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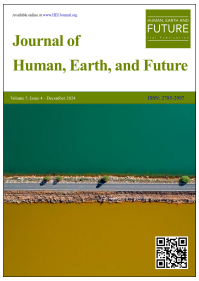

Analysis of the Establishment, Development and Future of Agricultural Reconversion

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Abstract

Economic, social, and crop management and environmental factors are important for the development and establishment of successful productive units. The objective of this study was to evaluate the interactions between the characteristics of productive units and the perceptions of producers. Different areas of performance were considered in the establishment of lemon and avocado crops in the municipality of Calvillo, Aguascalientes, Mexico. 49 agricultural producers who carried out productive reconversion of their parcels for the establishment of lemon and avocado crops were interviewed. Semi-structured surveys were applied to evaluate the characteristics of the management and operation of the agricultural farms. Likewise, the perceptions of producers were measured in the economic (ECO), social (SOC), and environmental (CULT/AMB) areas. Through a PERMANOVA and binary logistic models, the groups of variables analyzed were simultaneously analyzed. The areas analyzed (ECO, SOC, and CULT/AMB) were found to be significantly affected ($p<0.001$) by the source of water, the expectations of continuity of the farms, and the crop prior to productive reconversion. The novelty of these findings demonstrates the importance of decision-making for the establishment of alternative crops in the search for higher incomes by agricultural producers and to ensure the continuity of productive farms for the development of rural areas.

Keywords: Sustainability; Sustainable Development; Land Use; Agri-Food Markets.

1. Introduction

Humans have transformed and modified ecosystems in most of the terrestrial biosphere throughout history [1]. Approximately half of the ice-free land surface has been modified by human activities through the replacement and modification of natural habitats by agricultural and urban systems [2, 3]. On a global scale, agriculture has been the main driver of land use change [4]. In Aguascalientes, Mexico, since the second half of the previous century and with greater emphasis in the first two decades of the 21st century, there has been an intense process of transformation of the agrarian production system due to changes related to low productive, commercial, and climatic performance that affect the production chain [5, 6].

Agricultural activities have been affected by the relocation and restructuring of production processes [7]. The constant and rapid development of industrialization can jeopardize the continuity of the productive vocation of agricultural territories in emerging countries [8]. However, the implementation of new crops can be an opportunity for

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a significant increase in household income and the reduction of social gaps [9]. Transitioning from a natural management production system to a large-scale production system implies the change of conventional agroecosystems, the organization of production units, and the development of markets linked to the various products that agrobiodiversity offers [10].

The implementation of strategies and public policies that address the economic, social, and environmental aspects should be considered as central axes of the development of the agricultural sector. In order to achieve sustainability, increase food production, maintain the continuity of economic units, and integrate the communities related to food production [11]. This study arises from the need to critically address modern agriculture. It considers a sustainable transition of this fundamental activity in the search for favorable economic, environmental, and social results for producers. In particular, the scientific questions that need urgent answers are: Could intelligent and innovative solutions be found for the redesign of the use, management, and conservation of natural resources in agriculture? Would agricultural production units make permanent structural changes? And would producers look for sustainable alternatives for the continuity of their plots?

The state of Aguascalientes has stood out for its important participation in the national agricultural production sector due to the production of guava (*Psidium guajava)* [12]. Desirable characteristics have been identified [13] in the quality of guava produced in the state, with similar characteristics to those produced in other states of the country. Producers face problems in consolidating agricultural products in the face of competition. In this sense, the continuity of guava production in the state is threatened [14]. In Mexico, the implementation of crops such as lemon (*Citrus limon*) and avocado (*Persea americana*) has been identified [15, 16] as a viable alternative to boost the economic development of productive units in the agricultural sector, due to their advantages in the marketing of products in relation to other agri-food products with lower demand internationally.

In the present study, the relationship between productive factors and characteristics of agricultural production units in the municipality of Calvillo, Aguascalientes, Mexico, was identified. The key factors considered for the study were the origin of the water, the previous crop, and the perspectives on the future of the reconversion. Likewise, it was considered whether simultaneously the productive factors affected the perceptions of the producers in the economic, social, and crop management or environmental spheres. Analyzing the productive factors jointly achieves a complete perception of the phenomenon of agricultural productive reconversion. By studying them together, different questions about the agricultural productive reconversion in Calvillo, Aguascalientes, will contrast. The rest of the article is organized as follows: a section that includes the bibliographic study, then the methodology used is presented, and finally, the results obtained and implications of the study are shown.

The change of activities in a parcel of low productive aptitude has been pointed out as one of the causes of productive reconversion processes [17]. In the same way, the development of the rural sector is triggered through the implementation of competitive and sustainable business strategies [18]. Producers must carry out analyses of agricultural holdings [19], evaluate social perspectives and the environment [20], and determine the economic results of adopting new crops [21].

Agricultural reconversion is implemented in productive units seeking alternatives for production that contribute to the development of the environment. With agricultural reconversion, production costs are reduced, the efficiency in the use of resources is increased, market prices are improved, and greater profitability is generated [11, 18, 21-23]. The lack of marketing channels, the increase in production costs, as well as soil degradation, have been identified as factors that trigger the productive reconversion of productive units in the rural sector [24].

Agricultural productive reconversion can also be seen as a change in the way the same crop is produced. In this sense, producers have made efforts to achieve a change in the productive dynamics of the parcels to promote agricultural production with less impact on the soil through a decrease in the use of toxic agents [25]. The implementation of new crops with favorable commercial potential is a viable alternative to boost the economic development of productive units. In addition, a systemic approach to consolidation must be considered, including technical, economic, social, and environmental aspects of crop management [15].

The success of implementing productive reconversion programs in the agri-food sector does not depend solely on a single condition or variable, but rather on the interaction of environmental conditions, the participation of producers, and other factors that are elements to be considered for the proposal of this type of project [26]. Likewise, several key elements (integrated soil management, pests, crop management components, and the efficient use of natural resources, among others) must be considered for the consolidation of agricultural productive improvement [27]. Also, it has been identified that the resources available in rural communities are an important part of the livelihood of the inhabitants, who adapt to the socioeconomic and environmental conditions [28]. The implementation of productive reconversion models should seek to consolidate the economic and social development of the rural sector to improve the lives of producers and families [29]. In addition, the increase in the quality of life of the population is due to an increase in income obtained from productive activities [30]. This will create favorable environments for the development of rural localities.

