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Estimation of the impact (cost-benefit) of bean production in the South Pacific, Mexico

Estimación del impacto productivo (costo-beneficio) del frijol en el Pacífico Sur, México

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Abstract

Garcia-Chavez et al. (2020) stipulates that beans represented 3.3% of the total energy intake of the diet of people older than 5 years; 3.7% in adults; In addition, it is considered a very important product in the general population, not only because it represents a food product that they grow, mostly, for self-consumption, but also because of the intrinsic monetary value of not paying out income for the purchase of this product in the market. In recent years, this grain has represented the livelihood of indigenous rural families dedicated to productive activities and, in general, the bean is used for self-consumption. However, its traditional production generates an important economic activity since agricultural families stop paying purchase costs, saving the cost for daily sustenance. The objective of this research work is to estimate the impact of ProAgro on bean producers in the productive sector of the Mexican South Pacific in rural households with the greatest social needs. It is evident that there is a substantial difference between those who receive the Program, self-consumption expenses and those who receive labor income. The latter is greatly reduced in localities with 2,500 inhabitants or less.

Indigenous localities, Economic, Agricultural sector, Bean consumption

Resumen

En el presente trabajo se analiza el impacto del sector productivo del frijol, ya que es fundamental para la alimentación de los mexicanos, como lo menciona García-Chávez et al. (2020) estipula que el frijol representó el 3.3% de la ingesta energética total de la dieta de las personas mayores de 5 años; el 3 7% en adultos; además, se considera un producto muy importante en la población en general, no sólo porque representa un producto alimenticio que cultivan, en su mayoría para autoconsumo, sino también por el valor monetario intrínseco al no tener que pagar ingresos por la compra de este producto en el mercado. En los últimos años, este grano ha representado el sustento de las familias rurales indígenas dedicadas a actividades productivas y, en general, el frijol es utilizado para el autoconsumo. Sin embargo, su producción tradicional genera una actividad económica importante porque las familias campesinas ya no tienen que gastar en la compra, ahorrando así dinero para su sustento diario. El objetivo de esta investigación es estimar el impacto del ProAgro a los productores de frijol del sector productivo del Pacífico Sur mexicano en los hogares rurales con mayores necesidades sociales. Es evidente que existe una diferencia sustancial entre los que reciben el Programa, los gastos de autoconsumo y los que reciben ingresos laborales. Este último se reduce considerablemente en las localidades de 2,500 habitantes o menos.

Localidades indígenas, Económico, Sector agrícola, Consumo de frijol

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Introduction

According to Lépiz-Ildefonso (2007) cited by National Seed Inspection and Certification Service (SNICS, 2016). in Mexico there are 70 bean species of the 150 existing worldwide and they represent more than 95% of the grain consumed in the country. Likewise, the common bean (*Phaseolus vulgaris* L.) is a very important product in food consumption in Mexico. (Lara-Flores, 2015, p. 1; Kaplan & Lynch (1999, p. 269) The results of an accelerator mass spectrometry (AMS) study estimated that the cultivation of common beans in Mexico, *P. vulgaris* L., and tepari, *P. acutifolius* Gray, occurred no earlier than approximately 2500 B.P. in the Valley of Tehuacan"; in Tamaulipas it is about 1300 years, and in the Valley of Oaxaca 2100 years. For their part, Barrera-Sánchez et al. (2020). The changes in climate generate new patterns that affect diversity, including beans; on the other hand, there are varieties that adapt to heterogeneous climatic conditions.

García-Chávez et al. (2020) stipulates that beans represented 3.3% regarding the total energy intake of the diet of people older than 5 years; 3.7% in adults; in addition, it is considered a very important product in the general population, not only because it represents a food product that they grow, for the most part, for self-consumption, but also because of the intrinsic monetary value by ceasing to disburse income for the purchase of this product in the market. This information is strengthened by analyzing the National Public Health Survey (ENSANUT) of the National Institute of Public Health (2019) The frequency of consumption of beans prepared at home (de la olla) among adolescents and adults (12 years and older) was distributed as follows: in localities with less than 2,500 inhabitants, 23.8 million people nationwide; however, in the states of Guerrero, Oaxaca and Chiapas, hereafter referred to as the South Pacific Region (SPR), it represented 21% of this total (5.08 million people).08 million people); localities of 2,500 to 100 thousand inhabitants there are 30.0 million representing frequency of consumption of beans prepared at home (de la olla) where the SPR is 16%, and in localities of 100 thousand inhabitants and more the frequency was 48.4 million with 6% in the SPR.

Of the estimated population that consumes beans in the form of preparations from the pot (at home) in the South Pacific in localities with less than 2500 inhabitants, 58% consumes it once a day, which is the equivalent of one cup, 38% twice and, 2% between three and four times, respectively. In localities with 2,500 to 100,000 inhabitants, an estimated 4.1 million households consume beans; of this total, 71% consume beans once a day, 26% twice and 3% three times. In towns with 100,000 or more inhabitants there are 22 million inhabitants who consume beans; of this total, 62% consume beans once a day, 32% twice and 6% three times (own data generated from ENSANUT (2019) in National Institute of Public Health (2019). This is evidence of the importance of beans in the diet of households in the South Pacific, especially those living in marginalized and rural areas.

