Reception: **August 28, 2022** | Acceptance: **October 13, 2023** | Publication: **February 1, 2023**

Analysis of the basic strategic crops of Mexico through the Food Self-Sufficiency Index, 2011-2020

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To quote this article:

Favila Tello, A. Análisis de los Cultivos Estratégicos Básicos de México, a través del Índice de Autosuficiencia Alimentaria, 2011-2020. *Espacio I+D, Innovación más Desarrollo, 13*(35). https://doi.org/10.31644/IMASD.35.2024.a03

— Abstract—

The objective of this study is to calculate the Food Self-Sufficiency Index (FSI) for a set of nine of the basic strategic crops indicated by the Ministry of Agriculture and Rural Development of the Government of Mexico, the selected ones being rice, oats, cocoa, coffee, beans, apples, soybeans, sorghum, and wheat, for the period 2011-2020. The FSI helps to measure the state and evolution of the national capacity to satisfy its internal supply of a certain good. Low FSI values indicate that the supply of said product is highly dependent on the conditions prevailing in its international markets. For the Mexican case, the lowest FSI values were found in soybeans, rice, and oats. The products that showed the most favorable conditions were coffee, beans, apples, and sorghum.

Keywords:

Food; sufficiency; staple crops; imports; exports.

Food self-sufficiency is achieved when the food needs of the population are met through local production. Among other factors, this depends on the activities to promote the production of a given set of goods, the availability of inputs (seeds, fertilizers, fuels, and machinery), and the action of public policies, in particular those related to competition and trade. In such a scenario, food self-sufficiency implies not only increasing local production but also decreasing dependence on food imports and procuring exports, hoping that these will bring fresh resources that will help energize the Mexican countryside (Cruz et al., 2021).

On the other hand, the name of basic and strategic crops comes from the Rural Development Law of the year 2000. This classification obeys a set of characteristics such as the number of people employed in them, their relevance to the national economy, their ecological importance, their implications for maintaining health, public safety, and their participation in the diet of Mexicans. In addition, the law included as strategic activities the production, supply, and industrialization of eggs, milk, beef, pork, poultry, and fish (CEDRSSA, 2019).

The basic and strategic nature of these crops gives them a series of legal protections and makes them subjects of specific promotion activities for their cultivation, supply, and transformation. Therefore, it includes giving preference in its commercialization to national production, facilitating producers of these goods access to financing, ensuring that these goods are affordable for all Mexicans, and providing these activities with a priority in the negotiation of international trade agreements (CEDRSSA, 2019).

According to the Ministry of Agriculture and Rural Development (SADER), rice, oats, cocoa, coffee, sugar cane, beans, white and yellow corn, apple, oilseed rape, safflower, sunflower, soybean, sorghum, and wheat are considered basic strategic crops (SADER, 2017).

Despite the relative legal advantages expressed, the current situation of several of these crops is extremely complicated, and national self-sufficiency in their supply is subject to what happens to them in international markets. Proof of this is the recent setbacks experienced in the production of several of these goods in recent years.

If the period from 2011 to 2020 is taken into consideration, it can be seen that the production of at least four of the strategic staple crops in Mexico decreased. Cocoa decreased by 30%, coffee by 26%, sorghum by 32%, and wheat by 18% (FAO, 2022). This casts doubt on whether the aforementioned preferential measures have translated into improvements in self-sufficiency or food sovereignty.

This work, with descriptive aspirations, aims to measure the Food Self-Sufficiency Index (FSI) for a set of nine Mexican strategic staple crops, for the period from 2011 to 2020. The selection of these nine crops and the study period was based on the availability of information in the databases of the Food and Agriculture Organization of the United Nations (FAO). The crops chosen were rice, oats, cocoa, coffee, beans, apples, soybeans, sorghum, and wheat. The aim is to demonstrate the descriptive hypothesis that indicates that in most of these crops, Mexico is not self-sufficient and is dependent on imports. Below is a review of the literature on the subject, followed by the presentation of the method used and the results found and then closing with the conclusions of the study.

