



Received: 25 October 2015
Accepted: 09 February 2016
Published: 07 March 2016

*Corresponding author: J. Nahed,
Department of Agroecology, El Colegio
de La Frontera Sur, San Cristobal de Las
Casas, Chiapas, Mexico
E-mail: jnahed@ecosur.mx

Reviewing editor:
Pedro González-Redondo, University of
Seville, Spain

Additional information is available at
the end of the article

ANIMAL HUSBANDRY & VETERINARY SCIENCE | RESEARCH ARTICLE

Possibilities for converting conventional cattle production to the organic model in the Grijalva River Basin, Mexico

J. Nahed^{1*}, D. Grande², J.R. Aguilar¹ and B. Sánchez³

Abstract: The possibilities for converting conventional cattle production to the organic model were evaluated in the Grijalva River Basin, Mexico, and possible interventions were identified. A multi-criteria organic livestock conversion index (OLCI) with 10 indicators comprising 35 variables was used. Information was obtained through participatory workshops, direct observation, and interviews to 91 farmers of 11 different communities in the municipalities of Mazapa de Madero ($n = 17$), Huitiupán ($n = 30$), and Tacotalpa ($n = 44$). Results show higher OLCI values in Mazapa (56.8%) and Tacotalpa (56.7%) than in Huitiupán (49.0%). The production units evaluated show: (i) limitations with respect to indicators *ecological weed control in pastures and crops, veterinary prevention and treatment, food safety, and ecological management*, and (ii) strengths to reach the organic standards are: *feed management, sustainable pasture management, soil fertilization, ecological pest and disease control in pastures and crops, breeds and reproduction, and animal well-being*. In order to revert the future scenario of conventional livestock production and to transition to organic cattle raising, it is necessary to: (1) train and advice farmers regarding ecological production techniques and management, principally with respect to the limitations pointed out, and (2) implement a policy for development of livestock raising with specific functional and structural changes.

ABOUT THE AUTHOR

J. Nahed is a specialist in animal production systems; Nahed has participated in several scientific meetings, and he has taught undergraduate and graduate courses and published several articles in national and international journals on issues related to animal production systems, agricultural production systems, silvopastoral systems and organic farming. He is a National Researcher Level II in the National Research System of Mexico's National Council on Science and Technology (CONACYT according to its Spanish initials), and is an honorary member of the State System of Researchers in Chiapas, Mexico.

PUBLIC INTEREST STATEMENT

In this research, the opportunities and limitations for converting conventional cattle production to the organic model in the Grijalva River Basin, Mexico, were evaluated. The purpose of the research has a wider societal relevance for the farmers of the three communities studied, because conventional livestock production is an important activity in the zone and has a great potential for converting to the organic model.

The research began by the interest in the topic of a group of farmers, which were supported by several researchers of our team. To conduct the research, an intense field work with farmers was carried out, and eventually got to know the main aspects of conventional livestock that favor or limit its transformation to the organic model, in addition to its approximation to this model. The hope of our research team is that farmers in this zone achieve the development of organic livestock production.

Subjects: Bioscience; Environment & Agriculture; Environmental Studies & Management

Keywords: organic livestock conversion index; indicators; cattle production; agricultural sustainability; ecological management; Organic livestock production systems

1. Introduction

Currently, organic agriculture is becoming increasingly important worldwide due to a growing demand for healthy, safe, responsibly produced food (Pimentel, Hepperly, Hanson, Douds, & Seidel, 2005; Pingali & Raney, 2005). This type of agriculture is based on ethical, holistic principles of health, environmental conservation, equity, precaution, and responsibility (International Federation of Organic Agriculture Movements (IFOAM), 2005). In this context, organic livestock raising production systems are based on grazing, which although is not mandatory in the regulations is desirable and advisable, thus closing the soil-plant-animal cycle in a natural, integrated manner. These production systems conserve ecosystems and their biodiversity, promote animal welfare, avoid use of chemically synthesized substances, and offer consumers food with a high nutritional and hygienic-sanitary quality (IFOAM, 2009).

Organic certification could be one of the competitiveness keys in order to market agricultural products (Stofferahn, 2009) because it allows for more market options and better prices by virtue of its quality (von Borell & Sørensen, 2004) and with a proper trade channel. This type of livestock raising promotes clean production as it restricts or prohibits use of toxic agrochemicals; contributes to maximizing interactions among crop agriculture, livestock, silviculture, and the physical environment; maximizes land productivity, efficiently managing the biological principles of animal and plant production; and promotes congruence between use and conservation of natural resources (Gutteridge, 1991). Furthermore, it provides environmental services (Dagang & Nair, 2003; Steinfeld, 2002) such as water catchment and filtration, mitigation of climate change effects, generation of oxygen and assimilation of contaminants, biodiversity protection, soil retention, refuge for wild fauna, and scenic beauty (Comisión Nacional Forestal (CONAFOR), 2012). Furthermore, organic livestock raising with silvopastoral management more greatly reduces enteric methane emissions as compared to pastoral systems because the foliage of fodder tree species is more digestible than grasses (Blaxter & Clapperton, 1965; McCrabb, 2002).

In order to guarantee consumers and certifying agencies that products are authentically organic, there is a need for clear, concise, precise indicators based on ethical and technical principles of this type of agriculture (IFOAM, 2009; Kouba, 2003). Various studies report indicators for evaluating sustainability of agricultural production (Coffey, Reynolds, & Hale, 2004; Galan, Peschard, & Boizard, 2007; Nahed, Castel, Mena, & Caravaca, 2006; Peacock & Sherman, 2010), animal well-being (Napolitano, De Rosa, Ferrante, Grasso, & Braghieri, 2009; Phythian et al., 2011), and environmental effects on milk quality in organic farms (de Boer, 2003; Müller-Lindenlauf, Deittert, & Köpke, 2010; Nauta, Baars, & Bovenhuis, 2006; Rozzi, Miglior, & Hand, 2007). Some of them assess technical and economic behaviors in biological breeding or rearing (Benoit & Laignel, 2009) and farmer attitudes toward conversion of their conventional systems to organics (Midmore et al., 2001), while others criticize organic production because animals are often underfed or infested with parasites due to restrictions on the use of antihelminthic medicines (Vaarst, Padel, Hovi, Younie, & Sundrum, 2005). However, few studies (e.g. Lamine & Bellon, 2009; Mena et al., 2012; Nahed et al., 2009; Olivares, Gómez, & Meraz, 2005) address the use of indicators to evaluate the transition from conventional to organic systems. These four studies allow for orienting agricultural research and development efforts toward organic conversion and recognizing limitations, potentials, and opportunities of existing livestock systems to design strategies for planned functional and structural intervention (Scoones, 1998). Functional impediments may be overcome by substituting one factor of production with another, for example, chemical fertilizers with organic ones, or chemical pest control with biological control. Structural limitations, on the other hand, are a product of the existing social relationships, which are not easy to modify; rather their transformation depends on multiple changes in the social structure in order for social and political processes to evolve (Long & Villarreal, 1993).

