ENVIRONMENTAL MANAGEMENT IN THE VEGETABLE SECTOR OF MEXICO

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ABSTRACT

The major environmental concerns of agriculture in Mexico are related to water resources and deforestation, in addition to the increasingly important issues of pesticide use, pollution, greenhouse gas emissions and soil erosion. This situation worsens in arid or semiarid regions, such as the state of Zacatecas, where the main source of water is 34 aquifers, 15 of which are overexploited. One option for reducing environmental deterioration is to encourage production units to adopt environmental management systems (EMS). These systems, however, are not well known to growers at the local or national level. The establishment of an EMS in the agricultural sector is relatively new, although it is widely used in other industrial sectors. This study determined the views, drivers and barriers to adopting an EMS in the vegetable sector of the state of Zacatecas, Mexico. A questionnaire was given to 202 technicians or owners of vegetable production units. The data were analyzed using confirmatory factor analysis and structural equation modeling. Improving access to markets was the most important driver for EMS adoption, while the lack of government support was the main barrier. The study demonstrated that views of sustainability are closely related to attitudes toward environmental management actions and environmental sustainability.
Keywords: environmental management systems, environmental protection, natural resources management.

1 INTRODUCTION

Agriculture is the main user of land, water, and biotic resources in most countries, greatly affecting the environment as well as society [1]. Actions that help to guarantee sustainability of the agricultural sector are of growing importance. As part of the food supply chain, agricultural enterprises face great challenges and opportunities in terms of sustainability.

The OECD [2] points out that Mexico's major environmental concerns in agriculture are related to water resources and deforestation. However, other agriculture-related issues are of growing importance: pesticide use, soil pollution caused by misuse of chemical products, greenhouse gas emissions, and soil erosion. These problems are more severe in arid or semi-arid regions, such as the state of Zacatecas, where 88.3% of the farmland is rainfed and 11.7% is irrigated [3]. Water for irrigation is extracted from 34 aquifers, of which 44% are overexploited.

In this context, sustainability is a huge challenge for agricultural production units. Progress toward managing this problem can be made through transparency of the impact of the production processes of the organizations in their ecological and social ambients [4]. To

contribute to this process, a series of mechanisms for voluntary adoption have emerged [5, 6]. One of these mechanisms is environmental management systems (EMS). A growing, but still limited, number of publications have reported theoretical and empirical study of what determines the adoption of voluntary mechanisms [7–9, among others] in non-agriculture sectors [10–12]. Moreover, in the agro-food sector, Grolleau *et al.* [6] analyzed the factors that determine voluntary adoption of the EMS ISO14001 or EMAS in agro-industrial enterprises in France. Hauschildt and Schulze-Ehlersb [13] analyzed the relationships between sustainability views, drivers and barriers, and procurement practices for sustainability in the German food service industry.

In the case of the agricultural sector, the first studies related to the voluntary adoption of EMSs appeared at the end of the twentieth century [14, 15]. Newbold *et al.* [16] studied the informal environmental management options used in agriculture. Carruthers [17] reports interviews with 40 growers and administrators of production units in Australia and New Zealand, who had either adopted a recognized EMS or had used a less formal one.

In spite of widely divulged information on EMS internationally, it is recognized that there is still little economic or social analysis of the determinants of its adoption, especially at the sector level [6]. In the particular case of Mexico, most of the agricultural production units report a lack of information on the administration of natural resources and care and protection of the environment [18]. Also, few studies report what perception agricultural producers have of the impact agriculture has on the environment, the importance farmers give to the sustainability of their production units, or their perceptions of the drivers and barriers to adoption of an EMS in this sector. This study aims to fill the gap in the information on the adoption of voluntary mechanisms by production units of the agriculture sector relative to environmental aspects. This will provide the different agencies involved in the development of the sector with information that will help them to improve their decision-making in planning short- and medium-term activities, and contribute to economic, social, and ecological sustainability of this productive sector.

