería Desarrollo Rural Pesca y Alimentación, Sistema Agroalimentario y Pesquero), CONEVAL (Consejo Nacional de Evaluación de la Política de Desarrollo Social) and Consejo Nacional de Población. Multivariate principal component analysis (PCA) has been used to generate new variables and stratify municipalities according to productive and socioeconomic characteristics. Results: Four main components accumulate an explained variability of 81.79%. Subsequently, a Pearson correlation was made between the components and variables under study in order to determine groups of associated variables. From the first component, five stratums of producing municipalities were generated in order to relate their levels of socio-economic and productive development. Today the state of Yucatan has the technological and scientific conditions, as well as infrastructure and human capital, to boost the economy of the henequen industry and generate an infrastructure for producing biofuels.

Sisal, Principal component analysis, Public policy

Resumen

Este trabajo busca analizar las tendencias del mercado y la previsión del Henequén (Sisal: planta originaria de México, fuente de fibra textil, agave y tequila) en el estado de Yucatán, construir una estratificación de municipios productores utilizando características productivas, deficiencias sociales e infraestructura. Para ello, hemos utilizado variables obtenidas de SAGARPA para sus iniciales en español (Secretaría de Agricultura Ganadería Desarrollo Rural Pesca y Alimentación, Sistema Agroalimentario y Pesquero), CONEVAL (Consejo Nacional de Evaluación de la Política de Desarrollo Social) y Consejo Nacional de Población. El análisis de componentes principales multivariados (PCA) se ha utilizado para generar nuevas variables y estratificar a los municipios de acuerdo con las características productivas y socioeconómicas. Resultados: Cuatro componentes principales acumulan una variabilidad explicada de 81.79%. Posteriormente, se realizó una correlación de Pearson entre los componentes y las variables en estudio para determinar grupos de variables asociadas. A partir del primer componente, se generaron cinco estratos de municipios productores para relacionar sus niveles de desarrollo socioeconómico y productivo. Hoy el estado de Yucatán tiene las condiciones tecnológicas y científicas, así como infraestructura y capital humano, para impulsar la economía de la industria del henequén y generar una infraestructura para la producción de biocombustibles.

Sisal, Análisis de Componentes principales, Política pública

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Introduction

Unfortunately, in Mexico as of 2014, there is no record of henequen production, being the Yucatán state the most important producer of the Mexican Republic. This situation reflects a reality of loss of the main product that had greater economic booms at the beginning of the last century in that region. Although henequen has been given a significant promotion as a potential product for the development of the region, the results of production show a significant reduction of cultivated soils, and therefore, a decrease in the income of small producers in recent years. This reality is not different from other agricultural sectors, such as the case of Jatropha curcas where its production has deteriorated in Chiapas, Mexico (Soto, Ellison, Kenis, Diaz, Muys y Mathijs, 2018).

The situation of small producers in Mexico is in an uncertainty about the henequen market, economic disincentives to continue without adding value to the product, high transaction costs, lack of innovation and technological development applied to small producers, as well as, high emigration of people from rural areas to urban areas. However, the Federal Government has a tool to transfer resources to areas with higher levels of marginalization called Prospera. But, according to results obtained by Parker and Vol (2017) estimate that the effects will be observed by the new generations of children in education, work, income and economic status given the characteristics of the Program. In this way, it could be inferred that the income of small producers dedicated to the cultivation of henequen can be rewarded by welfare programs that are currently implemented by the federal government.

Productive context of global Henequen

Henequen (Agave fourcroydes) is a monocot plant, agave genus belonging to the family of Agavaceae. It originates from Yucatan and has been successfully introduced into some areas of Tamaulipas, Veracruz, and in Cuba. In countries like Brazil and East Africa, it is known by the name of sisal; as recorded by Food and Agriculture Organization statistics (FAO, 2014). Henenquen is originally known by the Mayan name "Sacci" (sak-CHEC) in the state of Yucatan.

For its fiber quality, the cultivation of Sac ki or white hemp has been the most widespread among plantations; however, the Yaax ki, of lower quality and performance, is in danger of extinction as it is no longer cultivated (Financiera Rural, 2011; Martínez *et al*., 2011).