However, it is of vital importance to consider that environmental conditions are constantly evolving and changing. According to Padilla et al. (2013, p. 38) According to the National Institute of Forestry, Agricultural and Livestock Research (INIFAP) South Pacific Regional Research Center, "The productive diversity and intensification of cultivated land through associations such as corn and beans generate the system called "milpa", which takes advantage of reduced spaces and difficult to work land". In recent years, this grain has represented the livelihood of indigenous rural families dedicated to productive activities and, in general, beans are used for self-consumption. However, its traditional production generates an important economic activity, since farming families no longer have to spend money on purchases, thus saving money for their daily sustenance. In some major cities of the South Pacific, "farmers' markets" are developed where there is a culture of exchanging food (barter) at various levels of marketing in many small (rural indigenous) producers.

In the RPS, 13,544 lands dedicated to beans in open fields were reported in Chiapas with a total area of 76,208.86 ha; 2,887 lands in Guerrero (33,521.07 ha) and 7,877 lands in Oaxaca (101,285.12 ha) (Marco Censal Agropecuario del National Institute of Statistics and Geography, Agricultural Census - INEGI 2016.). In total, 211,000 ha were dedicated to beans, which represents a significant area dedicated to the activity in the RPS, mainly in localities with very high levels of marginalization (Figure 1).

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Figure 1 Territories with rainfed bean production in the P-V cycle in the South Pacific
Source: Own elaboration with data from the SADER-SIAP (2020), (CONEVAL, 2020)

The objective of this research is to estimate the impact of the bean production sector in the Mexican South Pacific on rural households with the greatest social needs. It is estimated that direct farm support and subsidy transfers can create distortions in the labor market and, above all, generate some form of dependency in the medium and long term among the beneficiary population. Most of the production is generated under rainfed conditions in the spring-summer production cycle (PV) and, to a lesser extent, in autumn-winter (OI) (Table 1).

Cycle	Production volume (t)	Value (actual)	Area planted	Harvested area	Price (actual)	Yield (t/ha)
O-I	36,203.84	435,000,000	54,066	54,066	12,092	0.89
P-V	72,041.40	913,000,000	115,320	115,299	12,188	0.68

Note: The information is deflated with Base=100 INPC of BANXICO (2022)

Table 1 Production characteristics of beans in the South Pacific (2020)
Source: Own elaboration based on SADER-SIAP (2020)

The bean plant is essentially grown in 23 Rural Development Districts (RDD) classified in the RPS according to SADER-SIAP (2020), totaled 169,387.45 ha planted with beans. During the 2010-2020 period, the area planted has experienced a reduction in the Average Annual Growth Rate (AAGR) of approximately -0.32% (Figure 2).

On the other hand, the RDDs that have mostly reduced the amount of planted area are Altamirano with -10.80%; Comitán (-0.67%), Iguala (-5.46%), Motozintla (-1.13%), Palenque (-0.14%), Selva Lacandona (-0.21%), Tapachula (-4.48%), Tuxtla Gutiérrez (-0.72%), Valles Centrales (-4.00%).

On the other hand, the ratios of real farm-gate prices paid to producers show a reduction with an average annual growth rate ranging from -7.94% to -1.23% in 20 of the RDDs in the region from 2010-2020. The only 3 RDDs with real growth in price received at producers are: Las Vigas (2.70%), Atoyac (1.54%) and Chilpancingo (0.67%).

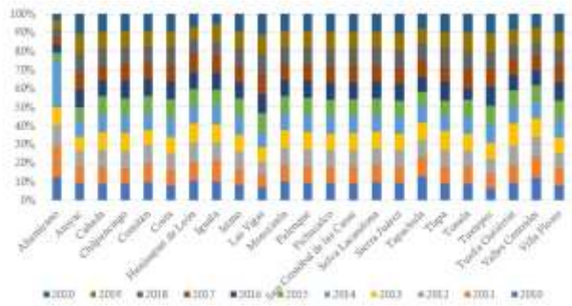

Figure 2 Area planted to P-V/O-I beans in the South Pacific Region (2010-2020)
Source: Own elaboration with data from the SADER-SIAP (2020).

Rural income from bean sales according to dietary conditions

Rural incomes from bean sales according to food insecurity conditions present heterogeneity according to the level of locality size in the South Pacific. Our own results obtained from the evidence that the INEGI-ENIGH (2020) The results themselves obtained from the evidence that the indigenous-speaking population experiences a very interesting pattern; namely, as food insecurity increases, the price per kilogram on average also experiences a very significant increase. On the contrary, in the non-indigenous-speaking population, the opposite effect occurs; as food insecurity increases, the price per kilogram of beans sold is lower. It also highlights the existence of unavailable information, especially when food insecurity increases in the indigenous-speaking population. It is hypothesized that the majority of this population uses beans as a product for self-consumption rather than a product to offer in the market. This positive relationship of self-consumption is in line with the characteristics of the marginalized population where, generally, the production uses beans for food and daily life and as an alternative form of expenditure substitution.