From this perspective, two scenarios of evolution of livestock systems may be defined (Mojica, 1991). One is the probable scenario, which would be the result of allowing those prevalent tendencies in conventional cattle production and their environment to continue their current trajectory. The other is the desirable scenario, which is the result of a planned intervention that would modify the current tendencies, moving toward organics, so that the processes undergo significant changes in order to overcome the probable scenario mentioned above. The point of departure for plans responding to both scenarios is the current situation or base line of a given farm (Scoones, 1998).

In southeast Mexico, particularly in the Grijalva cross-border River Basin (Nahed et al., 2010), conventional cattle raising is generally characterized by varying levels of use of local and external inputs. Such systems are based on extensive grazing with varying extents of tree cover and histories of use, interdependence with crop associations for production of basic crops (principally maize and beans), rotation in land use, and use of foliage of fodder trees and shrubs from forested areas as animal feed. The low level of technological development and capital investment is principally evidenced by the following aspects: (i) use of family labor, (ii) precarious infrastructure, (iii) manual means of labor, (iv) basic infrastructure (roads, electricity, water), (v) lack of advisory and training, and (vi) a low level of integration among production, transformation, and marketing.

Based on these aspects, the objective of the present study was: (i) to evaluate the level of approximation of conventional cattle production units (CPU) to the organic model in communities of the upper and middle regions of the Grijalva River Basin, Mexico; and (ii) to identify the limitations and potentials as well as the functional and structural interventions (corrective management measures) necessary for moving the CPU toward organic certification and sustainable development.

2. Methodology

2.1. Location and characteristic of the study site

The Grijalva River Basin has a total area of 56,895 km², of which 9.5% are in Guatemala and 90.5% in the Mexican states of Chiapas, Oaxaca, and Tabasco (García, 2010). This basin includes three portions or regions: the upper, middle, and lower portions. The upper section is principally located in Guatemala and annually provides 2.4 km³ of surface water to the Grijalva River (also known as the Rio Grande de Chiapa); the mid-section lies in the Mexican states of Chiapas, Oaxaca, and part of Tabasco State, and the lower section and the outlet to the sea in the state of Tabasco.

The chemical quality of the soil in over half the watershed has been degraded, negatively affecting its fertility (Colegio de Postgraduados [COLPOS], 2002) and in turn rural development and social processes; García-Barrios et al. (2009) have documented this phenomenon in another region of Chiapas.

The Grijalva River Basin includes 15,144 localities (86.9% in Mexico and 13.1% in Guatemala) with 4,804,794 inhabitants (82.1% Mexican and 17.9% Guatemalan). Due to the diversity of climates, soils, vegetation, and agricultural systems, and the cultural diversity of the indigenous and mestizo populations in this vast territory, management of the river basin is certainly complex. As a contribution to such management, this paper addresses a strategy for intervention in management of sustainable livestock systems in two micro-watersheds located in the upper and middle regions of the Grijalva River Basin (García, 2010).

2.2. Obtaining of information

Information was obtained through participatory workshops, direct observation in the cattle production units, and a semi-structured interview with cooperating farmers (Gillham, 2005). The farms number selection was based on the willingness of the farmers to participate in the study, and in all cases the number of farmers interviewed exceeded 30% of all producers in each municipality studied.

In the upper part of the Grijalva Watershed, 17 farmers from the municipality of Mazapa de Madero (MA), Chiapas State were interviewed: 3 from Colonia Horizonte, 3 from Libertad Frontera, and 11 from the community of Mazapa. In the middle region 74 farmers were interviewed: 30 from the municipality of Huitiupán (HU), Chiapas (10 from Cubilete, 10 from Buen Paso, and 10 from Remolino), and 44 from the municipality of Tacotalpa (TA), Tabasco State (15 from Oxolotan, 5 from Tomas Garrido, 7 from La Pila, 7 from La Cumbre, and 10 from Cuviac).

2.3. Design of the methodology for evaluation

Based on organic standards (Council of The European Union, 2007; IFOAM, 2009), variables and fundamental indicators were defined in order to design a simple methodological approach which would allow for evaluating the approximation of conventional cattle production units to the organic model. In this manner, the OLCI was constructed with 10 indicators comprising 35 variables (Table 1).

In our case study, upon adapting the organic livestock proximity index (OLPI) methodology proposed by Mena et al. (2012), the following changes were made to the original methodology in order to suit our purposes: (i) the original OLPI which has nine indicators was modified to 10 indicators due to the fact that the original OLPI combines weed control in pastures and crops and pest and disease control in pastures and crops into 1 indicator, and the modified OLCI separates them into 2 indicators; (ii) the original OLPI includes 56 variables, and the modified OLCI 35 variables; (iii) the original OLPI was applied to goat raising systems in southern Spain, and the modified OLPI was successfully applied to cattle raising systems in southeast Mexico; (iv) some of the original OLPI's weighting coefficients of the indicators were modified, adjusting them according to the management conditions of the livestock production systems studied; (v) equations of the original OLPI were slightly modified as a function of changes in number of indicators, number of variables, and the weighting coefficients.

Selection of variables and indicators was based on organic livestock raising principles with respect to: (i) use of permitted, prohibited, and restricted substances to prevent, cure, and eradicate illnesses and pests; (ii) non-contaminating agroecological technologies which are not dependent on capital and do not degrade the physical environment because they are based on efficient use of local resources, allowing for maintenance of biological diversity and the soil's long-term productive capacity (Guzmán & Alonso, 2001); and (iii) implementation of mechanisms for management and promotion of ecological livestock raising. Based on the strengths, weaknesses, opportunities, and threats (SWOT) analysis, the main strengths and weaknesses for defined indicators and variables were identified.

Variables were binomially coded (0, 1) in order to homogenize the original units of measure and facilitate calculating the real value of each indicator (without weighting); that is, the arithmetic average of the responses 0 or 1 (Grimm & Wozniak, 1990). In this manner, the 10 indicators were standardized to a percentage (%) or common relative scale. Thus, the optimum value (100%) was obtained for an indicator without weighting when the responses of all its variables were positive (coded as 1).

The percentage value of each indicator was obtained by means the sum of the responses of the indicator's variables (0 or 1) multiplied by 100.