The objective of this study was to evaluate the interactions between characteristics of productive units and the perceptions of producers regarding different areas of performance (economic, social, crop management or environmental, and the continuity of farms) in the establishment of lemon and avocado crops in the municipality of Calvillo, Aguascalientes, Mexico.

2. Material and Methods

The municipality of Calvillo is located in the southwest of the state of Aguascalientes, Mexico, within the Juchipila River basin, in the Lerma Santiago hydrological region. In 2020, 756 concessions for water use were registered according to the Public Registry of Water Rights [31], of which 60% are for agricultural use (Figure 1). The municipality of Calvillo has a dry, steppe, semi-warm climate with summer rains; precipitation is an annual average of 615 mm. Calvillo has five dams with a storage capacity of 35 hm³ of water. The average annual temperature is 18 °C [32].

Semi-structured interviews were conducted with 49 producers who decided to change the productive vocation of the parcels (guava, forage cactus, peach, and tomato) to establish new crops in the region (avocado and lemon). The interviews focused on the management characteristics of the productive units and the decision factors for implementing new crops. Likewise, information was collected on the economic, social, crop management, and environmental factors related to the change of crop.

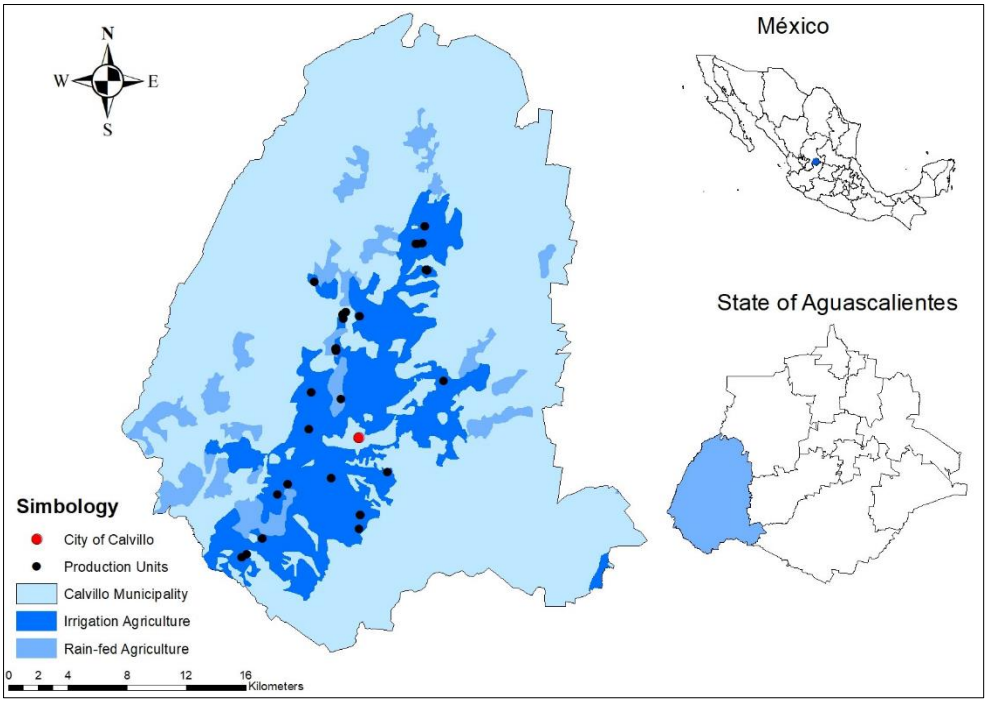


Figure 1. Study area (Calvillo municipality, Aguascalientes, Mexico). Land use characteristics. Prepared by the authors with data from INEGI [33, 34]

2.1. Variables

Using non-probabilistic convenience sampling, producers who planted lemon and avocado crops on their parcels were interviewed. A sampling frame was obtained from the data provided by the State Agri-Food Council with producers who participate in an agricultural reconversion program in the state of Aguascalientes (lemon, strawberry, asparagus, avocado, fig). The instrument used to obtain data from farms included questions about the management characteristics of farms, as well as the reasons for the change of crop, the origin of the water used and the prospects for the continuity of the farms (future of the reconversion).

The perception of producers in relation to the results obtained from the implementation of the crop change (avocado and lemon) in the economic, social, and crop or environmental management areas was also investigated (Table 1). A 5-point Likert scale was used to evaluate the perception of these variables based on the implementation of the new crop (1 = lowest degree of acceptance; 5 = highest degree of acceptance). For the statistical analysis, R Core Team was used [35].

Table 1. Producers' perception in the implementation of new crops

Code	Variable	Reference	Area
ECO 1	Financial gain per hectare	Calle Quintana [36], Linares-Bravo et al. [37]	Economic
ECO 2	Financial gain in the first year		
ECO 3	Product selling price		
ECO 4	Variation in the price of inputs		
ECO 5	Market for products	Porter [38]	
ECO 6	Competition from other producers		
ECO 7	Buyers define the selling price		
ECO 8	Sellers define the purchase price of inputs		
ECO 9	Financial problems (Inverted values)	Romero-Mora et al. [19]	
SOC 1	Total number of employed personnel	Brigido Morales [39], Linares-Bravo et al. [37], Londoño et al. [40]	Social
SOC 2	Number of temporary staff employed		
SOC 3	Number of employed family personnel		
SOC 4	Problems with employees (Inverted values)		
CULT/AMB 1	Volume/Demand of water per year	Rivera N. A. [41], Brigido Morales [39], Londoño et al. [40]	Crop management or environmental
CULT/AMB 2	Use of irrigation equipment		
CULT/AMB 3	Selecting quality seed or seedling		
CULT/AMB 4	Plant density per hectare		
CULT/AMB 5	Soil quality		
CULT/AMB 6	Fertilizers used per year		
CULT/AMB 7	Pests that affect the crop (Inverted values)		
CULT/AMB 8	Pesticides used per year		
CULT/AMB 9	Tillage per year		
CULT/AMB 10	Incorporation of organic matter		
CULT/AMB 11	Mechanization of cultivation		
CULT/AMB 12	Post-harvest operations of the product (cleaning, selection, etc.)		
CULT/AMB 13	Availability of inputs to carry out production		
CULT/AMB 14	Availability of qualified technical advisors for cultivation		
CULT/AMB 15	Crop care during establishment		
CULT/AMB 16	Care at harvest		
CULT/AMB 17	Problems in production (inverted values)		