Sisal has various pseudonyms by region and country where it is produced. According to la Estación Experimental de Citricultura y Zootecnía El Valle, D.F. (1942), the word sisal is derived from the Old Port of sisal in Yucatan; the Mayans called it "yacci". According to the United States Department of Agriculture USDA (1931), “Hard fibers are commonly known as Sisal (sisal hemp -agave sisalana- and -agave fourcroydes, Lem.). Currently in Yucatan, there are three varieties of hemp: Sac ki (white sisal), Yaax ki (green sisal) and Kitam ki (boar sisal).

In countries such as Cuba, Dominican Republic, Guatemala, Honduras and Nicaragua it is called sisal. In Mexico, the climax of domestic production of sisal corresponded to the period of 1880-1918 when the demand for fiber rose as a result of the mechanization of agriculture. In fact, a productive reconversion process took place transforming lands dedicated to the cattle and corn industry into those of henequen producing soils (Canto, 2002).

There were several factors that led to the gradual decline of henequen production in Yucatan. In the United States, a consortium of companies that monopolized the purchase of sisal from the Yucatan peninsula was formed, resulting in reduced fiber prices; there was also a lack of organization of Yucatan landowners, and more and more countries joined in on the production of sisal (Cuba, Kenya, Brazil, among others). Throughout the sixties, as a result of the aforementioned, cultivated areas diminished and high volumes of product were no longer obtained. The situation worsened in the nineties due to the furthering of productive diversification and economic crisis’ in Yucatan (Yucatan Produce Foundation, 2011). In the state of Yucatan according to SAGARPA and SIAP, 40% (43) of the 106 municipalities that the state is comprised of, have records of henequen cultivation. The state of Tamaulipas is the second largest entity that produces green sisal in Mexico.

The planted area of henequen in the state of Yucatan is distributed amongst 40 municipalities, with a total area of 8,512 hectares (2014), well below the 84.670 hectares that were sown in 2000 (SIAP-SAGARPA, 2015). There is a close relationship between marginalization and socio-economic characteristics of producing municipalities. Within the main strategies to increase the growth of henequen sector is the development of new frontier knowledge, technology and innovation to transfer it to small and medium producers to increase the added value of the by products: beverages, organic fertilizers, generation of raw materials for the footwear industry, fibers, among others.

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The most representative henequen producing countries in Africa are: Kenya with 26,000 tons and Tanzania with 37,400 tons in 2013, followed by South Africa, Madagascar and Mozambique, among others (FAO, 2014). In 2013, Brazil stood out in Latin America obtaining a production of 74,600 tons; however, during the period of 2008 - 2013 the AAGR was reduced from 6.7% (105,600 tons) in 2008 to 74,600 tons in 2013 (FAO, 2014).

From a commercial point of view, sisal is a product that takes on a new strategic economic dimension as well as an explorative outlook to the agro industry. According to FAO statistics and the configuration of the international market, the African continent has had an increase in henequen production from 66,900 tons in 2008 to 76,500 tons in 2013, representing an annual average growth rate of 2.7% (AAGR) 2008 – 2013.

In contrast, due to an interior impulse demand, Chinese sisal production increased from 53,000 tons in 2008 to 63,100 tons in 2013, representing an increase of 3.6% per year. Another Latin American country that ventured into the production of sisal was Cuba, which had a production of 1400 tons per year during the 2008 - 2013 period (FAO, 2014). According to FAO estimates, total world production of sisal and henequen has decreased slightly from 261,100 tons in 2008 to 257,000 tons in 2013; this represents a reduction of approximately 3% during that period.

It is worth noting that in 2013, there were other productions of other hard fibers like “Fique” that represented a total of 24,500 tons. In Argentina; Chile and South Africa, Phormium tenax is found (important fibre and ornamental plant native to New Zealand and Norfolk Island), together these 3 sites produce up to 3.3 billion tons each year. Furthermore, other hard fibers can be found in varying parts of the world including Brazil (caroa), Costa Rica (sisal), El Salvador (Latvian), Ethiopia (banana et doum), Mauritius (aloe), Philippines (maguey), Reunion (aloe) and other fibers which together in 2013 produced around 12 thousand tons. Among the countries that stand out in the exporting of sisal and henequen (fiber and manufacturing) are Brazil, Haiti, Kenya, Madagascar, Mexico, Mozambique, Tanzania, China, Europe, Costa Rica, Cuba, El Salvador, South Africa and Venezuela.