1. LITERATURE REVIEW

Food self-sufficiency is linked to the concept of food security. Food security is defined as the access of the population to sufficient, safe, and nutritious food, which allows a diet that promotes health and pleases the preferences of individuals; its basic dimensions are availability, accessibility, use, and stability. The availability dimension refers to the existing quantities of food, whether these come from national production (i.e. self-sufficiency) or imports (Pérez, 2020).

The access dimension refers to the capacities of the population to acquire the products required for their meals; the use refers to combining food, access to drinking water, health, and medical care to ensure well-being and public health; and finally, the stability dimension implies the absence of serious risks that compromise access to food (Pérez, 2020).

Therefore, self-sufficiency plays a fundamental role in the food strategies of nations, not only for production and supply, but also to generate favorable conditions of access, use, and stability. These conditions are not guaranteed in many products for the Mexican case, which has generated numerous investigations on the subject. Table 1 contains some recent research on this topic.

Table 1
Review of recent literature on food self-sufficiency in Mexico

Espinosa y Zubirán (2022)	Using trade data, it is confirmed that grain marketing led by developed countries weakened traditional agriculture in peripheral countries. In the case of Mexico, this led to the growth of grain imports and the adoption of the non-traditional agro-export model.
Borja y García (2022)	The effect of subsidized fertilizers on Mexican bean productivity and food self-sufficiency was evaluated, finding a positive correlation between these elements.
Cruz *et al*. (2021)	An adaptation of the FSI is used to assess self-sufficiency in rice and wheat in Mexico, finding that PROCAMPO supports have an effective impact on the productivity of these crops.
Rivera *et al*. (2021)	Using data on food imports and exports from Mexico, it is concluded that Mexico is highly dependent on food from abroad, largely due to an unequal distribution of subsidies and financing, which have mainly favored large producers.
Torres y Rojas (2020)	The authors calculate a series of self-sufficiency indices to conclude that more than half of Mexico's population is in some degree of food insecurity.
Pérez (2020)	Using indicators of food self-sufficiency, it was found that this is positively related to the value of agricultural production and distribution infrastructure, while it is negatively affected by inflation and unemployment.
Cotler *et al*. (2020)	The influence of erosion and soil degradation on the lack of food self-sufficiency was confirmed, especially in the states of Guerrero, Michoacán, Guanajuato, and the State of Mexico.
Martínez (2016)	The FSI is calculated for the case of Mexican amaranth, finding that it is a positive alternative to achieving food security.
Soria *et al*. (2015)	It is concluded that the main cause of the lack of food self-sufficiency lies in the way international markets operate. The research closes with a proposal for co-participatory production and consumption focused on the marginalized rural population.
Rivera *et al*. (2014)	A food self-sufficiency index is calculated for the cases of corn, beans, and wheat in Mexico from 2006 to 2012, a six-year period, finding in all three cases high rates of import growth and decreases in the areas sown and harvested.

Note. Own elaboration based on the cited sources.

As can be seen, there are commonalities in these investigations; for example, the calculation of indexes to measure self-sufficiency, the use of trade statistics to diagnose the phenomenon, and concern about Mexican performance in cereal production.

This is a complex issue related to population, climate, and market factors, as well as the influence of public policies. An example of this is the programs aimed at reducing hunger in Mexico, which have been aid-oriented, rather than aimed at solving the problems of the productive apparatus (Soria et al., 2015).

Other problems of the sector, derived from policy decisions, can be identified with the adoption of the agro-export paradigm. This model obeys the idea of the existence of central consuming countries and peripheral producing countries; in this way, the peripheral countries produce to export and meet the needs of the central countries, this being a necessary condition for their growth. In this paradigm, the responsibility for production and growth is transferred to the private sector; the government, for its part, assumes a role of facilitating these activities, favoring economically efficient branches, that is, those linked to international markets. In practice, the adoption of this model implied the neglect of the internal market and its needs, as well as the traditional social mechanisms of income redistribution (Acosta, 2006).