2.2. Internal Consistency of Variables: Economic, Social and Crop Management or Environmental

The economic domain (ECO) obtained a Cronbach's alpha of 0.5111. When removing the variables ECO 3 and ECO 4, the internal consistency of the measured variable was 0.6596. Although this value is below 0.70, authors such as Huh et al. [42] indicate that in exploratory research an internal consistency value greater than or equal to 0.60 is sufficient. Similarly, Loewenthal [43] suggests that an internal consistency value of 0.60 can be considered acceptable for scales with less than 10 items. For the perception of the social domain (SOC), a Cronbach's alpha of 0.7939 was obtained. Finally, for the perception of the crop or environmental management domain (CULT/AMB), a Cronbach's alpha of 0.4878 was obtained. By not considering the variables CULT/AMB 2, CULT/AMB 3, CULT/AMB 4, CULT/AMB 5, CULT/AMB 10, CULT/AMB 11, CULT/AMB 13, and CULT/AMB 14, the value of Cronbach's Alpha was 0.8005. The statistical analysis is conducted from the items not omitted.

2.3. Methodological Process

The analysis of the variables of this study was as follows:

1. Determination of the objective of the study.
2. Based on the literature review, construction of the three dependent variables for the evaluation of the perception of producers on the productive reconversion in the economic, social and crop management or environmental areas.
3. Information gathering.
4. Verification of the internal consistency of the items.

5. Identification and standardization of the dependent variables.
6. Establishment of the hypotheses to be contrasted, considering the comparison of the three dependent variables simultaneously with the independent variables and the interactions.

   H1: There are significant differences in the perception of producers regarding productive reconversion in the economic, social, crop management or environmental areas in relation to the origin of the water used in the parcels.

   H2: There are significant differences in the perception of producers regarding productive reconversion in the economic, social, crop management or environmental areas in relation to the perspectives of producers when carrying out productive reconversion.

   H3: There are significant differences in the perception of producers regarding productive reconversion in the economic, social, crop management or environmental areas in relation to the previous crop.
7. Verification of assumptions for multivariate analysis (MANOVA). If assumptions are not met, the study hypotheses are verified for the PERMANOVA analysis.
8. Generation of distance matrix, using Euclidean distance.
9. Calculation of the three components of variability: a. total variation, SC_T (total sum of squared distances divided by the number of observations), b. variation within groups, SC_W (sum of squares within groups: consists of the sum of the squares of the distances from the centroids of individual objects or sampling elements to their own group centroid; calculated in the same way as SC_T but separately for each group and summing the result for each group) and, c. variation between groups, SC_A (sum of squares between groups: consists of the sum of squared distances from the individual group centroids to the overall centroid; calculated by subtracting $SC_A=SC_T-SC_W$).
10. Calculation of the statistic using the expression:$pseudo\ F = \frac{SC_A/(t-1)}{SC_W/(n-1)}$, where t is the number of groups to be compared, and n is the number of producers interviewed.
11. Evaluation of statistical significance through a permutation test: a. permutation of the assignment of producers to groups (variables); b. recalculation of the pseudo-F statistic, denoted as F^{π}; c. repetition of steps a and b 9999 times (which generates the distribution of the pseudo-F statistic); d. calculation of the *p*-value of the test as the proportion of permutations that produce a pseudo-F value equal to or greater than that obtained for the original data.

$$p - value = \frac{Number\ of\ F^{\pi} \geq pseudo\_F}{Number\ of\ F^{\pi}} \quad (1)$$

12. Graphically evaluate the results of PERMANOVA through Principal Component Analysis (PCA) [44].
13. Univariate Analysis
14. Discussion of results.

Figure 1, shows the flowchart of the research methodology through which the objectives of this study were achieved.

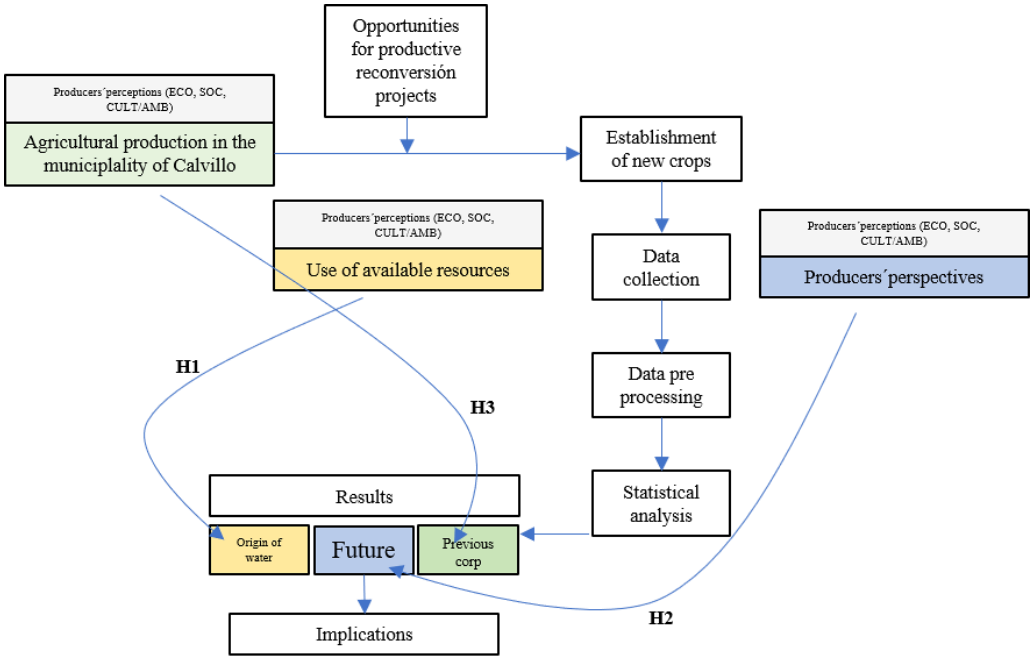


Figure 2. Methodology diagram

2.4. Statistical Analysis

To evaluate the interaction of this study's variables, the Multivariate Analysis of Variance (MANOVA) was used as a first step. It was found that the correlations between the dependent variables are not significant (p>0.05), which indicates a non-compliance with one of the assumptions of MANOVA. Using Mahalanobis distances, it is confirmed that no producer can be considered as atypical. To identify the outliers, the value $\chi^2_{3,0.999} = 16.266$ is considered. With the multivariate Shapiro-Wilk test, it was verified that the fulfillment of the assumption of normality cannot be assumed (p=0.005). Using the M-Box test, it was found that the assumption of homoscedasticity is fulfilled ($\chi^2_6 = 1.303$, p=0.972). Thus, since the assumptions associated with MANOVA were not met, the non-parametric approach was applied as an alternative analysis, which is a powerful, flexible technique that does not start from assumptions such as multivariate normality.