The weighting coefficient or specific weight of each indicator for the study region was defined by consulting 12 experts in organic livestock production from different Spanish and Mexican research institutions as a function of: (i) the importance of that indicator to the agroecological principles of organic livestock raising; and (ii) the difficulty of eliminating or substituting inputs or practices prohibited by the organic standards (Table 1). In this sense, for the three indicators *sustainable pasture management*, *food safety*, and *ecological management* the greatest weights were assigned, because of their agroecological importance and the difficulty for the CPU in the Grijalva River Basin to reach them. In contrast, *soil fertilization*, *ecological weed control in pastures and crops*, *ecological pest and disease control in pastures and crops*, and *breeds and reproduction* indicators were assigned a lower score as, in general, the initial situation of the CPU for which the method is proposed is the closest to

Table 1. Indicators, weighting factors, and variables comprising the OLCI for cattle raising

(1) Feed management (0.12):

- (1.1) Using only animal feed permitted by the organic standards
- (1.2) Grazing
- (1.3) At least 60% of DM of daily ration is common fodder
- (1.4) At least 50% of feed comes from the same farm or another organic farm

(2) Sustainable pasture management (0.15):

- (2.1) Rotation of pastures
- (2.2) Appropriate stocking rate
- (2.3) Association of fodder crops
- (2.4) Cultivation of woody fodder plants (trees and/or shrubs)
- (2.5) Management of silvopastoral systems

(3) Soil fertilization (0.06):

- (3.1) Use of synthetic chemical fertilizers
- (3.2) Use of organic or ecological fertilizers

(4) Ecological weed control in pastures and crops (0.06):

- (4.1) Use of synthetic chemical herbicides
- (4.2) Use of organic or ecological herbicides

(5) Ecological pest and disease control in pastures and crops (0.06):

- (5.1) Use of synthetic chemical pesticides
- (5.2) Use of organic or ecological pesticides

(6) Veterinary prevention and treatment (0.12):

- (6.1) Apply vaccines only against endemic illnesses
- (6.2) Quarantine introduced or sick animals
- (6.3) Natural treatment of illnesses (herbs, homeopathy, or nothing)
- (6.4) Natural internal and external anti-parasite treatments (herbs, homeopathy, or nothing) and permitted allopathy

(7) Breeds and reproduction (0.06):

- (7.1) Only local animals or those adapted to the region
- (7.2) Natural procreation

(8) Animal well-being (0.07):

- (8.1) Natural lactation until eight months
- (8.2) Sufficient space per animal in roofed enclosures and outside
- (8.3) Sufficient feeders and troughs
- (8.4) Protection against inclement weather (cold, heat, rain, humidity)
- (8.5) Horns are cut (young animals) or clipped in animals of any age

(9) Food safety (0.15):

- (9.1) Strict hygienic-sanitary control (of facilities, equipment, milking, and milk management)
- (9.2) Animals have been demonstrated to be free of: (i) brucellosis (ii) tuberculosis
- (9.3) Animals seropositive to: (i) brucellosis and (ii) tuberculosis are sacrificed
- (9.4) Products have been demonstrated to be free of: (i) antibiotics, (ii) hormones, and (iii) pesticides

(10) Ecological management (0.15):

- (10.1) The farmer receives advisory and training for organic certification
- (10.2) The farmer has an organic development plan or is certified
- (10.3) The farmer carries out internal control of the organic process
- (10.4) The farmer receives incentives for quality organic livestock production
- (10.5) The farmer receives a fair or constant sale price for products year-round

Note: Numbers in parentheses are the weighting coefficient of each indicator.

the organic model of production. The greatest and lowest assigned values for the indicators are similar to those used by Mena et al. (2012), but they are lower than those used by Olivares et al. (2005).

The weighted value was obtained by multiplying the value of each indicator by its specific weighting factor.

2.4. Organic livestock conversion index

The OLCI is based on the multi-criteria approach with respect to weighting and aggregating information (Falconi & Burbano, 2004; Munda, 2004; Munda, Nijkamp, & Rietveld, 1994) as a tool to: (i) understand the technological and environmental limitations and potentials of the CPU in a particular economic and social context, and (ii) guide decision-making toward organic production. The OLCI was obtained for each livestock production unit by summing the weighted values of the 10 indicators.

3. Results and discussion

3.1. Approximation of cattle raising to the organic production standard

Values of 10 indicators and OLCI in CPU's for three municipalities are showed in Table 2. The values for *sustainable pasture management*, *breed and reproduction*, *animal well-being*, and *food safety* indicators vary among municipalities. Tacotalpa scored higher statistically significant differences than the other municipalities for *sustainable pasture management* and *animal well-being*; Mazapa scored the highest statistically significant differences in *breeds and reproduction*. The municipalities Mazapa and Tacotalpa scored higher values for *food safety* indicator than did Huitiupán, both scoring the same no satisfactory value (50%). The three municipalities: (i) satisfactorily comply for *feed management* and *organic fertilization*; (ii) acceptably comply for *ecological pest and disease control in pastures and crops*; and (iii) fail to comply with *ecological weed control in pastures and crops*, and *veterinary prevention and treatment*. The municipalities Mazapa and Tacotalpa scored higher statistically significant difference in the OLCI value (57%) than Huitiupán (49%), both scoring the same satisfactory value. Coming up next each of 10 indicators will be analyzed.

- (1) The first indicator—referring to *feed management* (Table 2)—shows that the CPU of all three municipalities satisfactorily reaches the organic standards. That is due because cattle management in these municipalities is exclusively based on grazing, which means complying with

Table 2. Mean values (\pm standard error) of 10 approximation indicators to the organic standard in cattle production units of three municipalities in the Grijalva River Basin

Indicators	Municipalities			F (df1;df2)	p-value
	Mazapa	Huitiupán	Tacotalpa		
N	17	30	44		
Feed management	100.0 (\pm 0.0)	100.0 (\pm 0.0)	99.4 (\pm 0.6)	0.52 (2; 88)	N.S
Sustainable pasture management	58.8 (\pm 1.1) ^b	74.1 (\pm 1.9) ^a	77.2 (\pm 1.2) ^a	30.1 (2; 88)	0.0001
Soil fertilization	100.0 (\pm 0.0)	100.0 (\pm 0.0)	100.0 (\pm 0.0)	–	–
Ecological weed control in pastures and crops	64.7 (\pm 11.9)	40.0 (\pm 9.1)	31.8 (\pm 7.1)	2.83 (2; 88)	N.S
Ecological pest and disease control in pastures and crops	88.2 (\pm 8.0)	86.7 (\pm 6.3)	84.1 (\pm 5.6)	0.10 (2; 88)	N.S
Veterinary prevention and treatment	29.4 (\pm 1.8)	27.5 (\pm 1.5)	29.8 (\pm 1.4)	0.66 (2; 88)	N.S
Breeds and reproduction	100.0 (\pm 0.0) ^a	86.7 (\pm 4.1) ^b	85.2 (\pm 3.5) ^b	3.30 (2; 88)	0.05
Animal well-being	62.3 (\pm 1.6) ^b	62.7 (\pm 1.3) ^b	68.2 (\pm 1.5) ^a	4.99 (2; 88)	0.01
Food safety	50.0 (\pm 0.0)	0.0 (\pm 0.0)	50.0 (\pm 0.0)	–	–
Ecological management	0.0	0.0	0.0	–	–
Organic Livestock Conversion Index	56.8 (\pm 0.7) ^a	49.0 (\pm 1.0) ^b	56.7 (\pm 0.6) ^a	33.95 (2; 88)	0.0001