The objective of this study is to determine the views on sustainability, drivers and barriers to adopting an EMS in the vegetable sector of the state of Zacatecas, Mexico. The research questions that this study answers are: What are the drivers and barriers to adoption of an EMS in the vegetable sector? What is the relationship of vegetable producers' views on sustainability to attitudes toward environmental management actions and toward environmental sustainability actions?

2 MATERIALS AND METHODS

2.1 Data collection and sample definition

The owners and technicians of four vegetable production units in the state of Zacatecas were interviewed in April and May 2014. The objective of the interviews was to identify production and environmental care and protection practices, as well as those related to environmental management among their activities. Based on these interviews and a review of literature on sustainability and environmental management, a questionnaire was designed. The questionnaire was piloted in February 2015.

The number of growers or technicians to be surveyed was determined by obtaining a representative sample of the production units (PUs) that grow vegetables. The universe for selection of the sample was the census of vegetable growers available in SAGARPA, Delegation Zacatecas (chili, tomatoes and garlic) and growers associations such as Cluster de

Agricultura Protegida, A.C. and the Sistema Producto Tomate. The sampling method was simple random selection [19]. The sample was determined with a confidence level of 95%, a level of variability of 0.25 (considering a criterion of maximum variance and a level of precision of 7%). With the universe of 2,204 growers registered in the censuses (chili = 1,749, tomato = 278 and garlic = 177) and adjusting with a correction factor of finite population, the minimum sample was 180 questionnaires. From March to July 2015, 207 questionnaires were applied; 202 were completely answered and were found useful for the study. The selection criteria for the PU to be surveyed were the following: (a) an open field vegetable cultivation area of ≥ 10 hectares, or one hectare under protected agriculture, b) agricultural activity reported during 2014, and (b) willingness of the technician or owner to answer the questions. The characteristics of the PUs surveyed are presented in Table 1.

2.2 Data analysis

To determine producers or technicians' perception of what the drivers and barriers to adopting an EMS are, seven questions in each case were included. The participants were asked to respond on a scale of 1 to 5 where 1 = not important and 5 = highly important. Two analyses were performed: one grouping the PUs by whether or not they had some kind of certification and the other by whether or not they exported. To determine the relationships of views on sustainability (VSUS) to attitude toward environmental management actions (AEMS) and

Table 1: Characteristics of the surveyed production units (n = 202).

Total planted area of the PUs and type of cultivation	Open field (ha)	8,568.8
	Protected agriculture (ha)	415.5
	Total (ha)	8,984.2
Type of cultivation in the PUs	Only field cultivation	123
	Only protected agriculture	36
	Open field cultivation and protected agriculture	43
Market type where the PUs sell their produce	Local	76
	National	64
	Local and national	54
	Local, national and international	1
	Nacional and international	7
Certifications	PU has some sort of certification	37
	PU has no certification	165
Formal education of the survey participants	Elementary school	38
	Secondary school	44
	High School	31
	Bachelor's degree	76
	Graduate degree	13

toward environmental sustainability actions (ASUS), a first order confirmatory factor analysis (CFA) model was applied, considering the proposal of Epstein and Roy [20] (Fig. 1). The indicators or variables observed of the views on sustainability (VS1-VS16) were adapted from Rankin *et al.* [21] and Hauschildt and Schulze-Ehlersb [13]. The indicators of environmental management actions (AE1-AE8) were obtained from SENASICA [22, 23], and environmental sustainability actions (AS1-AS7) from Carruthers [17]. A 1 to 5 scale was used to measure each of the indicators in which 1 = not done or don't agree, and 5 = done or totally agree. The initial first-order CFA model was run to test the interrelationship of the factors VSUS, AEMS and ASUS, as well as to obtain the representability of the indicators or observed variables attributed to each factor (latent construct), avoiding unreliable and redundant indicators.