Indigenous language speaker						
Location	Size of locality	Food safety	Mild food insecurity	Moderate food insecurity	Severe food insecurity	Total
100,000 and more inhabitant	Price per kilo			nd	nd	
	Quarterly income	4,223	8,144	nd	nd	7,464
15,000 to 99,999 inhab.	Price per kilo		nd	nd	nd	
	Quarterly income	nd	nd	nd	nd	0
2,500 to 14,999 inhab.	Price per kilo					
	Quarterly income	2,332	2,281	1,695	1,127	2,127
Less than 2,500 inhab.	Price per kilo					
	Quarterly income	1,851	2,225	1,247	831	1,787
Total average	Price per kilo					
	Quarterly income	1,940	2,337	1,303	867	1,889
Non-indigenous language speaker						
Location	Size of locality	Food safety	Mild food insecurity	Moderate food insecurity	Severe food insecurity	Total
100,000 and more inhabitant	Price per kilo	nd		nd		
	Quarterly income	nd	1,057	nd	41,250	31,529
15,000 to 99,999 inhab.	Price per kilo					
	Quarterly income	15,820	2,849	4,244	3,554	8,055
2,500 to 14,999 inhab.	Price per kilo					
	Quarterly income	7,514	4,239	2,382	3,279	5,296
Less than 2,500 inhab.	Price per kilo					
	Quarterly income	3,106	2,109	1,947	2,923	2,423
Total average	Price per kilo					
	Quarterly income	4,305	2,296	2,058	4,579	3,066

Table 2 Production characteristics of beans in the South Pacific (2020)
Source: Own elaboration based on SADER-SIAP (2020).
Note: The information is deflated with Base=100 INPC of BANXICO (2022)

Methodology

Impact assessment model Propensity Score Matching (PSM)

Rosenbaum and Rubin (1983a, p. 41) state that the PMS tool "is the conditional probability of assignment to a particular treatment given a vector of observed covariates." In this study, the analysis is focused on bean producers in the P-V cycle in the South Pacific, including those who are beneficiaries of ProAgro government support considered as the control group and those who did not receive it (treatment group) based on the year 2020. The information base for the analysis comes from the National Survey of Income and Expenditures of Households of the National Institute of Statistics and Geography (INEGI-ENIGH, 2020). Likewise, we include those producers who have or do not have a labor income as a control variable, in order to differentiate the disparities that exist among small indigenous rural producers in the region.
Jalan & Ravallion (2003) state that "Anti-poverty programs often require participants to work in order to obtain benefits.

These *workfare* programs have been used in crises [...] in which large numbers of the able-bodied poor have become unemployed". Typically, rural support programs seek to increase the welfare of rural families and, above all, their income, so that they can have better living conditions to face the food crisis. for this reason, it is essential to know the impact of the income distribution of the programs, especially to identify the main incentives they generate in the context of the rural population of the region under study.

Rubin & Thomas (1996, p. 2049) point out that:

> "Matched sampling is a methodology for reducing bias due to observed covariates in observational studies of causal effects. The basic situation involves a sample of subjects treated with N_t and a larger sample of control subjects with $N_{c,}$ where the paired "p" variables $X = (X_{1,} \ldots, X_{p)}$ have density $f_{t,}$ between subjects treated with mean $\mu_{t,}$ and variance-covariance matrix $\sum_{t,}$and density $f_{c,}$ among control subjects with mean $\mu_{t,}$ and variance-covariance matrix $\sum_{c}$."

For their part, Rosenbaum and Rubin (1983a) explain that "the N units are viewed as a simple random sample from some population, and the quantity to be estimated is the average treatment effect", defined as:

$E(ri) - E(r0)$, where $E(.)$ denotes expectation in the population. (1)

Rosenbaum and Rubin 1983a, 1984. cited by Cerulli (2015, p. 78) show that "the propensity score is the conditional probability of receiving the treatment, given the x confounding variables. Interestingly, given D is binary." The support that producers receive from those who receive ProAgro are identified with 1 and, zero otherwise, whose equality is:

$$p(x) = Pr(D = 1|x) = E(D|x) \quad (2)$$

Vargas and Eguiarte (2017, p. 71). suggest that "the mean estimate of a program's results is shown by equation [3], being πi the result of comparisons of causal effects."

$$\pi i = \mathrm{E}\left[{Yi(1)}/{\mathrm{T}(i) = 1}\right] - \left[{Yi(0)}/{\mathrm{T}i = 0}\right] \quad (3)$$

A selection of producers was generated including x variables with observable characteristics including age, indigenous language speaker, poverty conditions, quantity of bean sales, price per kilo, standardized quarterly self-consumption, following with the methodology proposed by. Vargas and Eguiarte (2017).. The average effect of labor income is generated, segmenting the base in those who receive the ProAgro, in contrast, with those rural producers who do not receive it. The aim is to compare between the population of the RPS. This is explained by:

$$E[Yi(0) - Yi(1)] = E[Yi(0)|Ti = 0, \mathrm{x}] - E[Yi(1)|Ti = 1, \mathrm{x}] \quad (4)$$

Vargas and Eguiarte (2017, p. 71). explain "the hypothesis that an individual or family has the same probability of being placed in any of the groups, defined as conditional independence":

$$E[Yi(0), Yi(1)|Ti, \mathrm{X}] \text{ y } E[Yi(0)|Ti = 0, \mathrm{x}] = E[Yi(1)|Ti = 1, \mathrm{x}] \quad (5)$$

Cerulli (2015, p. 78) denotes that the "Balance of confounding variables, given the propensity score: if p(x) is the propensity score [...] implying that, conditional on p(x), the treatment and the observables are independent," then:

$$\mathrm{D} \perp x|p(\mathrm{x}) \quad (6)$$

Vargas and Eguiarte (2017, p. 72) describe that "for each probability estimated for individuals in the treatment group there is a similar probability in the control group."