Notes: Different superscript letters (^a, ^b, ^c) in the same line indicate significant differences ($p < 0.05$). N.S.: Not significant.

requisites that at least 60% of dry matter (DM) of the daily ration is green fodder (grazed or cut), hay, or silaged fodder, and that at least 50% of feed comes from the same farm or another organic farm. Very few external supplements are used; only a few CPU sporadically provide non-ecological commercial mineral salt to the animals. The fact that feeding in the three municipalities evaluated is based on grazing and negligible use of prohibited feed such as animal excrement, commercial products, or chemically synthesized additives (Council of The European Union, 2007; IFOAM, 2005; Müller-Lindenlauf et al., 2010) represents a strength of these systems; however, a few farms need to substitute the salt currently used with a permitted type of salt. Based on SWOT analysis, Table 3 shows the strengths and weaknesses of the indicators and variables identified for the three municipalities studied.

- (2) For the *sustainable pasture management* indicator, the municipalities Huitiupán and Tacotalpa have a favorable approximation to the organic model (>70%)—greater ($p > 0.05$) than that of Mazapa (59%). This is due to use of a variety of techniques in the first two municipalities, such as: pasture rotation (MA = 12.4%; HU = 9.1%; TA = 6.0%); stocking rate (MA = 81.8%; HU = 81.5%; TA = 95.9%) with an average of $1.8 (\pm 1.5)$ AU/ha of pasture owned (32.4 ± 26.7 ha); association of fodder crops (100% in all three municipalities); and management of silvopastoral systems (MA = 100%; HU = 80%; TA = 84%). On the other hand, cultivation of woody fodder plants (MA = 0.0%; HU = 100%; TA = 100%) is lower in the upper region in relation to the mid-region. In order to achieve sustainable pasture management, there is a need to improve these variables, favoring association of leguminous species in pastures with monocrops of grasses and promoting the planting of local woody fodder plants such as *Guazuma ulmifolia*, *Leucaena* sp., *Gliricidia sepium*, *Erithryna* sp., and *Brosimum alicastrum* (Aguilar-Jiménez, 2008; Calderón, 2008; Jiménez, López, Nahed, Ochoa, & de Jong, 2008) in agronomic arrangements. Diversified pastures provide greater protection to the soil, promote greater biodiversity, and provide other environmental services such as CO₂ capture, reduction of CH₄ and nitrous oxide emissions, and mitigation of climate change (Müller-Lindenlauf et al., 2010; Pimentel et al., 2005).
- (3) Regarding to the *soil fertilization* indicator, the CPU of the three municipalities comply with the organic production model, although in these regions, pastures are almost exclusively fertilized through defecation during grazing; a few CPU occasionally use chemical fertilizer in addition. Chemical fertilizers should be substituted by appropriate management of manure and organic fertilization techniques, such as composts (including bocashi and worm composting), biofertilizers, biofermentation, green manures, and cover crops (Labrador & Porcuna, 2006; Lague, Landry, & Roberge, 2005; Nogueroles & Sicilia, 2006).
- (4) For the *ecological weed control in pastures and crops* indicator, the CPU of the municipality of Mazapa have the highest approximation (64.7%) to the organic standard. Many farmers avoid use of synthetic herbicides, preferring manual tools to eliminate weeds (MA = 64.7%; HU = 40.0%; TA = 31.8%), while others use a combination of both techniques (MA = 35.3%; HU = 60.0%; TA = 68.2%). Successful ecological weed control involves maintaining populations of undesired species which grow spontaneously in pastures and crops at acceptable levels, without completely eradicating them, although excessive multiplication is prevented (Menalled, Gross, & Hammond, 2001).
- (5) For the *ecological pest and disease control in pastures and crops* indicator, the CPU of all three municipalities have a favorable approximation to the organic model (> 80%). In Huitiupán, close to 70% of farmers mentioned the presence of pests in grasses (principally fungal disease and worms). In Tacotalpa, just over 50% reported the presence of *Aeneolamia* spp. In Mazapa, less than 25% said they had problems with pests, the principal problem being the larvae “blind hen” (genus *Phyllophaga*). The majority said they avoided use of synthetic pesticides (MA = 88.2%; HU = 86.7%; TA = 84.1%), principally using mechanical pest control through grazing. Use of botanical insecticides and repellants (Isman, 2006) and integrated pest management, which includes ecological control of soils and biodiversity (Cook, Khan, & Pickett, 2007), are efficient substitutes for pesticide use (IFOAM, 2005).

Table 3. Strengths and weaknesses of indicators and variables for cattle production units in three municipalities of the Grijalva River Basin

Indicators and variables	Municipalities					
	Upper region		Middle region			
	Mazapa		Huitiupán		Tacotalpa	
	S	W	S	W	S	W
(1) Feed management	X		X		X	
(1.1) Using only animal feed permitted by the organic standards	x		x		x	
(1.2) Grazing	x		x		x	
(1.3) At least 60% of DM of daily ration is common fodder	x		x		x	
(1.4) At least 50% of feed comes from the same farm or another organic farm	x		x		x	
(2) Sustainable pasture management	X		X		X	
(2.1) Rotation of pastures	x		x		x	
(2.2) Appropriate stocking rate	x		x		x	
(2.3) Association of fodder crops	x		x		x	
(2.4) Cultivation of woody fodder plants (trees and/or shrubs)		x	x		x	
(2.5) Management of silvopastoral systems	x		x		x	
(3) Soil fertilization	X		X		X	
(3.1) Occasional use of synthetic chemical fertilizers	x		x		x	
(3.2) Organic fertilization through defecation during grazing	x		x		x	
(4) Ecological weed control in pastures and crops	X			X		X
(4.1) Avoids the use of synthetic chemical herbicides	x			x		x
(4.2) Use of a combination of techniques to eliminate weeds		x	x		x	
(5) Ecological pest and disease control in pastures and crops	X		X		X	
(5.1) Avoids the use of synthetic chemical pesticides	x		x		x	
(5.2) Use of organic or ecological pesticides						
(6) Veterinary prevention and treatment		X		X		X
(6.1) Apply vaccines only against endemic illnesses		x	x		x	
(6.2) Quarantine introduced or sick animals		x		x		x
(6.3) Natural treatment of illnesses (herbs, homeopathy, or nothing)		x		x		x
(6.4) Natural internal anti-parasite treatment (herbs, homeopathy, or nothing) and permitted allopathy	x		x		x	
(6.5) Natural external anti-parasite treatment (herbs, homeopathy, or nothing) and permitted allopathy	x			x		x
(7) Breeds and reproduction	X		X		X	
(7.1) Only local animals or those adapted to the region	x		x		x	
(7.2) Natural procreation	x		x		x	
(8) Animal well-being	X		X		X	
(8.1) Natural lactation until eight months	x		x		x	
(8.2) Sufficient space per animal in roofed enclosures and outside	x		x		x	
(8.3) Sufficient feeders and troughs	x		x		x	