Permutational Multivariate Analysis of Variance (PERMANOVA) is a technique that employs the decomposition of a matrix of distances between the different sources of variation. It assesses statistical significance using free distribution permutation methods. Using Huygens' Theorem [45], the sum of squares of the differences between observations and their centroid, equivalent to the sum of total squares, is equal to the sum of squares of the inter-point distances, divided by the number of observations (geometric approach based on any distance measure ignoring the correlation between variables). In PERMANOVA analysis, the variation within groups can be calculated directly from a distance or dissimilarity matrix [45]. That is, a "pseudo-F" test statistic is constructed. The p-value is calculated from permutations, to verify the null hypothesis that there are no differences in the location of the centroids for the chosen distance measure. This technique is used in various areas of scientific research [46]. The precision of the p-value obtained will depend on the number of permutations performed. The analysis assumes the interchangeability of the permutable units, considering that there are no differences between the groups being compared. Because this test can be sensitive to multivariate dispersion if the sample sizes in each group are very different, the dispersion in the groups was verified using a homogeneity test [47]. With this analysis, the significance of the PERMANOVA is with respect to the mean values (centroids) and not in relation to the dispersion of groups [45].

Dependent variables were standardized and analyzed through a PERMANOVA with three factors (water origin, previous crop, and producers' perspectives on the future of the reconversion) using the "vegan" package of the R Core Team statistical software [35] for a significance level of 5%.

In addition, to identify the differences between groups of (independent) variables that had an impact on the perception of producers regarding the implementation of agricultural productive reconversion programs in the economic, social, crop management or environmental areas separately, an ANOVA and Kruskal Wallis were performed to compare means/medians of two or more groups.

When checking the assumption of normality, it was found that it was only fulfilled for the perception of producers regarding the assessment of productive reconversion in the economic sphere (Kolmogorv-Smirnov, p=0.183). Compliance with homoscedasticity was verified for the three conditions and in each of the independent variables (Table 2).

Table 2. *p*-value for normality and homoscedasticity tests in the univariate analysis of the dependent and independent variables

Test	Economic area	Social area	Crop management or environmental area
Kolmogorv-Smirnov	0.183	<0.001	<0.001
Levene			
Water origin	0.330	0.123	0.126
Producers' perspectives on the future of the conversion	0.654	0.331	0.814
Previous crop	0.47	0.545	0.313

The variable of future of the reconversion was evaluated through a binary logistic model [48, 49] with a global significance level of 5 % to determine the degree of association with the other variables analyzed (ECO, SOC, CULT/AMB, government support (GOV SUPP)).

$$p = \frac{e^{b_0+b_1x_1+b_2x_2+\ldots}}{1+e^{b_0+b_1x_1+b_2x_2+\ldots}} \quad (2)$$

where: p = probability of continuing with the new crops, b_0 = constant, $b_{1,\,2,\,\ldots}$ = coefficients associated with each variable, $x_{1,\,2,\,\ldots}$ = variables evaluated (ECO, SOC, CUL/AMB, …).

The logistic model, once linearized was given as:

$$log\left(\frac{p}{1-p}\right) = b_0 + b_1x_1 + b_2x_2 + \cdots \quad (3)$$

3. Results

The agricultural productive reconversion programs in the state of Aguascalientes are an initiative of the state government to trigger the growth of the countryside, new crop proposals with better marketing schemes for agricultural products produced in the region are also part of those programs, all with the intention of consolidating productive units that diversify production and increase income from the sale of products.

The information was collected in 2023, and producers (n=49) identified in the study had converted their crops (nopal, peach, tomato, guava) to lemon or avocado production (163 ha) and employed more than 200 people in the previous year. In this study, 32 producers established lemon cultivation and 17 established avocado cultivation. The main factor considered by producers to carry out the productive reconversion in the municipality of Calvillo was to test the new crop (40.82%). This reflects the need for producers to look for alternatives for production and improve their profitability [11, 18, 21]. Another factor considered by producers in converting crops was the low profitability of the production of the previous agricultural product (36.73%), data similar to that found by Garín et al. [24]. Other factors that have been taken into account by producers to carry out the productive reconversion are good comments from other producers about the new crop, positive results in the implementation of the crop with other producers, government support for the establishment of new crops, among others. Although government support for the establishment of new crops in the region was not the main cause identified by producers, it was found that more than 75% of producers received some type of support related to the establishment of new crops, mainly for the acquisition of certified seedlings (Table 3).

Most of the producers interviewed had less than 5 years of experience working with the new conversion crop. The perceptions of the producers regarding the new crop were evaluated in the economic, social, and crop management or environmental areas. In this sense, it was possible to identify that more than 60% of the producers see the change of crop as positive, since they have a positive expectation in the establishment of the new crop. However, it was found that only 57% of the producers belong to an association or group of producers, which makes it difficult to integrate the productive chains for the acquisition of technological packages for the members. These findings show that the producers, despite having little time in the production of these new crops, see the change as an opportunity to promote the development of their environment, which coincides with what other authors have pointed out [15, 26].

The interviewed producers also pointed out the difficulties they have had in implementing the new crops. The main problems identified in the establishment of avocado and lemon crops were the impact of different types of pests (41%), problems with the marketing of their products (31%), climatic problems due to frost, hail, or drought (24%), and problems with the soil due to the low adaptability of the new plants or low productivity (12%). The problems detected in this study coincide with those established by Rodríguez-Robayo et al. [27], who pointed out the importance of efficient crop management in different operational areas.