In 2013, world exports rose to 152,600 tons; fibers corresponding to 77,900 tons with an increased AAGR of 4.5% during 2008 – 2013; meanwhile, manufacturing fluctuated by 74,700 tons reducing exports in this same period to a -4.5% AAGR. Notably, Brazil exported 60,700 tons of sisal globally; 29,700 tons of which were fiber, 24,200 tons of cordage (rope) and other manufactured products (Yarn-Carpets) 6,800 tons. Kenya came in second to Brazil, with 24,000 tons of fiber and 600 tons of cordage; Tanzania followed up with 16,900 tons of fiber and 5,500 tons of cordage (FAO, 2014).

FAO registry of exports to Mexico reached only 1.9 billion tons per year in 2012 and 2013 respectively; this indicates an international share of only 1.25% of sisal and henequen exported worldwide. This situation reveals a large window of business opportunity for the state of Yucatan to increase its efforts with public policies aimed at increasing productivity, competitiveness and the economy of the sector.

Regions that excelled in 2013 regarding henequen as a raw fiber import (in thousands of tons) were: Europe with (22.3), Africa (5.8) and Latin America (4.1); importation of fiber used for manufacturing in the same year were: Canada (2.6 thousand tons), United States (27.2), the European Union (17.8), France (4.4), Germany (3.0), East Asia (6.8), Latin America and the Caribbean with (2.6) (FAO, 2014).

Mexico, as of 2007, became an importer of mainly Brazilian sisal fibers. According to the “Tariff Information System via the Internet” from the Secretary of Economy (Sistema de Información Arancelaria Web: SIAVI)”, in 2014, Mexico imported 1,742 tons of sisal (tariff code 53050005) with a value of $2,431,283. During the period of January to August 2015 they imported about 1,656 tons of sisal with a value of $2,744,988. Contrastingly, in 2014, Mexico exported 43.34 tons of fiber with a value of $60.699 US dollars (SIAVI, 2015).

New perspectives on the use of henequen

For many years henequen has been used as a raw material for producing fiber. The Scientific Research Center of Yucatan A.C (Centro de Investigación Científica de Yucatan: CICY) notes that this process represents only 5% of the whole plant (CICY, 2010). This situation creates a opportunity to prospect and undertake new uses of farming in the areas of food, pharmaceutical, personal care and as a raw material in biofuel production (Fonseca *et al.*, 2014).

Also, the Innovation Agenda of the Yucatan National Council of Science and Technology (Consejo Nacional de Ciencia y Tecnología: CONACYT) rates henequen as a present specialized niche in the production chain from the primary sector up to the industrial sector (CONACYT, 2014).

Henequen can be used to produce alcoholic beverages and some recent studies show the possibility of bioethanol production (Martínez, *et al*., 2011; Cáceres *et al*., 2008). Also, there are several extracts that are worth mentioning: fertilizer, biogas, pulp for livestock feed, waxes for industrial use and hecogenin, among other highly demanded vegetable based steroids used worldwide. Henequen juice can also be used as a bio detergent for scrubbing and washing, as well as an emulsifier for fuels.

Currently there are studies investigating bioethanol production from molasses and henequen juice (Agave fourcroydes Lem.) using a mixture of yeasts; in the Yucatan peninsula, technologies are being developed to use this “juice” (byproduct of the fiber from the henequen industry (Agave fourcroydes Lem.)) in the production of bioethanol. In 2005, this industry processed 250 million leaves for the production of 5,000 tons of fiber that generated 75 million liters of juice as waste. The Mexican Society of Biotechnology and Bioengineering states that, “This substrate contains a high percentage of oligofructans that can be used in the production of bioethanol" (2009).

The CICY, in a joint effort with its chemistry department, has conducted research on new biotech trends from henequen extracts. It is stated that, "Henequen leaf ‘juice’, derived from the pulping process of the leaves and the concentration of the leaves for automated fiber extraction allow the obtainment of large amounts of juice concentrate rich in saponins steroids, such as hecogenin and tigogenin: raw materials used in the pharmaceutical industry as precursors of biologically active steroids "(CICY, 2010).