According to the Mardia index, the data follow a normal multivariate distribution [24]. Estimation of the parameters in the model was determined using Maximum Likelihood estimation. The items that correlated highly were eliminated from the model to prevent multicollinearity and because they were not considered representative of the factor. Another criterion applied to reduce observed variables was index modification to detect mis-specified error covariances and items. The applications were performed using AMOS v23 software. Tables 2–4 present the definitions of the variables of the analyzed factors.

3 RESULTS

3.1 Drivers and barriers to adoption of an EMS in the vegetable sector

The adoption of an EMS is multidimensional and refers to different factors, such as pressure from consumers and other agents in the value chain, the desire to improve performance and implement an integrated management system [6, 25]. These factors, however, change over time and vary with changes in individual circumstances and context.

Survey participants considered facilitating access to domestic and international markets (4.51) and reducing production costs (4.38) the most important motivations for EMS adop-
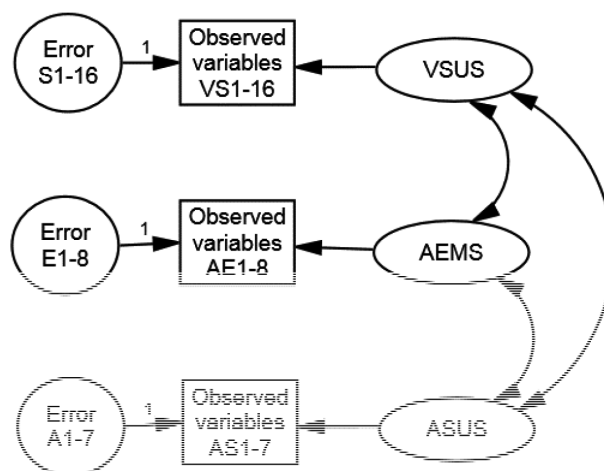

Figure 1: Initial confirmatory factor analysis model.

Table 2: Variables evaluated in the factor "Views of sustainability".

Factor	Variable observed	Variable definition
Views of sustaintability (VSUS)	VS1	Complying with laws and standards
	VS2*	Producing safe products for consumers.
	VS3	A way to strengthen image
	VS4*	A strategy for cost savings
	VS5*	A belief that leads to caring for and protecting the environment
	VS6	A strategy for improving market position
	VS7*	A way to impact employee satisfaction
	VS8	An opportunity for new revenue
	VS9*	A set of values that guide the work of the PU
	VS10	A strategy to improve the PU's position in the long run
	VS11	A method of risk management
	VS12*	A value integrated into the PU
	VS13*	A way of being solidary with other growers
	VS14*	Addressing hunger and societal welfare
	VS15	Reducing impact on the environment to preserve it for the future
	VS16*	An integral part of the core PU

* Removed from the model.
Scale: from 1 = does not apply or does not agree to 5 = in complete agreement.

tion, followed by improving PU sustainability (4.21) (Table 5). These responses are congruent with the findings of Carruthers [17]; Carruthers and Vanclay [25]. The motivation considered the least important was compliance with environmental protection standards (3.76).

Regarding the barriers to EMS adoption [6, 17, 25, 26], Table 6 presents the mean and standard deviation of the perception of the interviewees. Lack of government support (4.17) and additional expenses of monitoring, training, infrastructure and equipment (3.91) were the two indicators that, on average, the survey participants named as the most important barriers to EMS adoption. Another two barriers, with values above 3.75 were not knowing how to quantify environmental damage (3.84) and ignorance of environmental aspects of their management (3.78). Referring to the latter two indicators, Carruthers and Vanclay [25] point out that EMS users know more about their enterprise's impacts and look for solutions more actively than non-EMS users.

Lack of financial resources and ignorance of environmental problems are the most important barriers to adopting an EMS in the vegetable production units of Zacatecas. These two aspects were given more importance than time and work required by the activities related to environmental management. Carruthers and Vanclay [25] also considered that costs, concerns about the necessary skills, time, and resourcing are common barriers for EMS adoption and other practices.