$$E[Yi(0), Yi(1)|Ti, \mathrm{X}] \text{ y } E[Yi(0)|Ti = 0, \mathrm{x}] = E[Yi(1)|Ti = 1, \mathrm{x}] \quad (7)$$

Khandker et al. (2009, p. 55) note that "Conditional independence states that, given a set of observable covariates X that are unaffected by treatment, potential outcomes Y are independent of treatment assignment T". Thus, Y_i^T symbolizes the outcomes for those with ProAgro and the outcomes for those without ProAgro. Y_i^C the outcomes for those who do not participate, thus conditional independence implies:

$$(Y_i^T, Y_i^C) \perp T|x_i \quad (8)$$

Equation 8 "shows the average treatment effect obtained by the difference between the average outcome of the treatment group and the control group" (Vargas and Eguiarte, 2017, p. 72).

$$ATE = E\{E[Y(i)1|Ti = 1, p(\mathrm{xi})] - E[Y(i)0|Di = 0, p(xi)|Ti = 1]\} \quad (9)$$

Abadie et al. (2004, p. 301) indicate that the coincidence estimator that is average treatment effect for the inverse variance-treated weighting matrix (SAAT) is represented as follows:

$$\hat{V}^{sample,t} = \frac{1}{N_1^2}\sum_{i=1}^{N}\{W_i - (1 - W_i)K_M(i)\}^2\,\hat{\sigma}_{Wi}^2(X_i) \quad (10)$$

Wang et al. (2017, p. 1). suggest that untreated (ATU) and in-treated (ATT) mean treatment effects "are useful when there is interest in: assessing the effects of treatments or interventions on those who received them, the essence of treatment heterogeneity, or projecting potential outcomes in a (sub)target population."

Treatment variable. Binary *dummy* variable where rural producers who have ProAgro Yi(1) and those who do not have the benefit Yi(0).

Explanatory variables. Indigenous status, poverty conditions, quantity of bean sales, price per kilo, standardized quarterly self-consumption.

Response variable. *Quarterly per capita* income as a product of self-employment at work (expressed in real pesos).On the other hand, the Latin American Food Security Scale (ELCSA) constructed by the Food and Agriculture Organization of the United Nations (FAO) was used to generate the food security indicators: mild food insecurity, moderate food insecurity and severe food insecurity. Food and Agriculture Organization of the United Nations (FAO, 2012). to generate food security indicators; mild food insecurity, moderate food insecurity and severe food insecurity.

Results

Characteristics of the bean population in the region

Figure 3 shows the trends in average income and self-consumption of P-V/O-I bean-producing households in the RPS. The variables of analysis are described as follows: a) self-consumption: consumption by the household of goods produced or marketed by some of its members and for which no value has been paid (quarter). B) sales: income from the sale of beans. C) ing_mon: sum of income from wages, salaries or wages; Christmas bonus; household business; benefits from other social programs; financial payments; business with fishing, hunting and trapping activities. D) ing_lab: sum of income from wages, salaries or wages; income from work of persons under 18 years of age; business with fishing, hunting and trapping activities. E) ict: monetary income and non-monetary income (payment in kind, gifts in kind).

It is relevant to highlight that income from self-consumption, which is the "Consumption by the household of goods produced or marketed by some of its members and for which no value has been paid" INEGI-ENIGH (2020)constitutes an important implicit (non-tangible) stimulus to sustain their households. However, the monetary income of women farmers engaged in bean activities is lower than that of men. This is evidenced by the fact that only in 17 RDDs was income from sales recorded when the head of the household is a woman. Among them, the DRDs of Comitán, Las Vigas, San Cristóbal de las Casas, Iguala and Tlapa stand out with higher incomes; in contrast, where women bean producers receive less income are located in Huajuapán de León, Costa, Tuxtla Gutiérrez, Chilpancingo, Cañada, Palenque and Pichucalco. It should be noted that the income is considered on a quarterly basis according to data generated from the INEGI-ENIGH (2020). Undoubtedly, women bean growers living in the Pichucalco RDD have the lowest levels of average income from bean sales in the RPS (Figure 3). In contrast, the DDR of Tuxtepec, Las Vigas and Sierra Juarez achieved the highest levels of quarterly bean sales when the female head of household is considered. As previously mentioned, labor jobs represent an alternative to maintain a certain source of income, in addition to improving the distribution of income.

Barros & Ferreira (2000, p. 43) used the micro-simulation method to analyze the endogenous factors of labor income, labor aspects and education; consequently, they found that the latter has a strong influence on income distribution, and thus tends to reduce poverty. For their part, female heads of household engaged in bean activities that reached the highest levels of household income, in general, are located in Comitán, Iguala, San Cristóbal de las Casas, Las Vigas, Motozintla, Tlapa, among others.

Figure 3 Types of income of rural women P-V/O-I bean producers in the South Pacific Region (2020)
Source: Own elaboration with data from the SADER-SIAP (2020), INEGI-ENIGH (2020)

In the case of men dedicated to bean production activities, the highest levels of monetary income are found mainly in the Isthmus, Coast, Valles Centrales, Altamirano, Tuxtepec and Tapachula (Figure 4).