Agave strains are beginning to be considered “potential” raw materials for the production of bioenergy (bio-ethanol); this due to the fact that they are already well known in the production of “ethanol”. They can exist in arid lands where food crops cannot grow; thus, in the long run resulting in substantial profits.

Grade of marginalization	Sown surface area of henequen shown in hectares	Average population percentage of illiterate persons 15 years of age or older	Average population percentage having less than 5000 habitants (2010)	Population 2010	
(GMMA) Very high	36	20.26	100	Average	2,768.00
				Sum	2,768.00
(GMA) High	179.1	19.23	100	Average	3,898.00
				Sum	19,490.00
(GMM) Medium	359.31	13.89	69.58	Average	8,175.51
				Sum	286,143.00
(GMB) Low	11	7.84	22.32	Average	62,865.00
				Sum	62,865.00
(GMMB) Very low	57.5		4.85	Average	897,331.00
				Sum	897,331.00
(GMT) Total	315.72	14.27	71.22	Average	29,502.26
				Sum	1,268,597.00

Table 1 Socio-economic characteristics of sisal producing municipalities
Source: Based on data of the SIAP-SAGARPA (2011) and CONEVAL (2015)

Socioeconomic importance of henequen producing municipalities in Yucatan

Of the 106 municipalities in the state of Yucatan, 43 have sisal plantations (40% of the basic administrative units of the state), and according to 2010 marginalization levels, there are differences amongst the sown areas (Table 1). For example, in municipalities with a “very high” degree of marginalization, on average, 36 hectares are planted; areas with a “high” degree of marginalization typically plant 179.10 hectares and this is further reduced to 11 hectares in municipalities with “low” marginalization.

However, it is observed that the highest percentage of illiterate population (15 years or older) is located precisely in henequen producing municipalities with “very high” and “high” levels of marginalization, together having a population of 22,258 inhabitants; this figure 1 constrasts the 5,000 or less habitant norm which generally characterizes rural locations (CONAPO, 2015 and SIAP-SAGARPA, 2015).

The Sistema Producto Henequen (Henequen Product System (2012) presents a classification of producers according to their number of hectares in three blocks (Table 2): the most important being that which focuses on 1-5 hectares of farmland, accounting for 86.4% of total rated producers.

Corresponding to the level of technology, the Henequen Product System establishes that producers with low-medium technology levels, mainly pertinent to the social sector, make up 80% of the total; those with medium-high technology levels, mostly being from the private sector, make up for 20% of all total producers.

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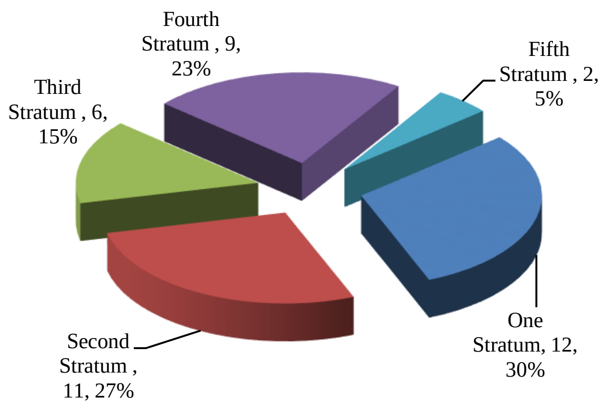
Number of hectares	Number of producers in the state	Total percentage
1 – 5	3,279	86.40%
6 – 20	479	12.60%
21 o más	36 1	0.00%
Total	3,794	100.00%

Table 2 Number of hectares and producers in the state of Yucatan
Source: Henequen Product System 2012

The CICY (2010) mentions that in the northwestern region of the state of Yucatan (henequen zone) there are 10,000 families dependent on this type of farming. This situation becomes relevant when analyzing the classification of the type of producer according to socioeconomic characteristics.