For the adoption of this model, between 1983 and 1989, multiple public companies dedicated to the agricultural sector were sold, liquidated, or transferred (Soria et al., 2015), which worsened unfair trade practices, accentuated the lack of subsidies to compensate for the support granted to producers in other countries and affected the availability of resources for agricultural financing and research (Schwentesius & Gómez, 1999).

Therefore, it is worth adding the low priority that cereals and other foods received in the negotiations of the North American Free Trade Agreement (NAFTA). NAFTA led to the deepening of neoliberalism in Mexico, which was expected to boost economic growth as a result of the increase in the production of export goods and the arrival of greater Foreign Direct Investment (FDI). However, the effects of NAFTA on the Mexican countryside were mixed and the dynamism of Mexico's agricultural production decreased in the years after NAFTA as a result of trade opening and the lack of protection of large sectors as trade barriers gradually fell (Escalante & González, 2018).

Regarding exports, it benefited as a result of the entry into force of NAFTA. However, this occurred with little socio-productive inclusion, since it is estimated that only 6% of producers in Mexico can export. The scheme adopted favored the production and export of the fruit and vegetable sector, to the detriment of grain producers, of which Mexico became a net importer (Escalante & González, 2018).

Other frequent concerns around the topic relate to the economic and political implications of food. There is a dynamic of hegemony and domination determined by the great economic powers that have transformed food into instruments for the protection of geopolitical interests. This has increased the subordination and food dependence of developing countries, to the detriment of marginalized productive units in international markets (Espinosa & Zubirán, 2022).

Another external sector issue related to food self-sufficiency is the provision of subsidies. These play a decisive role for agriculture to fulfill its function of providing food and raw materials at low cost and are fundamental for competition in international markets. High subsidies help central economies increase their exportable production, when this occurs, these countries can force the reduction of prices, causing a competitive disadvantage in underdeveloped countries, and privileging the consumption of imported goods (Rivera et al., 2021).

Additionally, there has been a significant reduction in agricultural land in Mexico (understood as the sum of arable land plus land used for grazing divided by the number of inhabitants), from the 1960s to the present day. While this indicator was 2.52 hectares (ha) in 1961, by 2018, it had decreased to only 0.85 ha (Ruiz, 2021).

This reduction in cultivable areas joins other problems such as those related to low technification and the limited availability of irrigation, which impact the productivity of the Mexican countryside. In 2018, the average yield in tons per hectare (TPH) for cereals in Mexico was 3.8 TPH, this same indicator was higher in countries such as Chile (7.1 TPH), Uruguay (5 TPH), Peru (4.5 TPH), Brazil (4.8 TPH), Colombia (4.5 TPH), and Paraguay (4.2 TPH) (Ruiz, 2021).

2. MATERIALS AND METHODS. THE FOOD SELF-SUFFICIENCY INDEX (FSI)

The FSI indicates to what extent the reference country is self-sufficient in the production of a given good, that is, to what extent it can satisfy its national consumption without the need for international trade (Ireta et al., 2015).

The FSI is determined by formula 1:

$$FSI = \frac{\text{National Production}}{\text{National Production} + \text{Imports} - \text{Exports}} * 100 \qquad [1]$$

The result of the FSI is expressed as a percentage; the higher FSI values indicate greater self-sufficiency and denote the existence of favorable conditions for competitiveness, that is, they indicate to what extent the country can dedicate part of its local production to trade without compromising its consumption. In addition, the low values of the FSI imply that the supply of the product may be compromised by changes in international markets, such as sudden increases in prices, logistical problems, international conflicts, and sudden drops in production; that is, these are products on which the country is vulnerable and dependent (Ireta et al., 2015).

3. RESULTS

Table 2 shows the FSI calculation for the case of Mexican rice. As can be seen, despite the increase in domestic rice production, this in turn corresponded to an increase in imports. Rice exports were only significant in 2017 and 2018. The FSI value of this good remained between 15 and 23%, which indicates that the supply of this good with national production does not cover even a quarter of what is necessary.