(Continued)

Table 3. (Continued)

Indicators and variables	Municipalities					
	Upper region		Middle region			
	Mazapa		Huitiupán		Tacotalpa	
	S	W	S	W	S	W
(8.4) Protection against inclement weather (cold, heat, rain, humidity)		x		x		x
(8.5) Horns are cut (young animals) or clipped in animals of any age	x		x			x
(9) Food safety		X		X		X
(9.1) Strict hygienic-sanitary control (of facilities, equipment, milking, and milk management)		x		x		x
(9.2) Animals have been demonstrated to be free of: (i) brucellosis and (ii) tuberculosis	x			x	x	
(9.3) Animals seropositive to (i) brucellosis and (ii) tuberculosis are sacrificed	x			x	x	
(9.4) Products have been demonstrated to be free of: (i) antibiotics, (ii) hormones, and (iii) pesticides.		x		x		x
(10) Ecological management		X		X		X
(10.1) The farmer receives advisory and training for organic certification		x		x		x
(10.2) The farmer has an organic development plan or is certified		x		x		x
(10.3) The farmer carries out internal control of the organic process		x		x		x
(10.4) The farmer receives incentives for quality organic livestock production		x		x		x
(10.5) The farmer receives a fair or constant sale price for products year-round		x		x		x

Notes: S = Strengths, W = Weaknesses.

- (6) Regarding to the *veterinary prevention and treatment* indicator, all three municipalities poorly approximate (< 30%) the organic production model because the CPU have limitations for complying with use of techniques permitted by the organic standards, including: (i) vaccination against endemic diseases (MA = 32.4%; HU = 63.3%; TA = 80.7%) such as bovine rabies, clostridiosis and pasteurellosis, (ii) quarantining introduced or sick animals (0.0% in all three); (iii) natural treatment of infectious diseases (0.0% in all three); and (iv) compliance with standards for control of internal parasites (MA = 100.0%; HU = 93.3%; TA = 72.3%) and external parasites (MA = 70.6%; HU = 0.0%; TA = 0.0%). Some farmers do not administer internal deparasitization treatments and others administer more than the two allowed per year by the organic standards. Almost all farmers use external deparasitization treatments, especially in Huitiupán and Tacotalpa due a greater incidence of tick infestation (*Amblyomma cajennense* and *Boophilus microplus*); these farmers use a high level of chemical products. The majority of farmers in all three municipalities sporadically treat their animals with antibiotics. *Veterinary prevention and treatment* could be improved using preventative measures which favor resistance to the environment and to diseases and animal well-being, adequate nutritional management, raising local breeds and their crosses, and substituting use of chemical medicines (antibiotics and anti-parasite medicines) with natural methods such as homeopathy, herbs, and acupuncture (Council of The European Union, 2007; IFOAM, 2005).
- (7) For the animal *breeds and reproduction* indicator, the CPU of all three municipalities have a favorable approximation to the organic standard (> 85.0%). However, they vary with respect to possession of local cattle breeds or those adapted to the region (MA = 100%; HU = 73.0%;

TA = 70.0%), while procreation in all municipalities occurs naturally, without control. Adaptation to local climatic and management conditions are reflected in acceptable rates of calving (MA = 69.7%; HU = 61.0%; TA = 72.4%), number of cows per breeding bull (MA = 6.8; HU = 11.2; TA = 8.2), and mortality of calves (MA = 7.8%; HU = 15.0%; TA = 10.3%) and adults (MA = 4.8%; HU = 3.0%; TA = 4.4%). Although the organic standards permit artificial insemination, in 100% of CPU mounting is natural (direct) and continuous, and estrus of females and calving are also continuous. These practices allow for avoiding use of chemically synthesized hormones; farmers pointed out the need to have local breeding bulls or cross-breeds adapted to the region, which are practices that promote harmony of cattle with a region's specific conditions, as well as development of resistance to predominant diseases and parasites (Council of The European Union, 2007; IFOAM, 2005; Rozzi et al., 2007).

- (8) Regarding to the *animal well-being* indicator, the CPU of all three municipalities show an acceptable approximation (MA = 62.3%; HU = 62.7%; TA = 68.2%) to the organic standards. This is partly due to the fact that, on the one hand, they comply 100% with respect to: calves being naturally breastfed until eight months; sufficient space per head in roofed enclosures and outdoors; and a sufficient number of feeders and troughs. On the other hand, protection against inclement weather (cold, heat, rain, humidity) is deficient, and few farmers cut or trim horns of animals of any age (MA = 12.0%; HU = 13.0%; TA = 41.0%). Improvement of variables regarding well-being should be oriented toward offering optimal conditions for the animals to reproduce and for production, in general satisfying the animals' biological and comfort needs (von Borell & Sørensen, 2004).
- (9) For the *food safety* indicator, the CPU of all three municipalities have a low approximation to the organic model (MA = 50.0%; HU = 0.0%; TA = 50.0%). In Mazapa and Tacotalpa, the value of *food safety* is greater (50%) than in Huitupán (0%) because the animals of Mazapa and Tacotalpa have been shown to be free of brucellosis (using the plate agglutination test) and tuberculosis (using the bovine tuberculin test), although the few that are seropositive are eliminated from the herd, which does not occur in Huitupán. Another reason is that none of the CPU of the three municipalities have strict hygienic-sanitary control of facilities and work equipment, of milking management, and of the milk; and so far the products (milk, cheese, and meat) have not been shown to be free of antibiotics, hormones, pesticides, and other chemical substances. Evidence of food safety of animal products (meat, milk, and cheese) is the farmer's guarantee of quality to the consumer. The low level of compliance with respect to this indicator is an obstacle to meeting the organic standards in all three municipalities evaluated. In order to overcome this, strict hygienic-sanitary control must be implemented for infrastructure, tools, and the milking process, avoiding use of chemical substances (pesticides, antibiotics, and detergents, among others); undesirable biological contaminants (viruses, bacteria, molds, parasites), and harmful physical substances (pieces of metal, splinters, manure, garbage, etc.). Compliance with such requirements, together with meeting certain organoleptic characteristics (flavor, smell, and color of the meat, milk, and cheese) and nutritional characteristics increase the food's sanitary and nutritional quality and promote consumer confidence (Vaarst et al., 2005).
- (10) For the *ecological management* indicator, the CPU of all three municipalities have not achieved almost any approximation to the organic standards with respect to the five corresponding variables because of a lack of training and advice; thus, there is a need to establish procedures that would allow farmers to obtain the necessary advice and training in order to transition to organics. Also, there is a need for internal control of the production process, processing, and marketing according to organic stipulations (Certificadora Mexicana de Productos y Procesos Ecológicos [CERTIMEX], 2007). Management involves negotiation and establishment of incentives to improve quality, as well as fair or constant sale prices year-round in order to motivate farmers to improve their products using sustainable techniques (Nahed et al., 2006, 2009; von Borell & Sørensen, 2004).