Graph 1 Stratification of henequen producing municipalities in the state of Yucatan
Source: Unique elaboration based on results of standardization of first component indicators

The fall of henequen production in the state of Yucatan has been very important. In 2000, 84,670 hectares were sown, whereas in 2014, the sown henequen areas in hectares were as little as 8,513 (SIAP-SIACON, SAGARPA 2015); this represented an average annual growth rate of -12%. According to SAGARAPA records, in 2014 the volume of crop production in Yucatan was 6,098 tons with a production value of 44,376,535 pesos. This situation reflects the potential output that the state of Yucatan could represent in meeting the international demand for henequen products and derivatives (fiber, chemicals, biofuels) under current conditions of use and added value needed for market supply.

The only Mexican federal entity that follows Yucatan in this crop production is the state of Tamaulipas which registered having a green henequen sown area of 1,775 hectares in 2014.

Stratification of henequen producing municipalities for the design of public policies

For the stratification of henequen producing municipalities, it was necessary to utilize information from SAGARPA, CONEVAL and CONAPO. When this sector's socio-economic and productive characteristics are related we are able to contextualize the peculiarities of the 43 producing municipalities in order to design more efficient and effective public policies. The analysis variables are:

1. Sown area of Henequen (ha),
2. Production (tons)
3. Yield (ton / ha)
4. Average rural price (price per ton)
5. Production value (thousands in dollars)
6. Average population percentage of illiterate persons 15 years of age or older,
7. Population percentage in dwellings without electricity,
8. Population in extreme poverty,
9. Persons lacking access to food,
10. Percentage of people 15 years of age or older with incomplete primary education,
11. Percentage of households with some level of overcrowding,
12. Population percentage having less than 5000 habitants (2010),
13. Percentage of occupants in houses with dirt floors and
14. Total population.

In 2010, henequen producing municipalities in Yucatan had the following characteristics: On average, 14.62% of the population identified as being 15 years or older and illiterate, 1.37% of the population occupied dwellings without electricity, 37.17% of the population aged 15 years or older identified as having incomplete primary education, 73.38% of the local population had less than 5,000 habitants and 50.01% of households had some level of overcrowding (CONAPO, 2015).

From this point we continued with methodology of principal component analysis (PCA) generating new variables that express the information in the original dataset; that is, reducing the dimensionality of the problem being studied as a first step for future analysis, and eliminating where possible, original variables if they provided too little information (Pla, 1986).

This methodology can be used to analyze and relate socioeconomic variables, with issues of health, education, poverty, among others (Farinelli, Baquero, Stephan, yb Chiaravalloti-Neto, 2018). Table 3 shows the total variance of the Eigenvalues (values of each component) that are associated with the correlation matrix. The characteristic value associated with the first component is well above the rest, outlining 33.02% of the variable variance under study. The four components in the model can explain approximately 81.79% of the total variability of the data which can be interpreted as an acceptable percentage.

Component	Initial Autovalues			
	Total	Percentage of variance	Accumulated percentage	Total
1	4.62	33.02	33.02	4.62
2	3.5	25.02	58.05	3.5
3	1.88	13.49	71.55	1.88
4	1.43	10.23	81.79	1.43
5	0.85	6.1	87.89	
6	0.51	3.69	91.58	
7	0.38	2.76	94.34	
8	0.28	2.04	96.39	
9	0.23	1.67	98.06	
10	0.14	1	99.07	
11	0.08	0.61	99.68	
12	0.02	0.19	99.88	
13	0.01	0.11	99.99	
14	0	0	100	

Table 3 Total variance explained
Source: Extraction method: Principal Component Analysis

Conversely, with an approximate Chi-squared value of 671.38 and 91 degrees with a significance of p = .000, it is evident that we are not dealing with an identity matrix and the study of the variables in Table No. 1 with the PCA are able to be made; moreover, the value of KMO corresponds to 0.73 and therefore can be considered an acceptable model. Subsequently, we proceeded to correlate the components of the variables used by henequen producing municipalities with the ACP model to generate four groups of independent variables that guided the analysis features.

Table 4 shows that the first component (CP1) is significant to level 0.01 (bilateral) and is positively related with total population and households with some level of overcrowding; in contrariety, it presents a negative relationship with the local population of less than 5000 inhabitants, able to be considered "urban population and housing". It is noted that the second component (CP2) is significant to level 0.01 (bilateral) and is associated positively with area, production and production value of henequen municipality able to represent the "productive sector of henequen".