Figure 4 Types of income of rural male P-V/O-I bean producers in the South Pacific Region (2020).
Source: Own elaboration with data from the SADER-SIAP (2020), INEGI-ENIGH (2020)

Socioeconomic vulnerability of bean producers

The bean production sector in the PRS suffers from high levels of vulnerability for multiple structural reasons - land ownership - external reasons - confirms that inflation has a regressive impact on inequality - and internal reasons related to traditional production packages and systems (Morley, 2000, p. 108).

The bean production sector in the PRS suffers from high levels of vulnerability for multiple reasons: structural - land ownership - external - confirms that inflation has a regressive impact on inequality - and internal - related to traditional production packages and systems. Figure 5 shows that bean producers with at least one social deprivation (deprivation) are above 97.5%, with a predominance of people in rural areas; People with deprivation due to access to social security (ic_segsoc) 92.2% in the rural population and 88.1% in urban areas; People in poverty (poverty) 84.8% in rural localities and 87.1% in urban areas, being proportionally higher in urban areas, although in absolute terms it is higher in rural areas; Persons lacking access to basic services in housing (ic_sbv) 83.3% and 57.2%, and Persons in extreme poverty (pobreza_e) 46.3% in rural areas and 38.6% in urban areas, respectively.

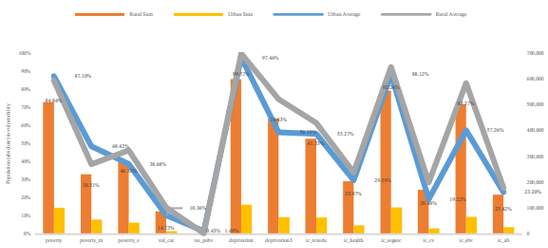

Figure 5 Level of vulnerability of the P-V/O-I bean producer in urban localities of the South Pacific Region (2020)
Source: Own elaboration with data from the SADER-SIAP (2020), CONEVAL (2021), INEGI-ENIGH (2020)

The description of the variables is as follows:

Poverty People in poverty

poverty_mPeople in moderate poverty

poverty_ePeople in extreme poverty

vul_car Vulnerable people due to social deprivation

no_pobvNon-poor and non-vulnerable people

deprivationPopulation with at least one deprivation

deprivations3People with three or more social deprivations

ic_rezeduPeople with educational backwardness

ic_healthPeople lacking access to health services

ic_segsocPeople with lack of access to social security

ic_cv People with housing quality and space deficiency

ic_sbv Persons lacking access to basic services in housing

ic_ali People with food deprivation

In addition to the conditions described above in bean producers, the following conditions are added: People in moderate poverty (pobreza_m) 38.5% rural and 48.4% urban; People deprived by housing quality and spaces (ic_cv) 28.4%, 19.2%; People deprived by access to food (ic_ali) 25.4%, 23.1%; Persons vulnerable due to social deprivation (vul_car) 14.7%, 10.3%; Persons lacking access to health services (ic_asalud) 33.9%, 29.5% , and Non-poor and non-vulnerable persons (no_pobv) 0.43% and 1.69%, respectively (Figure 5).

Figure 6 shows the distribution of the bean farming population for both cycles P-V/O-I in the region by level of marginalization and gender. It can be seen that the majority live in territories with high and very high levels of marginalization, in contrast to those localities with lower levels of marginalization. Consequently, it is confirmed that the population presents the same patterns of inequality and marginalization.

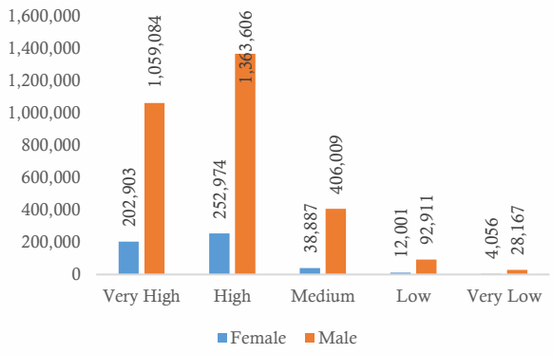

Figure 6 Distribution of bean producers (heads of household plus members) P-V/O-I in the South Pacific Region (2020)
Source: Own elaboration with data from the SADER-SIAP (2020), CONEVAL (2021), INEGI- ENIGH (2020).

Level of food security of the bean population

Based on the indicators included in the INEGI-ENIGH (2020) the Latin American Scale of Food Security (ELCSA) constructed by the United Nations Food and Agriculture Organization (FAO) was used. Food and Agriculture Organization of the United Nations (FAO, 2012).. The classification of food (in)security according to importance is distributed as follows: 28.25% of the bean farming population is in conditions of food security; 43.14% mild food insecurity, followed by the population with moderate food security with 18.57% and severe food insecurity 10.13%. Figure 7 shows the absolute numbers of population in absolute terms - heads of household plus members.

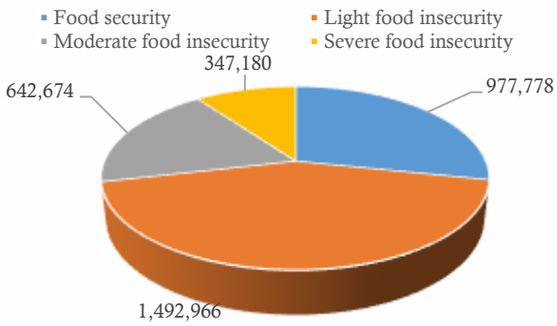

Figure 7 Food security level of the bean population in the South Pacific Region (2010-2019).
Source: Own elaboration with data from the SADER-SIAP (2020), CONEVAL (2021), INEGI-ENIGH (2020).