Table 2

FSI calculation for rice in Mexico

Year	Production in tons	Imports in tons	Exports in tons	FSI
2011	115 698	666 830	1843	15 %
2012	119 251	604 361	1589	17 %
2013	119 911	673 877	1682	15 %
2014	154 850	657 165	1859	19 %
2015	157 424	640 812	2024	20 %
2016	169 447	671 533	9066	20 %
2017	177 133	868 592	88 360	19 %
2018	189 270	737 156	108 770	23 %
2019	163 560	972 795	10 275	15 %
2020	196 990	764 986	7553	21 %

Note. Own elaboration with data from FAO (2022).

On the other hand, oats show a behavior similar to that of rice, but in a less drastic way. Despite the sustained increase in the quantity produced, this is matched by an increase in imports and, throughout the period, there were no significant exports of this good. Therefore, as can be seen in Table 3, the percentage of national oat consumption that can be solved with national production was between 30 and 57%.

Table 3
FSI Calculation for oats in Mexico

Year	Production in tons	Imports in tons	Exports in tons	FSI
2011	50 582	115 374	21	30 %
2012	84 404	147 735	4	36 %
2013	91 049	110 972	19	45 %
2014	93 021	70 587	13	57 %
2015	84 789	92 668	76	48 %
2016	71 152	123 652	22	37 %
2017	72 092	132 099	36	35 %
2018	99 305	161 872	66	38 %
2019	100 672	151 619	59	40 %

Note. Own elaboration with data from FAO (2022).

With cocoa, the situation seems even more complex. During the study period, domestic production contracted by 30%, while imports increased significantly until 2019. If we compare cocoa imports from Mexico in 2011 with those made in 2019, we can detect that they were 2.4 times higher. The only year with low cocoa imports was 2020, a situation probably related to the pandemic. Likewise, exports of the goods were insignificant in most of the years considered. On the other hand, as can be seen in Table 4, the FSI value was between 38 and 89%.

Table 4
FSI Calculation for cocoa in Mexico

Year	Production in tons	Imports in tons	Exports in tons	FSI
2011	42 175	18 922	238	69 %
2012	38 825	13 590	277	74 %
2013	33 284	22 953	2246	62 %
2014	26 969	28 659	210	49 %
2015	28 007	23 521	134	54 %
2016	26 863	38 293	169	41 %
2017	27 287	41 322	1032	40 %
2018	28 399	38 547	476	43 %
2019	28 452	46 607	115	38 %
2020	29 429	3711	26	89 %

Note. Own elaboration with data from FAO (2022).

Another case that draws attention is that of Mexican coffee, which, despite having contracted its production during the study period by 26%, it also had exports considerably higher than imports, as shown in Table 5. In other words, it is a crop in which Mexico shows food self-sufficiency and solvency to supply international markets.

Table 5

FSI calculation for coffee in Mexico

Year	Production in tons	Imports in tons	Exports in tons	FSI
2011	237 056	11 635	112 452	174 %
2012	246 121	5895	160 771	270 %
2013	231 596	8153	140 090	232 %
2014	214 667	31 114	102 447	150 %
2015	188 934	48 027	91 998	130 %
2016	151 714	65 669	79 916	110 %
2017	153 777	31 232	112 988	214 %
2018	158 308	22 700	113 354	234 %
2019	165 712	39 771	97 986	154 %
2020	175 555	25 193	100 767	176 %

Note. Own elaboration with data from FAO (2022).

Mexican beans also appear to perform well. It was a crop that steadily increased its production during the period and with relatively high FSI values, as shown in Table 6, which were in a range between 83 and 99%.

Table 6

Cálculo del IAA para el frijol en el caso de México

Year	Production in tons	Imports in tons	Exports in tons	FSI
2011	567 779	104 897	37 593	89 %
2012	1 080 857	235 687	16 879	83 %
2013	1 294 634	134 494	32 908	93 %
2014	1 273 957	82 206	65 051	99 %
2015	969 146	88 543	36 800	95 %
2016	1 088 767	163 791	32 892	89 %
2017	1 183 868	151 215	74 343	94 %
2018	1 196 156	166 030	51 196	91 %
2019	879 404	123 491	43 823	92 %
2020	1 056 071	143 529	48 059	92 %

Note. Own elaboration with data from FAO (2022).