Typology	Component			
	1	2	3	4
1. Sown area of Henequen (ha),	0.24	0.908**	-0.18	-0.07
	0.13	0	0.27	0.68
2. Production (tons)	0.13	0.968**	-0.05	0.08
	0.42	0	0.74	0.62
3. Yield (ton / ha)	0.11	0.06	-0.03	0.921**
	0.51	0.69	0.84	0
4. Average rural price (price per ton)	-0.29	0.03	-0.17	0.836**
	0.07	0.87	0.28	0
5. Production value (thousands in dollars)	0.12	0.966**	-0.06	0.11
	0.47	0	0.69	0.51
6. Average population percentage of illiterate persons 15 years of age or older,	-0.1	-0.03	0.898**	-0.08
	0.55	0.84	0	0.64
7. Population percentage in dwellings without electricity,	-0.14	-0.06	0.691**	-0.03
	0.4	0.71	0	0.84
8. Population in extreme poverty,	0.1	-0.26	0.711**	0.21
	0.52	0.11	0	0.19
9. Persons lacking access to food,	-0.23	-0.28	0.27	-0.18
	0.16	0.08	0.09	0.26
10. Percentage of people 15 years of age or older with incomplete primary education,	-0.03	-0.2	0.841**	0.12
	0.86	0.21	0	0.47
11. Percentage of households with some level of vercrowding,	0.498**	-0.26	0.630**	-0.317*
	0	0.1	0	0.05
12. Population percentage having less than 5000 habitants (2010)	-0.823**	0.15	0.08	-0.06
	0	0.36	0.64	0.72
13. Percentage of occupants in houses with dirt floors	0.18	0.07	0.665**	-0.2
	0.26	0.68	0	0.23
14. Total population.	.869**	.429**	-0.06	-0.07
	0	0.01	0.72	0.65
**. Pearson correlation is significant at level 0.01 (bilateral). *. Pearson correlation Correlation is significant at level 0.05 (bilateral).				

Table 4 Pearson correlation coefficient matrix with components
Source: Based on the Principal Components method in SPSS

Considering "the socioeconomic conditions of henequen municipalities", the third component (3) has a positive relationship between the variables of: illiterate population 15 years or older, incomplete primary education, population in extreme poverty, homes without electricity and percentage of occupants in houses with dirt floors.

Finally, component four (4) is positively associated with performance, rural housing and negatively with homes having some level of overcrowding, explaining the "living conditions of the population and productivity of henequen".

Stratification of henequen producing municipalities according to social and productive characteristics was performed with the Dalenius and Hodges technique (1959); this technique seeks to minimize the variance of municipality data establishing more heterogeneous groups among producing municipalities and homogeneous among the populations that comprise them. The importance of generating stratums is radicated in the idea that municipalities need to design and implement public policies according to their needs from an interdisciplinary perspective.

Table 5 classifies municipalities according to the obtained stratums. It is important to note that the relationship between the Marginalization Index and the obtained stratums from the ACP vary according to the henequen producing municipality. This situation reinforces the need to work differentially in agricultural and municipal social development policies. The first component from the coefficient matrix proceeded to be combined linearly with the 14 variables of the first already standardized dimension.

The results fluctuated between values of 1.13 and 3.34. Subsequently, the optimum stratification, developed by Dalenius and Hodges, was applied to a set of values and grouped together as homogeneously as possible within the stratums and more heterogeneously amongst themselves. Interval limits for the stratification of the municipalities are: a. [-1.13, -0.69]; b. [-0.69, 0.24]; c. [0.24, 0.66]; d. [0.66, 1.55] and e. [1.55, 3.34]. In this way, each henequen producing municipality was grouped according to their population and urban housing characteristics.

Table 5 shows municipalities engaged in the production of henequen with data from 2011 SIAP-SAGARPA (2011) according to marginalization levels from the National Population Council (2010).