Table 3: Variables evaluated in the factor "Attitude toward environmental management actions".

Factor	Variable observed	Variable definition
Attitude toward environmental management actions (AEMS)	AE1	A record of inputs used during crop development
	AE2	Application of documented procedures related to worker hygiene, good use and management of agrochemicals, harvest, packing, worker training, among others.
	AE3*	Planning activities required for protecting the environment
	AE4*	A written policy for dealing with empty agrochemical containers.
	AE5	A manual of procedures for storing pesticides, handling water for spraying, containing spills, pesticide classification and toxicology, among others.
	AE6*	A defined organizational structure and organization manuals
	AE7*	Application of a documented program of pollutant surveillance.
	AE8*	Adoption of a System of Contamination Risks to prevent pesticide contamination.

* Removed from the model.
Scale: from 1 = not done to 5 = always done.

Table 4: Variables evaluated in the factor "Attitude toward actions relating to environmental sustainability".

Factor	Variable observed	Variable definition
Attitude toward actions relating to environmental sustainability (ASUS)	AS1	Water
	AS2	Soil
	AS3*	Biodiversity
	AS4	Agrochemicals
	AS5	Pollution
	AS6	Waste management
	AS7	Business environmental management

* Removed from the model.
The value of the variable was the average of four items evaluated on a scale from 1 = not done or not applicable to 5 = always done or applied.

It is notable that 37 (18.3%) of the studied PUs have some type of certification related to safety or quality of their products, environmental protection and/or worker well-being, such as PrimusLabs, Buenas Prácticas Agrícolas and BUMA. The other 165 (81.7%) do not have any certification. Of the group of certified PU, eight ship their products to the international

Table 5: Drivers to adoption of an EMS.

Drivers	Mean	Standard deviation
Consistent with personal principles	3.92	.989
Prevent harm to workers	4.01	.990
Improve the production unit's image	4.11	.978
Improve production unit sustainability	4.21	.886
Reduce production costs	4.38	.902
Facilitate access to domestic and international markets	4.51	.806
Compliance with environmental protection standards	3.76	.963

Table 6: Barriers to adoption of an EMS.

Barriers	Mean	Standard deviation
Ignorance about environmental aspects and their management	3.78	1.122
Lack of knowledge on how to quantify environmental damage	3.84	1.086
Additional expenses for monitoring, training, infrastructure and equipment	3.91	1.168
Lack of PU personnel trained in actions that help to protect the environment	3.71	1.054
Lack of government support	4.17	1.090
Too much paperwork and document requirements	3.26	1.187
Not sufficient time to plan and implement environmental actions	3.24	1.199

market. The *t* test for the difference between two means demonstrated that there are significant differences (p-value ≤ 0.05) between certified and uncertified PU in average values of both drivers (certified = 4.52 and uncertified = 4.04) and barriers (certified = 3.45 and uncertified = 3.76) to adoption of an EMS. The same t test also found differences (p-value < 0.05) between the average value of the drivers of the PU that export (4.66) and those that do not (4.11). However, in the case of the barriers, the latter two groups were not significantly different (p-value = 0.214) in their opinion regarding the barriers (exporters = 3.39 and non-exporters = 3.72).

3.2 Views on sustainability and attitude toward environmental management actions and toward environmental sustainability actions

A summary of the selected fit indices to evaluate the hypothesized and the end model is presented in Table 7. The values obtained for the initial first-order EMS model in three key

Table 7: Goodness-of-fit indices (n = 202).