Table 3. Descriptive data of the productive units

Variables	Description	Avg.	Desv. Std.
Age	Age of the producer in years	56.63	13.42
Experience	Number of years dedicated to agricultural activity	30.6	15.99
Experience in reconversion	Number of years dedicated to the new crop	3.756	4.669
Schooling	Number of years attended school	6.898	5.439
ECO	Summation of the variables of the ECO perspectives on the new crop	21.184	4.829
SOC	Summation of the variables of the SOC perspectives on the new crop	10.571	3.156
CULT/AMB	Summation of the variables of the CULT/AMB perspectives on the new crop	20.94	7.37
Future of reconversion	1= If the producer sees a favorable future for the establishment of the new crop	0.6327	0.4871
Government support	1= If the producer had support from the government for the establishment of the new crop	0.7755	0.4216
Contracts	1= If the producer has a contract for the sale of his products	0.0408	0.1999
New crop	1= If the producer established lemon as a new crop	0.6531	0.4809
Member of organization	1= If the producer belongs to a producer organization	0.5714	0.5

ECO: Economic area variables; SOC: Social area variables; CULT/AMB: Crop or environmental management area variables.

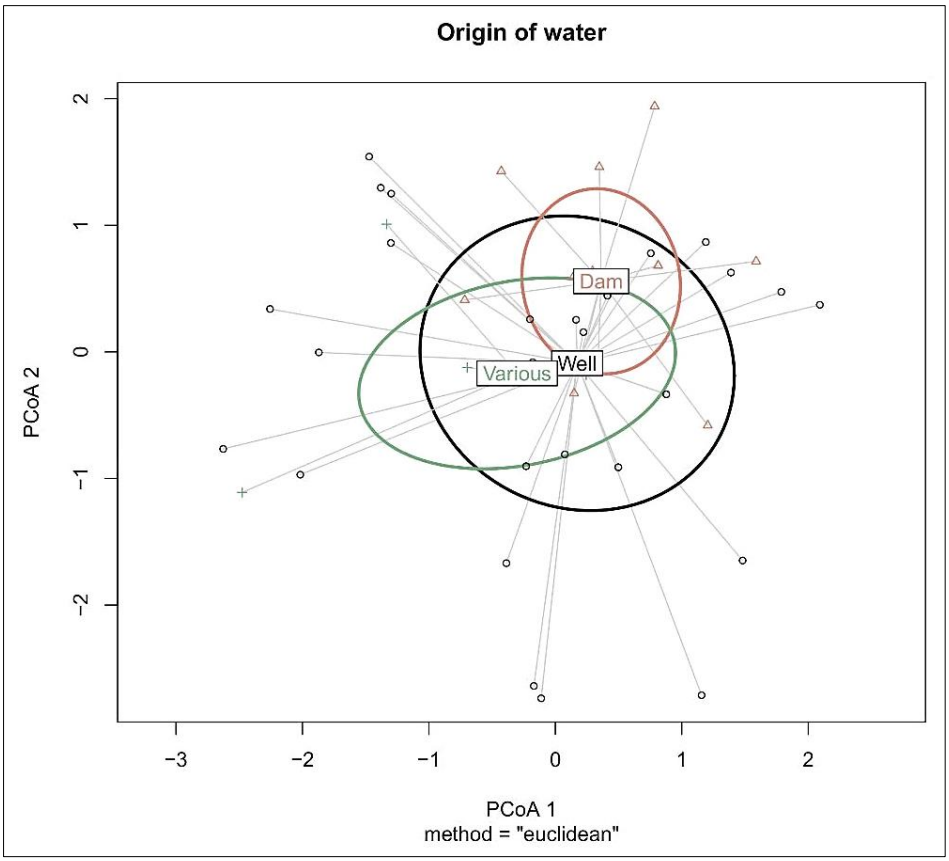
3.1. Multivariate Analysis

For the independent variables, water origin, future of the reconversion, and previous crop, the homogeneity of variances was verified using the betadisper function in the "vegan" package for the R Core Team software [35]. The PERMDISP method (a test analogous to the Levene test) proposed by Anderson [46] was used. With 9,999 permutations in the three independent variables, compliance with homogeneity of dispersion ($p>0.05$) is assumed for the water origin, for the future of the reconversion, and for the crop prior to productive reconversion.

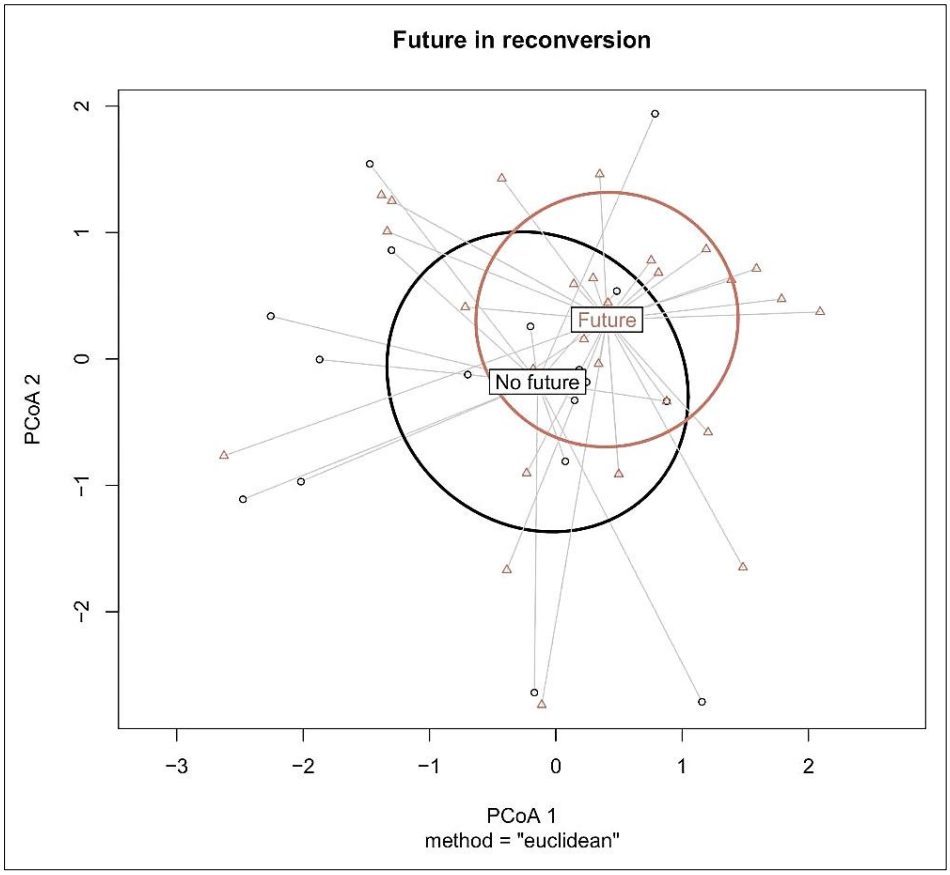
A test was performed that simultaneously calculates the general significance of the impact of the origin of water, the future of the reconversion, and the previous crop on the variables that measure the perception of producers in the economic, social, and crop or environmental management areas. Significant results were obtained (pseudo-$F(8,40) = 3.0543$, $p<0.001$). In this way, it is verified that there are significant differences ($p<0.001$) between the calculated centroids. Therefore, it was possible to verify that the variables that evaluate the origin of water, the future of the reconversion, and the previous crop simultaneously influence the perception of producers in the economic, social, and crop or environmental management areas.