3.2. Viability of organic conversion of livestock raising

Evaluating the level of approximation of conventional cattle raising to the organic production model provides the opportunity to identify limitations, potentials, and opportunities for promoting development of organic livestock production (Guzmán & Alonso, 2001; Nahed et al., 2009; Niemeyer & Lombard, 2003; Pimentel et al., 2005).

The values of OLCI for the CPU of Mazapa (56.8%) and Tacotalpa (56.7%) have intermediate levels of approximation as compared to values (55–75%) reported by Olivares et al. (2005) for organic cattle raising in Tabasco, and these values are greater than those for conventional cattle raising in the Frailesca (48.0%; Aguilar-Jiménez, 2011) and Marqués de Comillas regions (53.3%; Nahed et al., 2009) of Chiapas. This is due to the fact that the CPU of the three municipalities show higher values of approximation to the organic production model for the indicators *feed management*, *soil fertilization*, *ecological pest and disease control*, and *breeds and reproduction*, and similar values for indicators of *sustainable pasture management*, *animal well-being*, *veterinary prevention*, and *treatment* and *food safety* compared to those of conventional cattle raising of the Frailesca and Marqués de Comillas regions. In the case of Huitiupán, the OLCI value (49.0%) is somewhat lower than the values obtained for all these authors, and this lower value is due overall to food safety indicator.

In general, the level of approximation to the organic model of the CPU evaluated is principally a result of traditional management with low use of external inputs, more than the implementation of other sustainable production technologies and mechanisms of ecological management. The fact that the farmers have not received advice and training are only a general causes that limit the viability of organic conversion of the CPU evaluated, but it is necessary to deep about the causes of the different aspects for each indicator showed in Table 1, regardless of the fact that in the majority of these CPU, traditional production methods—and few external inputs—are used.

There is also a need to train farmers to substitute capital-dependent technologies which degrade the physical environment, with others technologies based on efficient use of local resources, thus promoting maintenance of biological diversity and the soil's long-term productive capacity (Guzmán & Alonso, 2001; Pimentel et al., 2005). The list of permitted, prohibited, and restricted substances indicated by the organic standards should be reviewed and respected, and implement mechanisms of management and promotion of organic livestock raising.

To achieve the objectives of organic production, from a functional point of view it is necessary to maximize the strengths offered by OLCI in the municipalities evaluated, particularly the related to the indicators *feed management*, *sustainable pasture management*, *ecological soil fertilization*, *ecological pest and disease control in pastures and crops*, *breeds and reproduction*, and *animal well-being*. On the other hand, the main weaknesses which currently limit the viability of organic conversion of the CPU evaluated in three municipalities of southern Mexico are related with the indicators *ecological weed control in pastures and crops*, *veterinary prevention and treatment*, *food safety*, and *ecological management*.

From a structural perspective, interventions require strengthening support mechanisms (financial, advisory, training, organization, and management) at all levels of the productive chain and establishing a development strategy for organic cattle raising, particularly a holistic policy of food sanitation and food safety which allows for meeting certification costs in order to distinguish products according to their quality; and permanent support in developing alliances among actors (production, marketing, transformation, and sale), as well as promotion of animal products in national and international markets. In this manner, meat, milk, and cheese produced in the three municipalities evaluated may be certified as organic—of maximum quality to be marketed in alternative niche markets, thus benefiting producers and consumers.

Regarding to other external factors that favor the development of organic farming, prevailing opportunities for the CPU to move toward organics are: diversification of the products obtained in the

CPU, increase in demand for products obtained in production systems friendly to the environment, reconversion of the productive chain toward value chain (the productive chain are currently limited due to low levels of quality control of the products and the lack of strategic relations or alliances among actors involved in order to transition toward value chains, which impedes selling in the formal market and causes prices to be significantly less than desirable), the upward trend in cattle prices, government programs for livestock development and foray of the producers into new market niches. Because of its great importance, highlights the use of organic or ecological pesticides for pest and disease control in pastures and crops (an internal factor that represents an opportunity).

On the other hand, the major threats facing the organic farming in the region are the fluctuations in the price of cattle, vulnerability of producers to changes in supply and demand for agro-food products, threats to livestock production caused by climate change (e.g. disease outbreaks, instability in the pasture productivity, and loss of adaptability) and the possibility of an economic crisis harming the chances of consumer purchasing. Do not apply vaccines against endemic diseases (internal factor) is a weakness, but it is also a threat to herd health.

4. Conclusions

The level of approximation of the CPU to the organic standard is higher in the municipalities Mazapa (56.8%) and Tacotalpa (56.7%) than in Huitiupán (49.0%).

The main strengths of the CPU in order to fully meet the organic standards lies in the indicators of *feed management, sustainable pasture management, ecological soil fertilization, ecological pest and disease control in pastures and crops, breeds and reproduction, and animal well-being.*

The weaknesses that the CPU in the three municipalities should overcome in order to increase the viability of organic certification are with respect to the following areas: *ecological weed control in pastures and crops, veterinary prevention and treatment, food safety and ecological management.*

The main opportunities for the CPU to move toward organics are: diversification of the products obtained in the CPU, increase in demand for products obtained in production systems friendly to the environment, reconversion of the productive chain toward value chain, upward trend in cattle prices, government programs for livestock development, and foray of the producers into new market niches.

The major threats for the organic farming are the fluctuations in the price of cattle, vulnerability of producers to changes in supply and demand for agro-food products, threats to livestock production caused by climate change (e.g. disease outbreaks, instability in the pasture productivity, loss of adaptability), and the possibility of an economic crisis harming the chances of consumer purchasing.