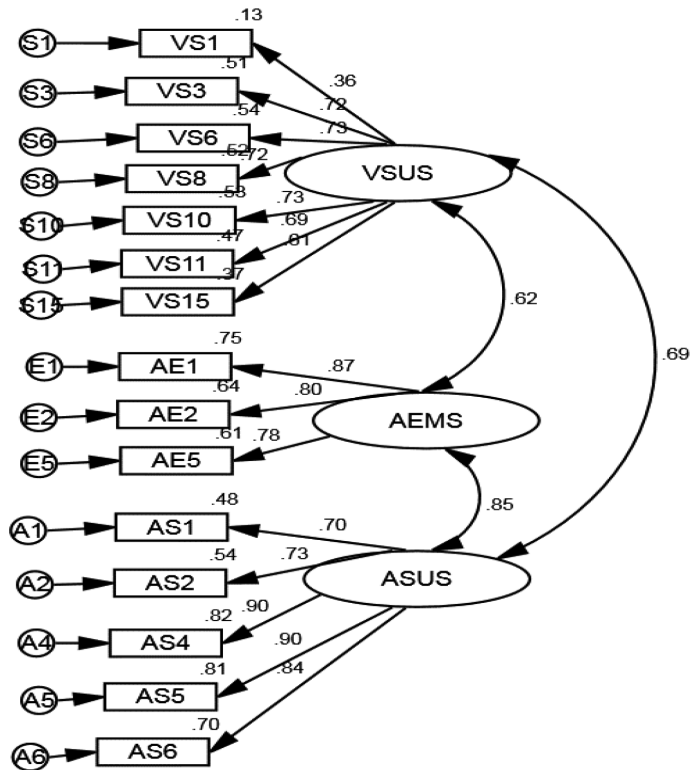|	Initial first-order EMS CFA model	Final first-order EMS CFA model
Number of latent variables	3	3
Total number of observed variables	31	15
Degrees of freedom (df)	431	87
X^2 Statistics	1041.050	143.787
p-value	0.000	0.000
x^2/df	2.415	1.653
Normed Fit Index (NFI)	0.780	0.921
Comparative Fit Index (CFI)	0.857	0.967
Root mean square error of approximation (RMSEA)	0.084	0.057
Closeness of fit (PCLOSE)	0.000	0.235
Expected cross-validation index (ECVI)	5.826	1.044

Figure 2: Final first-order EMS CFA model.

indices were = 1041.05, CFI = 0.857, RMSEA = 0.08, indicating a need to modify the model to improve the fit to acceptable levels (e.g., CFI > 0.90 and RMSEA ≤ 0.08). We thus proceeded to eliminate redundant or highly correlated items in each construct under the criteria indicated above. As recommended by Byrne [24], only one parameter was changed at every step. The Cronbach Alpha coefficient was used to measure scale reliability of the constructs. The values obtained were VSUS = 0.838, AEMS = 0.859 and ASUS = 0.915. Coefficients with Cronbach Alpha values of 0.70 or higher are for narrow constructs and 0.55 or higher for moderately broad constructs [27].

The final first-order EMS CFA model is presented in Fig. 2. Goodness-of-fit statistics related to this model were substantially satisfactory (= 143.78, CFI = 0.967, RMSEA = 0.057) (Table 7). All the structural parameter paths were statistically significant (p-value < 0.001). All the inter-factor correlations were positive, significant (p-value < 0.001), and above 0.60, suggesting the hypothesized relation between factors: views of sustainability and attitude toward environmental management actions and toward environmental sustainability.

4 CONCLUSIONS

The growers manifested that they had little information on EMS application in agriculture and exhibited uncertainty in determining the benefits and costs of its implementation. The most mentioned driver for adoption of an EMS was that it facilitates access to domestic and international markets, while the most mentioned barrier was lack of government support.

The fact that a production unit had the experience of achieving certification related to safety or quality of their products, environmental protection, and/or well-being of their workers significantly differentiated the opinions of the growers or technicians regarding drivers and barriers to adopting an EMS. The same occurred with the drivers of the PU oriented toward international markets versus those that sell on the domestic market. However, between these two groups of PUs there is no difference in opinion regarding the barriers to EMS adoption. It was demonstrated that views on sustainability are positively related to attitude toward environmental management actions and to attitude toward environmental sustainability.

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