The PCA is a tool to visualize data in several dimensions that starts from a distance matrix [44]. The RVAideMemoire package of the R Core Team statistical software [35] was used to obtain the following representations of each of the key factors of interest (the origin of the water, previous crop, and the perception of the producers regarding the future in the reconversion of their parcels) in the variables of the economic, social, and crop or environmental management areas (Figure 3). In this analysis, significant differences were identified in the mean values of the variables that evaluate the perception of the producers on the economic, social, and crop and environmental management areas regarding the use of dam water with other types of supply (edges, springs) ($p<0.05$). Likewise, differences were found with the use of dam water and the use of well water to irrigate their parcels ($p<0.10$).

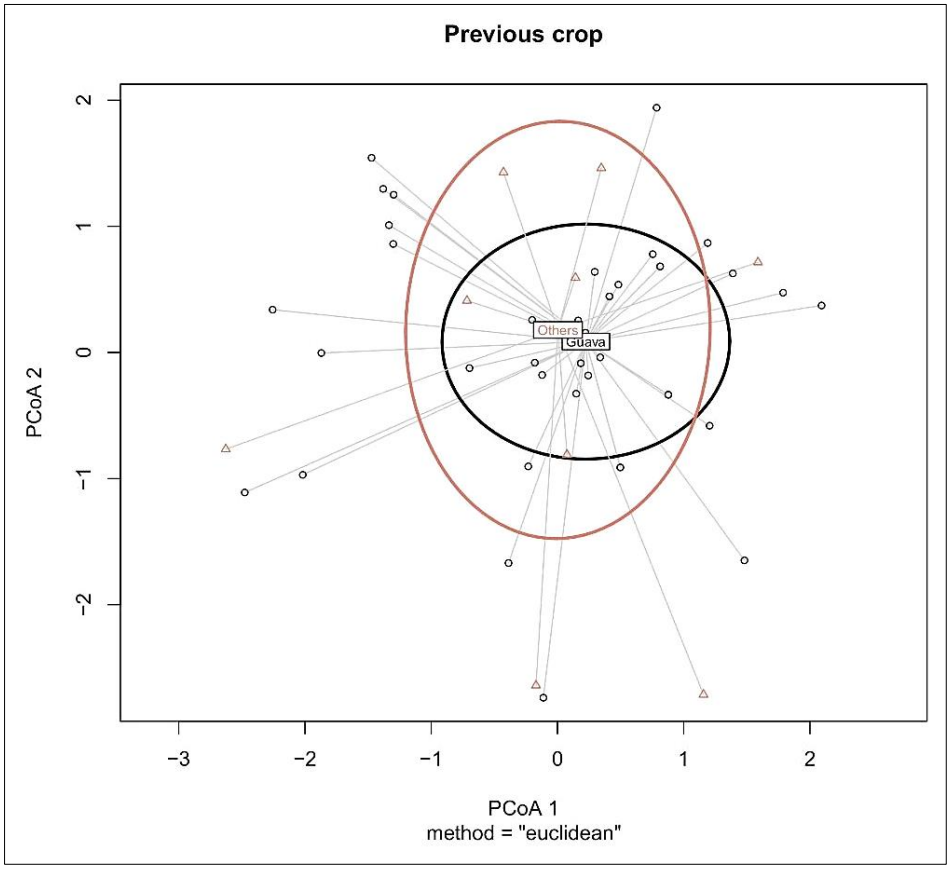
In this study, various factors are considered for the comprehensive analysis of agricultural environments and their changes. Jan et al. [50] have identified the need to integrate the socioeconomic and biophysical agricultural contexts for the development of strategies that contribute to the understanding of the phenomenon of agricultural reconversion. Similarly, Fiore et al. [51] point out the importance of the challenges of the agricultural sector through the study of socioeconomic factors and agroecological dynamics. This is for the reduction of existing gaps in the rural sector and the integration of strategies that promote the sustainability of the primary productive environment.



(a) Origin of the water - ECO, SOC and CULT/AMB variables



(b) Future in the reconversion - ECO, SOC and CULT/AMB variables.



(c) Previous crop - ECO, SOC and CULT/AMB variables

Figure 3. Principal component analysis of the variables analyzed

To measure the individual effect of the variables water source, future of reconversion and previous crop on the variables that measure the perception of producers in the economic, social and crop or environmental management areas, it was found that the water source significantly affects the CULT/AMB area ($p<0.01$). The future of the reconversion also had a significant effect if a higher level of significance is considered ($p<0.10$). In the case of interactions, the variables water source and previous crop significantly affect the CULT/AMB area ($p<0.05$). And the variables future of the reconversion and previous crop significantly affected the CULT/AMB area ($p<0.001$) (Table 4).

Table 4. PERMANOVA of the effect of the variables analyzed

Variables	Degrees of freedom	Sum of squares	pseudo-F	*p*-value
Origin of the water	2	13.893	3.1083	0.0091**
Future of the reconversion	1	5.707	2.5537	0.0594·
Previous crop	1	3.767	1.6855	0.1669
Origin of the water and Future of the reconversion	2	7.316	1.6368	0.1485
Origin of the water and Previous crop	1	9.295	4.1592	0.0106*
Future of the reconversion and Previous crop	1	14.629	6.5459	0.0002***
Residual	**40**	**89.393**		
Total	**48**	**144**		

Significance: * ($p<0.05$); ** ($p<0.01$); *** ($p< 0.001$); · ($p<0.1$).