As far as apples are concerned, Table 7 shows that this crop increased its increased and exports were lower, it retained adequate FSI values in a range between 61 and 77%.

Table 7

FSI Calculation for apples in Mexico

Year	Production in tons	Imports in tons	Exports in tons	FSI
2011	630 533	198 481	613	76 %
2012	375 045	235 893	261	61 %
2013	858 608	274 978	269	76 %
2014	716 865	235 502	305	75%
2015	750 325	306 402	313	71 %
2016	716 931	212 678	1656	77 %
2017	714 149	280 930	910	72 %
2018	659 692	278 859	683	70 %
2019	761 483	252 224	606	75 %
2020	714 203	247 522	414	74 %

Note. Own elaboration with data from FAO (2022).

Of the products selected, the one that shows the greatest vulnerability is soybeans. Imports of this crop far exceed national production and have even been up to twenty times higher. On the other hand, Mexican exports of this good were minimal during the study period and, as can be seen in Table 8, its values in the FSI were between 5 and 11%.

Table 8

Fsi calculation for la soybeans in Mexico

Year	Production in tons	Imports in tons	Exports in tons	FSI
2011	205 234	3 340 376	85	6 %
2012	247 500	3 477 274	74	7 %
2013	239 248	3 612 685	265	6 %
2014	387 366	3 891 859	353	9 %
2015	341 088	3 890 229	227	8 %
2016	509 114	4 038 864	80	11 %
2017	432 927	4 341 346	528	9 %
2018	324 011	5 175 784	111	6 %
2019	232 680	4 851 030	1253	5 %
2020	246 019	3 900 201	601	6 %

Note. Own elaboration with data from FAO (2022).

Regarding sorghum, it showed strengths in its domestic production, which was higher than imports during the entire period studied. This contributed to the FSI values of this culture being between 73 and 99%, as shown in Table 9.

Table 9

FSI calculation for sorghum in Mexico

Year	Production in tons	Imports in tons	Exports in tons	FSI
2011	6 429 311	2 380 276	297	73 %
2012	6 969 502	1 726 232	386	80 %
2013	6 308 146	1 206 062	5 977	84 %
2014	8 394 057	72 702	7 249	99 %
2015	5 195 389	235 911	1 761	96 %
2016	5 005 837	645 966	653	89 %
2017	4 853 110	427 730	300	92 %
2018	4 531 097	220 378	2 427	95 %
2019	4 352 947	743 650	221	85 %

Note. Own elaboration with data from FAO (2022).

In the case of wheat, it can be identified that its imports were higher than national production during the entire period. The FSI values for this crop were between 42 and 55%, as shown in Table 10, which implies that Mexico is largely dependent on wheat imports to pay for its domestic consumption.

Table 10

FSI calculation for wheat in Mexico

Año	Producción en toneladas	Importaciones en toneladas	Exportaciones en toneladas	IAA
2011	3 627 511	4 047 832	835 908	53 %
2012	3 274 337	4 641 718	612 499	45 %
2013	3 357 307	4 166 753	732 745	49 %
2014	3 669 814	4 503 452	1 263 699	53 %
2015	3 710 706	4 182 851	909 195	53 %
2016	3 862 914	4 683 805	1 517 088	55 %
2017	3 503 521	4 900 848	490 031	44 %
2018	2 943 445	4 920 401	838 956	42 %
2019	3 244 062	4 804 838	736 296	44 %
2020	2 986 689	3 726 125	255 638	46 %

Note. Own elaboration with data from FAO (2022).

4. DISCUSSION

Calculating the FSI for the products mentioned in this study, as shown in Table 11, with data for 1990, that is, for a period before the intensification of trade opening in the mid-nineties, can put the results found in perspective.

Table 11

FSI calculation of the selected products. Data in tons for 1990

Product	Production	Imports	Exports	FSI
Rice	394 388	18 114	25	96 %
Oats	120 671	3931	16	97 %
Cocoa	44 045	3 495	10	93 %
Coffee	440 000	719	190 570	176 %
Beans	1 287 364	330 471	210	80 %
Apple	456 538	4 456	115	99 %
Soybeans	575 366	897 021	74	39 %
Sorghum	5 978 159	2 861 640	4410	68%
Wheat	3 930 934	338 771	2297	92 %

Note. Own calculation with data from FAO (2022).