Food insecurity shows that the majority of the population suffers from very complex conditions in terms of access to food and nutrition. Table 3 shows the main RLDs with heterogeneous food problems.

DDR	Food safety	Mild food insecurity	Moderate food insecurity	Severe food insecurity	Total
Altamirano	6,292	12,304	15,280	8,638	42,514
Atoyac	nd	10,049	1,244	nd	11,293
Cañada	18,726	36,579	31,932	6,372	93,609
Chilpancingo	29,903	57,091	48,784	1,298	137,076
Comitán	144,974	122,035	62,812	37,480	367,301
Costa	17,094	50,221	39,603	7,448	114,366
Huajuapan de Leon	57,874	76,737	69,935	33,989	238,535
Equal	18,338	22,313	9,068	2,380	52,099
Isthmus	1,860	4,780	620	nd	7,260
Las Vigas	36,060	85,374	30,767	21,672	173,873
Motozintla	56,506	113,148	29,406	10,631	209,691
Palenque	120,828	212,237	39,715	35,747	408,527
Pichucalco	39,225	80,324	12,217	6,431	138,197
San Cristobal de las Casas	130,219	127,100	25,896	11,984	295,199
Lacandon Jungle	4,936	nd	1,296	4,536	10,768
Sierra Juarez	18,244	13,658	5,757	nd	37,659
Tapachula	35,568	30,990	5,669	3,080	75,307
Tlapa	52,858	131,723	67,726	28,708	281,015
Tuxtepec	21,269	43,288	25,529	16,776	106,862
Tuxtla Gutierrez	55,269	94,189	21,610	63,988	235,056
Central Valleys	84,685	136,858	83,364	46,022	350,929
Villa Flores	27,050	31,968	14,444	nd	73,462

Table 3 Bean farming population with food (In)security according to DDR
Source: Own elaboration with data from the SADER-SIAP (2020), CONEVAL (2021), INEGI-ENIGH (2020)

Level of education of bean growers

Table 4 shows that 50.2% of the bean population in the South Pacific (1,737,262 heads of household plus members) have incomplete primary education or less. The population with complete primary education represents 26.02% of the total, incomplete secondary education 2.51% and complete secondary education 14.9%. It should also be noted that women have lower levels of educated population, in contrast to men.

Education level	Woman Frequency	Woman Percentage	Man Frequency	Man Percentage	Total Frequency	Total Percentage
Incomplete primary school or less	262,830	7.59	1,474,432	42.61	1,737,262	50.2
Completed elementary school	101,484	2.93	799,035	23.09	900,519	26.02
Incomplete high school	7,989	0.23	78,904	2.28	86,893	2.51
High school completed	97,101	2.81	418,686	12.1	515,787	14.9
Incomplete high school	20,964	0.61	nd	nd	20,964	0.61
Completed high school	21,646	0.63	114,825	3.32	136,471	3.94
Full Normal	3,868	0.11	nd	nd	3,868	0.11
Complete technical career	331	0.01	4236	0.12	4,567	0.13
Incomplete technical career	1,805	0.05	nd	nd	1,805	0.05
Full professional	7,488	0.22	22,695	0.66	30,183	0.87
Professional incomplete	10,147	0.29	12,132	0.35	22,279	0.64
Total	510,821	14.76	2,949,777	85.24	3,460,598	

Table 4 Bean population by level of education.
Source: Own elaboration with data from the SADER-SIAP (2020), CONEVAL (2021), INEGI-ENIGH (2020).

Table 5 shows that the DDRs with the largest bean-producing population in conditions of educational backwardness are: Palenque with approximately 245,250 people; San Cristobal de las Casas (223,499), Valles centrales (208,578), mainly, on the other hand, Atoyac, Istmo and Selva Lacandona have the lowest absolute levels of educational backwardness (own data generated from the INEGI-ENIGH (2020).

DDR	Indicator of educational backwardness		
	No deficiency	**Presents deficiency**	**Total**
Altamirano	20,888	21,626	42,514
Atoyac	8,693	2,600	11,293
Cañada	24,536	69,073	93,609
Chilpancingo	48,471	88,605	137,076
Comitán	190,362	176,939	367,301
Costa	20,655	93,711	114,366
Huajuapan de Leon	129,080	109,455	238,535
Equal	19,953	32,146	52,099
Isthmus	3,850	3,410	7,260
Las Vigas	72,583	101,290	173,873
Motozintla	90,866	118,825	209,691
Palenque	163,277	245,250	408,527
Pichucalco	57,858	80,339	138,197
San Cristobal de las Casas	71,700	223,499	295,199
Lacandon Jungle	5,584	5,184	10,768
Sierra Juarez	16,915	20,744	37,659
Tapachula	37,604	37,703	75,307
Tlapa	110,476	170,539	281,015
Tuxtepec	52,070	54,792	106,862
Tuxtla Gutierrez	61,903	173,153	235,056
Central Valleys	142,351	208,578	350,929
Villa Flores	36,241	37,221	73,462
Total	1,385,916	2,074,682	3,460,598

Table 5 Bean population by RDD and level of educational backwardness in the South Pacific
Source: Own elaboration with data from the SADER-SIAP (2020), CONEVAL (2021), INEGI-ENIGH (2020)

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Rural and urban bean population

Table 6 shows the pre-pandemic (2018) and early (2020) bean farming population. In principle, there is a larger sample in the last year of almost one million more people engaged in the activity. Consequently, there is an important change in the results: the population with food security in rural areas reached an increase of 78.31%, with mild food insecurity also increased by 29.12%, with moderate food insecurity 9.72% and with severe food insecurity 38.90%. This relationship also shows that approximately 1,721,889 people living in areas with less than 2,500 individuals have some level of food insecurity to a greater extent after the pandemic. In 2020, 61.9% of the producer population reported some level of food insecurity (mild, moderate and severe).