3.2. Univariate Analysis

When analyzing the ANOVA assumptions, it was identified that they were only fulfilled for the variable of perception of productive reconversion on the economic area. Kruskal Wallis tests were carried out for the variables of perception of productive reconversion on the social and crop or environmental management areas. The results are shown in Table 5.

Table 5. Univariate comparisons

Factors		ECO			SOC		CULT/AMB	
		n	Mean±DE	*p*-value	Mean±DE	*p*-value	Mean±DE	*p*-value
Origin of the water	Well	31	20.71 ± 4.80	0.923	10.23 ± 3.40	0.381	22.55 ± 8.27	0.233
	Damp	13	23.62 ± 3.50		11.92 ± 1.66		18.54 ± 4.98	
	Others	5	17.80 ± 5.93		9.20 ± 3.90		17.20 ± 2.95	
Future of the reconversion	No	18	18.72 ± 4.93	0.005*	9.89 ± 3.32	0.345	19.61 ± 7.99	0.148
	Yes	31	22.61 ± 4.22		10.97 ± 3.04		21.71± 7.01	
Previous crop	Guava	40	21.52 ± 4.69	0.302	10.53 ± 3.10	0.989	20.85 ± 6.73	0.534
	Other	9	19.67 ± 5.43		10.73 ± 3.60		21.33 ± 10.26	

* Significant differences between the means of the variables ($p<0.01$)

The producers interviewed in this study considered the implementation and permanence of new alternative crops in a positive way. This occurs when the economic impact factors on the agricultural production units are considered ($p<0.005$). Nguyen et al. [9] point out the importance of generating economically viable alternatives to improve the possibilities of receiving greater economic resources and contribute to the economic stability of their families.

In this study, the probability of success in the implementation of new crops in the municipality of Calvillo was evaluated (y=0, there is no future in the reconversion; y=1, there is a future in the reconversion). The perception of the producers on the variables ECO, SOC, CULT/AMB and GOV SUPP was considered. Several binary logistic models were evaluated to select the model that best explained the probability of success of the reconversion (Table 6). A selection of variables to be considered in the final model was made, this, through the verification of the following parameters: 1) the global significance of the model (Likelihood ratio test); 2) the significance of the independent or predictor variables (Wald chi test); 3) the McFadden pseudo R2 ("values of 0.2 to 0.4 represent EXCELLENT fit" [52]); 4) the Akaike Information Criterion (AIC) [53]; and, 5) the confusion matrix as an adjustment criterion (accuracy: percentage of correct predictions on the data; sensitivity: ability to detect y=1; specificity: ability to detect y=0).

Table 6. Logistic models evaluated

Variables analyzed	Likelihood ratio (*p*-value)	Pseudo R^2 McFadden	AIC	Accuracy (%)	Sensitivity (%)	Specificity (%)
ECO**	0.0049	0.123	60.5	71.4	87.1	44.4
ECO**, GOV SUPP*	0.0027	0.184	58.6	71.4	80.6	55.6
ECO***, CULT/AMB, GOV SUPP**	0.0021	0.229	57.7	73.4	83.9	55.6
ECO**, SOC, CULT/AMB, GOV SUPP**	0.0044	0.235	59.3	75.5	83.9	61.1

* Significance (p<0.10); ** significance (p<0.05); *** significance (p<0.01); AIC: Akaike Information Criterion.

The binary logistic model was determined by the independent variables ECO, CULT/AMB and GOV SUPP (p=0.0021) given by the linear equation:

$$ln\left(\frac{p}{1-p}\right) = -7.06 + 0.23 \times ECO + 1.73 \times GOV\ SUPP + 0.08 \times CULT/AMB \quad (4)$$

This model explains with greater precision the probability of success of productive reconversion. It was determined that the variables of economic perceptions and crop management or environmental, as well as the government support obtained were significantly associated (p<0.01) with the future of the agricultural productive reconversion. Previous studies agree in identifying economic, environmental and state intervention variables in the development of the agri-food sector [30, 50, 51]. The proposed model indicates different areas that must be interrelated to favor success in the implementation of the agricultural productive reconversion. This is done through the consolidation of markets to increase competitiveness, the care of available resources to ensure the continuity of the activity and government support as an agent of rural development.

4. Discussion

Decision-making in the agri-food sector is complex; the impacts of changes in farmland cannot be inferred from a single variable. This discussion of results aims to integrate the areas evaluated in the study to understand the phenomenon of agricultural productive reconversion.

Food production in the world represents a challenge for the agri-food sector. Small farms will play a fundamental role in food security in rural areas. However, to keep prices of agricultural products low, producers cannot meet consumer demands for equality or reduced environmental impact in production [54, 55]. These deficiencies arise mainly in developing countries because there are no requirements for the acquisition of consumer goods.

Another risk factor for this sector is the change in the seasonality of the rainy season, the volume of annual precipitation, and the availability of water, which represent threats to the continuity and/or establishment of new crops [56]. The use of agricultural machinery to achieve better production yields has caused a deterioration of some soils, so actions must be taken to balance, on the one hand, the economic benefits of increased productivity and, on the other, the conservation of available resources [57].

The lack of comprehensive strategies in the implementation of productive reconversion programs has had negative results due to the search for economic gain over community or environmental development of agricultural regions [37]. Also, negative impacts on the development of the agri-food sector have been identified due to the limitations of public policies, which fail to address the interests of all those involved in production [58]. In contrast, the strategies used by governments to encourage sustainable change processes in agricultural production parcels have been: 1) crop diversification; 2) integration of the productive chains of the agri-food sector; and 3) the introduction of fair marketing practices for producers and environmental care [59]. It is convenient that when sustainable change is carried out, socio-ecological systems should be understood, emphasizing the sustainability of biodiversity and social equity in the agri-food sector [60].

The premises of the implementation processes of productive reconversion programs are to increase the productivity and competitiveness of the agri-food sector under sustainability schemes [40]. Decision-making by agricultural producers must consider the economic, agro-ecological and environmental areas to achieve agricultural sustainability [50]. The above is supported by public policies that contribute to the comprehensive development of the sector.

In this same sense, decisions must have a balance between short-term and long-term economic, environmental and social impacts [51, 55]. Various strategies have been proposed to increase the competitiveness of agricultural production units, such as agricultural diversification [61], since previous experience in the establishment of crops with similar management and marketing characteristics can increase income from the sale of agricultural products at different times of the year [41]. An opportunity for the development of the agricultural sector in developing countries will be possible if the gaps in productivity and the increase in demand for agricultural products due to population growth are reduced [62].