As can be seen, the severe changes in the FSI occurred mainly in grains such as rice, oats, soybeans, and wheat. Even the FSI increased in some products, compared to 1990 and 2020, such as beans or sorghum.

Other studies that may be useful in contrasting the results of this research include the following:

Ayala et al. (2011) used the FSI to assess the performance of the Mexican agricultural sector, finding that, between 1993 and 2009, food self-sufficiency (calculated for this sector as a whole) went from being close to 100% to approaching only 88%, this in turn was strongly correlated with the increase in trade opening and the deficit in the agri-food trade balance, phenomena that occurred during the same period.

On the other hand, Ireta et al. (2015) found a relationship between the fall in the FSI and the increase in rice imports made by Mexico, which indicates a sustained loss in competitiveness in the trade of this product and the lack of national production to satisfy the supply.

Favila and Herrera (2023) measured the FSI for Mexican rice during the 2010-2018 period, using data from the Agri-Food and Fisheries Information System (SIAP); the resulting FSI values showed to be very similar to those obtained in this research, with only small variations of between 1 and 2%.

Another index that shares the sense of the FSI is the Cereal Import Dependency Coefficient, which is published by the FAO (2022). This coefficient is calculated over three-year periods and estimates the percentage that imports represent in the apparent consumption of grains. In the case of Mexico, for the 2014-2016 period, this indicator reached a value of 29.8%; for the 2017-2019 period, a value of 37%; and for the 2018-2020 period, a value of 39%; which reflects Mexico's dependence on grain imports and its growing trend.

The results obtained are consistent with what was pronounced in the study by Velázquez et al. (2020), who pointed out that Mexico lost its international competitiveness in grains since the mid-1990s. However, it maintained (or even increased) its competitiveness in those products benefiting from the agro-export paradigm (particularly in some fruits and vegetables).

This is consistent with the Baer and Sadowski (2019)'s work, who pointed out that, since the 1990s, countries assumed one of three possible positions in terms of their food self-sufficiency: a) countries that, due to their availability of capital and natural resources, can aspire to self-sufficiency and export; b) countries whose capital allows them to guarantee their food supply with imports; and c) countries whose food supply is compromised by economic and natural factors. It should be noted that dependence on imports may not necessarily be negative, as long as it allows economic efficiency and food in countries with economic and technological lags, or scarcity of natural resources. In this case, Mexico shows characteristics of group b, at least in those crops that are not oriented toward international markets.

CONCLUSIONS

The designation of basic strategic crops was rightly intended to encourage the production of certain goods to guarantee their supply. However, in practice, this was not enough to offset the effects of open borders, unfair competition, and falling trade barriers. These and other situations increased the intensity of competition and reduced the profitability of producing these crops in Mexico, thus increasing Mexican dependence on food imports.

The FSI is a tool that allows us to measure the extent to which a country is self-sufficient to pay for its consumption of a certain good. For the case of strategic commodities in Mexico, the FSI reveals important contrasts.

The products that showed the highest FSI values, that is, greater self-sufficiency and less dependence on imports, were coffee, beans, and sorghum. These products showed greater than 80% self-sufficiency for most of the period studied. Of these, coffee is the one that shows the most favorable conditions, that is, it shows the ability to supply the domestic market and export significant quantities consistently over time.

The most lagged products were soybeans and rice with self-sufficiency levels below 25% during the study period. Of these, soybean is the crop that shows the greatest dependence on imports and the lowest FSI values. The rest of the products studied show a moderate and changing dependence on imports over time, although some of them show worrying conditions in which domestic production falls and imports grow, such as cocoa and wheat.

Future lines of research can address these cases in detail, highlighting the incentives and subsidies that exist in the production of each of these crops, and reflecting on how international competition has compromised their viability in national production and their ability to supply the consumption of Mexicans.

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