Marginalization grade	Stratum (ACP)	Municipality	Production (Ton) 2011	Yield (t/ha) 2011	Percentage of occupied population with income of at least 2 minimum wages
Very high	Two	Dzoncauich	22.4	0.7	84.72
	Two	Hoctún	122.77	0.53	69.89
	Two	Huhí	89.13	0.58	74.86
	One	Sudzal	9.03	0.53	77.45
	One	Tekal de Venegas	36.82	0.53	78.99
	Three	Tetiz	34.17	0.6	75.42
	s.d.	Abalá			62.77
	Cuatro	Acanceh	39.01	0.49	51.34
	Two	Baca	248.5	0.62	69.75
	One	Bokobá	88.07	0.53	64.36
	Three	Cacalchén	77.39	0.53	54.31
	Three	Cansahcab	76.5	0.77	69.6
	Two	Cuzamá	11.7	0.45	61.26
	One	Dzemul	127.4	0.51	64.44
	Three	Dzilam González	2.8	0.7	61.16
High	Three	Hocabá	72.73	0.45	62.5
	Cuatro	Homún	54.12	0.55	73.56
	Cinco	Hunucmá	18.08	0.6	67.17
	Cuatro	Izamal	503.63	0.53	67.04
	Three	Kantunil	14.84	0.53	61.58
	Cuatro	Kinchil	4.88	0.6	73.76
	Two	Mocochá	12.5	0.48	59.51
	Cinco	Motul	665.72	0.65	60.06
	One	Muxupip	53.25	0.51	68.75
	Two	Sanahcat	22.33	0.45	67.46
	Cuatro	Seyé	56.92	0.45	50.63
	One	Sinanché	114.12	0.58	72.61
	Two	Suma	218.4	0.71	71.43
	One	Tahmek	409.53	0.53	67.91
	Cuatro	Tecoh	91.78	0.53	59.15
	One	Tekantó	190.06	0.53	69.29
	Cuatro	Tekit	0.8	0.5	70.94
	One	Telchac Pueblo	110.4	0.69	67.87
	Cuatro	Temax	67.2	0.7	79.84
	One	Tepakán	138.81	0.53	73.64
High	One	Teya	213.57	0.53	69.17
	Cuatro	Tixkokob	132	0.54	52.13
	Two	Tixpéhual	31.1	0.52	52.35
	Two	Xocchel	8.11	0.53	65.28
	One	Yaxkukul	47	0.47	59.44
	Two	Yobaín	28	0.7	73.73
Low	s.d.	Umán			55.07
Very Low	s.d.	Mérida			41.24

Table 5 Productive characteristics of henequen municipalities according to marginalization levels
Source: Based on data from SIAP-SAGARPA (2011) and CONEVAL (2015)

Discussion and conclussions

There are significant differences regarding social, economic and productive gaps between different henequen producing municipalities. This situation demonstrates the inequalities and conditions between different stratums indicating the need to treat socioeconomic needs diversely.

It is therefore necessary to generate differentiated municipal government actions towards henequen producing municipalities. Furthermore it is essential to focus federal and state programs aimed at improving the living conditions of producers in the area for the benefit of the population. Today the state of Yucatan has the technological and scientific conditions, as well as infrastructure and human capital to boost the economy of the henequen industry generating an infrastructure for producing biofuels. By doing this, coordination and organization between agencies; research centers (both public and private); farmers; businessmen; comercializers; industrialists; municipalities and members of the henequen production chain, will be able to reduce transaction costs, obtain greater added value to raw materials and aquire better wages and employment in the region.

The results obtained in the main components model seek to generate a prospective for the implementation of public policies focused in the sector and boost production and value chains that the henquen represents for the state of Yucatan as an engine of growth and development in the 43 municipalities. In particular, it would seek to benefit those localities, which maintain very high, high and medium marginalization.

To increase the competitiveness of henequen, it is essential to empower the actors in the production value chain by providing them with more infrastructure, training, technological packages, and knowledge in order to add value to by-products. The Henequen is very important for the textile industry, as well as for the use of bagasse in the generation of natural fertilizers and the improvement of infertile soils. To increase productivity the sector needs more efficient technological packages making use of natural resources based on sustainability.

In addition, public agricultural policies represent an important tool for the government sector to generate synergies among the different gubernamental institutions responsible for the primary sector (state, municipal and federal). In this way, the development of new technologies, innovation, research and development will promote growth in the sector and knowledge economy for the use and exploitation of the plant and its derivatives. As a result of applying agricultural policies implemented in biotechnology to the value chain of henequen, productive economies will strengthen and increase the efficiency and effectiveness of knowledge and science currently generated.

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