Furthermore, to improve productive units in productive reconversion processes, it is necessary to strengthen land ownership, access specialized technical support for producers, promote the integration of producers in supply chains and place the development of farmers at the center [63]. Horizontal integration in agricultural production has been identified as a factor that contributes to improving the productivity of productive units with paths to greater sustainability [64].

In agricultural production and in the diversification of crops, compensations for the positive impacts that productive changes have on the soil or community development must also be considered [65]. To achieve positive results in the transformation processes in the interactions between humans and the environment, models have been proposed that include the participation of public policy makers, academia, and the producers themselves as agents of social and productive change [66].

Kasumaningrum et al. [67] showed that social development in rural communities increases if there is greater social innovation because there are greater opportunities for productive units. Sustainable public policies require paying attention to agricultural areas due to the vulnerability of ecosystems that depend largely on available natural resources [68]. State participation is essential to guarantee the development of rural localities since, through public policies that impact investment growth, favorable results will be achieved in the economic, social and environmental fields [30].

The hypothesis contrast in this study helped to distinguish the perceptions of producers regarding the establishment of new crops on their parcels in the economic, social, crop management, or environmental areas. The importance of key factors for the implementation, development, and future of agricultural productive reconversion is shown, such as: a. (H1) the origin of water as a key element to carry out agricultural production [56]; b. (H2) the expectations of producers about the future of productive reconversion [50]; and c. (H3) the previous experience of producers with similar crops [41].

The problems faced by the rural sector in emerging countries have challenges to solve. On the one hand, food sovereignty is threatened by the implementation of new crops that could have negative impacts on the productivity and environmental sustainability of agricultural land; on the other hand, the value acquired by urban land is an obstacle to continuity of food production when the economic situation of producers is affected and they have the opportunity to capitalize by selling their parcels for the construction of housing [69]. Strategies that help to value the impact of food production, from an ecological and environmental point of view, will help to understand the phenomenon of reconversion towards sustainable agricultural production [70].

The challenges for food production are global; it is not possible to understand the phenomenon of productive reconversion with a variable that details the complexity of the sector. To better understand the decisions of producers seeking the growth and development of agricultural farms, it is necessary to take into account an analysis of the characteristics of the productive units, the culture of the producers, the care of the environment and public policies in a holistic way.

The above aims to: 1) Redesign the productive structure of agricultural units to meet the needs of the markets with the proper management of available agroecological resources. This is achieved through the establishment of public policies that promote rural development. 2) Success in the implementation of agricultural productive reconversion projects is tangible to the extent that production units adapt their processes to minimize risks and increase their productivity. 3) Efficiently harvest quality fruits without damaging the available environmental resources to promote regional development and improve the quality of life of producers and their families.

5. Conclusions

The availability of land for cultivation is limited in Calvillo, Aguascalientes; however, the growth of agricultural productivity is crucial for the development of the region. As urbanization increases, structural changes occur in the development of agricultural production units, in the availability of labor for agricultural production, as well as in the demand for consumer products. The challenges for food production are global; it is not possible to understand the phenomenon of productive reconversion with a single variable that, by itself, details the complexity of the sector.

This research visualized the impact of factors of the productive units with the future and development of agricultural reconversion in Calvillo, Aguascalientes, considering economic, social, and environmental aspects in the implementation of crops with high market potential to promote sustainability and development of the rural context.

The main findings were: 1) Agricultural productive reconversion is feasible and has encouraging results in the continuity of agricultural production in Calvillo, Aguascalientes. However, it is important to consider factors outside of production so that organizations are successful in a changing and turbulent business environment. 2) Producers have a positive perception of the implementation of new crops. Nevertheless, they have difficulties in integrating the production chain and, therefore, access to new technologies and alternatives in marketing is hindered [15, 26]. 3) It is essential for the reconversion of crops to establish convergent strategies to improve the integration of producers, the adequate management of threats to the crop (pests, hail, drought, etc.), responsible use and management of the soil, technical and administrative support in the production and marketing of products [27].

Finally, the challenges of productive reconversion at local and national levels go beyond technical knowledge. A structured intersectoral articulation is needed, involving academic knowledge, government support, and cooperation between producers. Likewise, the identification, development, and implementation of productive reconversion methodologies and strategies with a holistic and systematic approach are required to find specific solutions for the various types of crops and land. This, in order to contribute to the development of sustainable, nutritional agri-food systems, with food security and sovereignty for the populations, without putting their economic, social, and environmental rights at risk.

5.1. Limitations and Future Lines of Research

The present study faces some limitations due to the scarcity of findings on the analysis variables in emerging markets. This limits the ability to make in-depth comparisons across different contexts. Future research can address this limitation by including a larger sample and population with different circumstances and other types of crops to obtain more complete knowledge of the agricultural productive reconversion phenomenon and the relationship with extra variables. The integration of economic data from the productive units could enrich the measurement of crop and producer productivity.

There are several areas of opportunity for future research. For example, examining and comparing the results of productive reconversion among different groups of producers could shed light on replicable team dynamics and methodologies. In addition, analyzing and comparing the results of producers who have access to technology with those who have this limitation and identifying possible areas of opportunity. To finish, studying the access and support that different producers have to government resources and programs, with the aim of increasing the possibilities of implementing agricultural reconversion in a successful manner.

6. Declarations

6.1. Author Contributions

Conceptualization, C.E.R.B.; methodology, C.E.R.B. and M.C.M.L.; validation, C.E.R.B. and M.C.M.L.; formal analysis, C.E.R.B., M.C.M.L., and N.P.M.; investigation, C.E.R.B., N.P.M., H.A.C.P., and M.Y.G.V.; writing—original draft preparation, C.E.R.B., M.C.M.L., N.P.M., and H.A.C.P.; writing—review and editing, C.E.R.B., M.C.M.L., N.P.M., and M.Y.G.V. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available in the article.

6.3. Funding

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6.5. Institutional Review Board Statement

Not applicable.

6.6. Informed Consent Statement

Not applicable.

6.7. Declaration of Competing Interest

The authors declare that there are no conflicts of interest concerning the publication of this manuscript. Furthermore, all ethical considerations, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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