Year	Locations	Food safety	Mild food insecurity	Moderate food insecurity	Severe food insecurity	Total
2018	Urban	90,312	150,942	50,284	50,917	342,455
	Rural	451,185	990,886	519,195	211,808	2,173,074
	Total	541,497	1,141,828	569,479	262,725	2,515,529
2020	Urban	173,256	213,495	73,005	52,969	512,725
	Rural	804,522	1,279,471	569,669	294,211	2,947,873
	Total	977,778	1,492,966	642,674	347,180	3,460,598

Table 6 Bean population in urban and rural localities by food (in)security
Source: Own elaboration with data from the SADER-SIAP (2020), CONEVAL (2021), (INEGI-ENIGH, 2018), INEGI-ENIGH (2020)

Self-consumption and expenditures of bean households by quantile

The second major component of bean growers is their spending and the magnitude according to deciles. On average, a family (head of household) spends $2,344 pesos per quarter. However, this amount changes when examined by deciles. In the first decile the average expenditure is around $146 pesos; second decile $411 pesos, third $630, fourth $769 pesos and successively $1,057; $1,408; $1,862; $2,653; $4,087, until reaching the tenth decile with an average expenditure of $9,209.

Table 7 shows the importance of self-consumption in South Pacific households. The most representative DDR's in average terms are Palenque ($12,534), Sierra Juárez ($8,182), Iguala ($8,176), Altamirano ($7,986) and Costa ($7,025). In contrast, the territories with the lowest levels of self-consumption are: Cañada ($4,420), Tapachula ($4,107) and Istmo ($4,099).

DDR	Average	DDR	Average
Altamirano	7,986.3	Pichucalco	5,835.2
Atoyac	5,221.6	San Cristobal de las Casas	6,621.3
Cañada	4,420.3	Lacandon Jungle	6,928.4
Chilpancingo	4,825.4	Sierra Juarez	8,182.9
Comitán	7,940.4	Tapachula	4,107.8
Costa	7,025.5	Tlapa	5,627.8
Huajuapan de Leon	5,344.1	Tuxtepec	4,576.0
Equal	8,176.7	Tuxtla Gutierrez	6,677.7
Isthmus	4,099.8	Central Valleys	6,168.3
Las Vigas	6,533.3	Villa Flores	5,236.5
Motozintla	5,230.7	Total average	6,912.2
Palenque	12,534.4		

Table 7 Average quarterly expenditure of the bean population according to DDR ($MNN)
Source: Own elaboration with data from the SADER-SIAP (2020), CONEVAL (2021), INEGI-ENIGH (2020).

Cost-benefit impacts

The first quintile of bean producers in the region receive an average per capita labor income of $3,217 and the fourth quintile $6,589 pesos per quarter; agricultural income $4,205 and $5,224 pesos, respectively. It is evident that the agricultural income of primary sector households in Chiapas in the first quantile is slightly higher than in the rest of the states in the region (See Table 8).

Q	Edo.	ictpc	ing_lab	ing_mon	ing_tra	agrope	aexp	age	Members
1	Total average	1,322	3,217	4,720	1,498	4,205	36.91	47.2	2.41
2		1,617	4,038	5,684	1,645	4,404	37.96	49.6	2.44
3		1,493	4,074	5,683	1,568	4,307	40.21	50.4	2.34
4		2,111	6,589	9,241	2,628	5,224	37.68	49.2	2.49
1	Chiapas	1,323	3,438	4,848	1,399	5,969	36.65	47.7	2.45
2		1,679	4,197	5,766	1,569	5,326	38.40	49.6	2.56
3		1,376	4,147	5,320	1,079	5,657	39.16	47.7	2.43
4		1,536	4,174	6,908	2,686	3,916	37.19	46.7	2.57
1	Guerrero	1,334	3,098	4,791	1,693	2,442	36.95	45.4	2.38
2		1,176	3,417	4,750	1,333	2,930	36.60	47.8	2.44
3		1,347	3,791	5,522	1,720	2,273	40.00	49.0	2.46
4		2,437	8,481	11,050	2,568	6,693	36.15	50.5	2.43
1	Oaxaca	1,312	2,940	4,720	1,498	4,205	37.29	47.6	2.37
2		1,868	4,249	5,684	1,645	4,404	38.20	51.1	2.20
3		1,681	4,128	5,683	1,568	4,307	41.55	53.8	2.21
4		2,620	8,233	9,241	2,628	5,224	39.68	51.4	2.45

Note: Q quantile; ing_lab quarterly labor income; ing_mon quarterly monetary income; ing_tra transfer income; ing_tra quarterly cash income; ing_lab quarterly labor income; ing_mon quarterly cash income; ing_tra transfer income

Table 8 Characteristics of real income ($MN), years of experience and age of bean producers in the South Pacific.
Source: Own elaboration based on data from the INEGI-ENIGH (2020)

Impact of ProAgro benefits to bean producers in the region

Table 8 shows the results of the estimates of the average treatment effect in the treated group using nearest neighbor matching for those who are beneficiaries of the ProAgro program considering total per capita autonomous (labor) income, age, indigenous language status, poverty, amount obtained from the sale of beans, quantity sold, price per kilo of the product (in logarithm), autonomous consumption valued by the household, of goods produced or marketed by some of its members and, for which no value has been paid (quarter). The weights for each household were used on the basis of the expansion factor in accordance with the ENIGH-INEGI (2020) in the calculations. With this, the sample can be extrapolated to the whole population with statistical significance. In addition, the income of individuals was classified by quantiles considering the quarterly current income 2020.

As noted in the methodology, the matching method (PSM) sought to match each bean producer with an identical non-participant and then measure the average difference in ProAgro support outcome between the benefited and non-benefited producers, also considering labor income as a control variable. We sought to satisfy the equilibrium property.

Average treatment effect by nearest neighbor matching

Table 9 shows the results of estimating the average treatment effect of female participation in ProAgro support at the 2,500 locations. It is important to note that a female bean producer who receives ProAgro support receives, on average, $2,669 pesos of labor income, in contrast, quarterly valued autonomous consumption reaches $1,388 pesos. In contrast, the female sector without ProAgro receives 4,395 pesos for labor income on average, and the amount for autonomous consumption valued in a quarter is $983 pesos.

Location	Sample	Differences	S.E.	t
Less than 2500 inhab. Woman	ATT[1]	-1,125	866	-1.300
	ATE[2]	-1,012	583	-1.735
	RM[3]	-510	888	-0.575
	ATTK[4]	-1,132	756	-1.498
Less than 2500 inhab. Man	ATT[1]	-517	538	-0.961
	ATE[2]	-134	401	-0.335
	RM[3]	-310	407	-0.762
	ATTK[4]	-72	349	-0.207
Less than 2500 inhab. Female/Male	ATT[1]	-81	440	-0.185
	ATE[2]	-264	356	-0.744
	RM[3]	-107	383	-0.281
	ATTK[4]	-265		-0.758
Largest 2500 inhab. Female/Male	ATT[1]	-1,049	1,641	-6.39
	ATE[2]	-802	.	.
	RM[3]	-2,642	1,908	-1.385
	ATTK[4]	-791	1,124	-704

Table 9 Impact of the ProAgro program on the autonomous income of bean producers by locality.
Source: Own elaboration based on data from the INEGI-ENIGH (2020)
[1]Effect through nearest neighbor matching.
[2]Average treatment effect by stratification matching.
[3]Average treatment effect using radius matching
[4]Average treatment effect using kernel matching

Robustness of the analysis of average treatment effects

The average treatment effect on the outcome of interest is estimated using direct nearest neighbor matching with one match per treatment in the bean production sector (Table 10).

Location	Sample	Differences	S.E.	z	P>|z|	[95% conf. interval]
Less than 2500 inhab. Woman	SATT	-2,398	755	-3.18	0.001	-3,879 -918
	ATE	-1,775		-3.47	0.001	-2,779 -771
Less than 2500 inhab. Man	SATT	-368	385	-0.96	0.340	-1,123 387
	ATE	-419	331	-1.26	0.207	-1,069 231
Less than 2500 inhab. Female/Male	SATT	-709	349	-2.03	0.042	-1,395 -24
	ATE	-487	273	-1.78	0.075	-1,024 49
Largest 2500 inhab. Female/Male	SATT	-2,288	975	-2.35	0.019	-4,200 -376
	ATE	-1,046	851	-1.23	0.219	-2,715 623

Table 10 Robustness of the impact of the ProAgro program on the autonomous income of the bean-producing sector in the region
Source: Own elaboration based on the Propensity Score Matching (PSM) technique with data from the INEGI-ENIGH (2020)
Note: Standard error. S.E. does not take into account that the propensity score is estimated. The contrast analysis variable is the per capita labor income of agricultural households in the region.
SATT = Average treatment effect for the treated.
ATE = Average treatment effect.

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Conclusions

The outputs show that the ProAgro program targets a population of bean producers with vulnerable characteristics and negative impacts on *per capita* labor income among heads of households in the region. It is evident that there is a substantial difference between those who receive the program and those who receive labor income. The latter is greatly reduced in localities of 2,500 inhabitants or less. The average treatment of treaties (ATT) in per capita autonomous (labor) income is reduced by $1,125 pesos in the female sector, on average, with respect to those who are beneficiaries of the ProAgro program in localities with less than 2,500 inhabitants, compared to the male sector, which decreases to a greater extent with $517 pesos. In contrast, in localities with more than 2,500 inhabitants, there is a reduction in labor income of $2,280 pesos, limiting the incentives to find jobs in the beneficiaries of the program due to the dependency that may be generated (negative externalities and economic-social costs in the beneficiary individuals). Consequently, it is necessary that the design and implementation of public policies present holistic solutions to the problems (innovations, technological packages, food security, jobs, etc.) and that government institutions at all levels establish greater monitoring systems and impact evaluations to focus (scarce) economic resources towards actions that improve living conditions; in addition, public management and administration of the most needy territories require strengthening actions from a social and solidarity economy approach and social impact that really have a positive impact on society.

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