Finally, it is necessary to train and advise farmers on production techniques and ecological management, as well as offering a comprehensive policy for the development of organic farming.

Funding

This publication was made possible thanks to the support of the Institutional Fund for Regional Fomentation of Scientific and Technological Development and Innovation (FORDECYT according to its Spanish initials) of Mexico's National Council on Science and Technology (CONACYT according to its Spanish initials) through agreement 143303: "Strategies for sustainable management for regional development in the Grijalva cross-border hydrographic basin," supported by matching funds by the Secretary of Natural Resources and Environmental Protection (SERNAPAM according to its Spanish initials) of the Mexican state of Tabasco.

Competing interests

The authors declare no competing interest.

Author details

J. Nahed¹
E-mail: jnahed@ecosur.mx
D. Grande²
E-mail: ifig@xanum.uam.mx
J.R. Aguilar¹
E-mail: robeaguilar@hotmail.com
B. Sánchez³
E-mail: jbersam@gmail.com

- ¹ Department of Agroecology, El Colegio de La Frontera Sur, San Cristobal de Las Casas, Chiapas, Mexico.
- ² Biological Sciences and Health Division, Universidad Autonoma Metropolitana Iztapalapa, Mexico City, Mexico.
- ³ Faculty of Medicine Veterinary and Zootechnic, Universidad Autonoma de Chiapas, Tuxtla Gutierrez, Chiapas, Mexico.

Citation information

Cite this article as: Possibilities for converting conventional cattle production to the organic model in the Grijalva River Basin, Mexico, J. Nahed, D. Grande, J.R. Aguilar & B. Sánchez, *Cogent Food & Agriculture* (2016), 2: 1153767.

References

- Aguilar-Jiménez, J. R. (2008). *Análisis de los sistemas de producción bovina en la Cuenca del río El Tablón, en la zona de amortiguamiento de la reserva de la biosfera La Sepultura, Villaflores, Chiapas* [Analysis of livestock production systems in El Tablón River Basin in the buffer zone of the Biosphere Reserve La Sepultura, Villaflores, Chiapas] (BSc Thesis). Tuxtla Gutiérrez: Universidad Autónoma de Chiapas.
- Aguilar-Jiménez, J. R. (2011). *Livelihoods and approximation of livestock systems to the organic standards in Villaflores, Chiapas* (Master Thesis). San Cristóbal de Las Casas: El Colegio de la Frontera Sur.
- Benoit, M., & Laignel, G. (2009). Technical and economic performance in biological breeding of sheep meat: Observations in biological research and experimental farms. *Innovations Agronomiques*, 4, 151–163.
- Blaxter, K. L., & Clapperton, J. L. (1965). Prediction of the amount of methane produced by ruminants. *British Journal of Nutrition*, 19, 511–522. <http://dx.doi.org/10.1079/BJN19650046>
- Calderón, P. J. C. (2008). *Tendencias de la ganadería bovina y oportunidades para su conversión a sistemas de producción orgánica en el municipio de Tecpatán, Chiapas* [Trends in cattle raising and opportunities for conversion to organic production systems in the municipality of Tecpatán, Chiapas] (BSc Thesis). Tuxtla Gutiérrez: Universidad Autónoma de Chiapas.
- Certificadora Mexicana de Productos y Procesos Ecológicos (CERTIMEX). (2007). *Regulations for production, processing, and marketing ecological products*. Oaxaca: Author.
- Coffey, L., Reynolds, J., & Hale, M. (2004). Small ruminant sustainability checklist. *Livestock Production Guide*, 1-800-346-9140. National Sustainable Agriculture Information Service. Retrieved from <http://www.attra.ncat.org>
- Colegio de Postgraduados (COLPOS). (2002). *Evaluación de la degradación del suelo causada por el hombre en la República Mexicana, escala 1:250,000* [Assessment of land degradation caused by man in Mexican Republic, scale 1:250,000]. Montecillo: Memoria Nacional 2001-2002, Secretaría de Medio Ambiente y Recursos Naturales-Colegio de Postgraduados.
- Comisión Nacional Forestal (CONAFOR). (2012). *Servicios ambientales* [Environmental services]. Retrieved from <http://www.conafor.gob.mx/portal/index.php/temas-forestales/servicios-ambientales>
- Cook, S. M., Khan, Z. R., & Pickett, J. A. (2007). The use of push-pull strategies in integrated pest management. *Annual Review of Entomology*, 52, 375–400. <http://dx.doi.org/10.1146/annurev.ento.52.110405.091407>
- Council of The European Union. (2007). Council Regulation (EC) No 834/2007 of 28 June 2007 on organic production and labelling of organic products and repealing Regulation (EEC) No 2092/91. *Official Journal of the European Union*, L 189, 1–23.
- Dagang, A. B. K., & Nair, P. K. R. (2003). Silvopastoral research and adoption in Central America: recent findings and recommendations for future directions. *Agroforestry Systems*, 59, 149–155. <http://dx.doi.org/10.1023/A:1026394019808>
- de Boer, I. J. M. (2003). Environmental impact assessment of conventional and organic milk production. *Livestock Production Science*, 80, 69–77. [http://dx.doi.org/10.1016/S0301-6226\(02\)00322-6](http://dx.doi.org/10.1016/S0301-6226(02)00322-6)
- Falconi, F., & Burbano, R. (2004). Economic tools for environmental management: Mono-criteria vs. multi-criteria decisions. *Revista Iberoamericana de Economía Ecológica*, 1, 11–20.
- Galan, M. B., Peschard, D., & Boizard, H. (2007). ISO 14001 at the farm level: Analysis of five methods for evaluating the environmental impact of agricultural practices. *Journal of Environmental Management*, 82, 341–352. <http://dx.doi.org/10.1016/j.jenvman.2006.06.025>
- García, A. (2010). *Instituciones y pluralismo legal: la hidropolítica de la cuenca compartida del río Grijalva* [Institutions and legal pluralism: The hydrogeopolitics of the shared Grijalva River Basin] (Doctoral Thesis). San Cristóbal de Las Casas: El Colegio de la Frontera Sur.
- García-Barrios, L., Galván-Miyoshi, Y. M., Valdivieso-Pérez, I. A., Maser, O. R., Bocco, G., & Vandermeer, J. (2009). Neotropical forest conservation, agricultural intensification, and rural out-migration: The Mexican experience. *BioScience*, 59, 863–873. <http://dx.doi.org/10.1525/bio.2009.59.10.8>
- Gillham, B. (2005). *Research interviewing: The range of techniques*. Berkshire: McGraw Hill Education.
- Grimm, J. W., & Wozniak, P. R. (1990). *Basic social statistics and quantitative research methods*. Belmont, CA: Western Kentucky University, Wadsworth Publishing.
- Gutteridge, R. C. (1991). Sustaining multiple production systems: 1. Forest and fodder trees in multiple use systems in the tropics. *Tropical Grasslands*, 25, 165–172.
- Guzmán, C. G., & Alonso, M. A. (2001). Design of the transition process to ecological agriculture. In *The practice of agriculture and ecological livestock raising* (pp. 341–348). Seville: Andalusian Committee of Ecological Agriculture.
- International Federation of Organic Agriculture Movements (IFOAM). (2005). *The IFOAM norms for organic production and processing* (Version 2005, 126 p.). Bonn: Author.
- International Federation of Organic Agriculture Movements (IFOAM). (2009). *The principles of organic agriculture*. Retrieved January 13, 2011, from http://www.ifoam.org/about_ifoam/principles/index.html
- Isman, M. B. (2006). Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. *Annual Review of Entomology*, 51, 45–66. <http://dx.doi.org/10.1146/annurev.ento.51.110104.151146>
- Jiménez, F. G., López, C. M., Nahed, J., Ochoa, S., & de Jong, B. (2008). Fodder trees and shrubs in the northern Tzotzil region of Chiapas, Mexico. *Revista Veterinaria México*, 39, 199–213.
- Kouba, M. (2003). Quality of organic animal products. *Livestock Production Science*, 80, 33–40. [http://dx.doi.org/10.1016/S0301-6226\(02\)00318-4](http://dx.doi.org/10.1016/S0301-6226(02)00318-4)
- Labrador, J. & Porcuna, J. L. (2006). Aproximación a las bases técnicas de la agricultura ecológica [Approach to the technical basis for organic farming]. In J. Labrador (Ed.), *Conocimientos, técnicas y productos para la agricultura y la ganadería ecológica, segunda edición* [Knowledge, techniques and products for organic agriculture and livestock raising] (2nd ed., pp. 19–34). Madrid: Sociedad Española de Agricultura Ecológica.
- Lague, C., Landry, H. & Roberge, M. (2005). Engineering of land application systems for livestock manure: A review. *Canadian Biosystems Engineering*, 47, 6.17–6.28.
- Lamine, C., & Bellon, S. (2009). Conversion to organic farming:

- a multidimensional research object at the crossroads of agricultural and social sciences: A review. *Agronomy for Sustainable Development*, 29, 97–112.
<http://dx.doi.org/10.1051/agro:2008007>
- Long, N., & Villarreal, M. (1993). Exploring development interfaces: From the transfer of knowledge to the transformation of meaning. In F. J. Schuurman (Ed.), *Beyond the impasse: New directions in development theory* (pp. 140–168). London: Zed Books.
- McCrabb, G. J. (2002). Nutritional options for abatement of methane emissions from beef and dairy systems in Australia. In J. Takahashi & B. A. Young (Eds.), *Greenhouse gases and animal agriculture* (pp. 115–124). Amsterdam: Elsevier.
- Mena, Y., Nahed, J., Ruiz, F. A., Sánchez-Muñoz, B., Ruiz-Rojas, J., & Castel, J. M. (2012). Evaluating mountain goat dairy systems for conversion to the organic model, using a multicriteria method. *Animal*, 6, 693–703.
<http://dx.doi.org/10.1017/S17517311100190X>
- Menalled, F. D., Gross, K. L., & Hammond, M. (2001). Weed aboveground and seedbank community responses to agricultural management systems. *Ecological Applications*, 11, 1586–1601.
[http://dx.doi.org/10.1890/1051-0761\(2001\)011\[1586:WAASCR\]2.0.CO;2](http://dx.doi.org/10.1890/1051-0761(2001)011[1586:WAASCR]2.0.CO;2)
- Midmore, P., Padel, S., McCalman, H., Isherwood, J., Fowler, S., & Lampkin, N. (2001). *Attitudes towards conversion to organic production systems: A study of farms in England*. Aberystwyth: Sefydliad Astudiaethau Gwledig Institute of Rural Studies.
- Mojica, S. F. (1991). *La prospectiva, técnicas para visualizar el futuro* [The prospective, techniques for visualizing the future]. Bogotá: Legis.
- Müller-Lindenlauf, M., Deittert, C., & Köpke, U. (2010). Assessment of environmental effects, animal welfare and milk quality among organic dairy farms. *Livestock Science*, 128, 140–148.
<http://dx.doi.org/10.1016/j.livsci.2009.11.013>
- Munda, G. (2004). Multicriteria methods and multicriteria processes for social evaluation of public policy. *Revista Iberoamericana de Economía Ecológica*, 1, 31–45.
- Munda, G., Nijkamp, P. & Rietveld, P. (1994). Fuzzy multigroup conflict resolution for environmental management. In J. Weiss (Ed.), *The economic of project appraisal and the environment* (pp. 161–183). Aldershot: Edward Elgar.
- Nahed, J., Calderón, J., Aguilar, R., Sánchez, B., Ruiz, J., Mena, Y., ... Salvatierra, B. (2009). Approximation of agrosilvopastoral systems of three micro-regions of Chiapas, Mexico, to the organic production model. *Avances en Investigación Agropecuaria*, 13, 45–58.
- Nahed, J., Castel, J. M., Mena, Y., & Caravaca, F. (2006). Appraisal of the sustainability of dairy goat systems in Southern Spain according to their degree of intensification. *Livestock Science*, 101, 10–23.
<http://dx.doi.org/10.1016/j.livprodsci.2005.08.018>
- Nahed, J., Gómez, H., Pinto, R., Guevara, F., Medina, F., Ibrahim, M., & Grande, D. (2010). Research and development of silvopastoral systems in a village in the Buffer Zone of the El Ocote Biosphere Reserve, Chiapas, Mexico. *Research Journal of Biological Sciences*, 5, 499–507.
- Napolitano, F., De Rosa, G., Ferrante, V., Grasso, F., & Braghieri, A. (2009). Monitoring the welfare of sheep in organic and conventional farms using an ANI 35 L derived method. *Small Ruminant Research*, 83, 49–57.
<http://dx.doi.org/10.1016/j.smallrumres.2009.04.001>
- Nauta, W. J., Baars, T., & Bovenhuis, H. (2006). Converting to organic dairy farming: Consequences for production, somatic cell scores and calving interval of first parity Holstein cows. *Livestock Science*, 99, 185–195.
<http://dx.doi.org/10.1016/j.livprodsci.2005.06.013>
- Niemeyer, K., & Lombard, J. (2003, October 2003). *Identifying problems and potential of the conversion to organic farming in South Africa*. Contributed paper presented at the 41st Annual Conference of the Agricultural Economic Association of South Africa. Pretoria.
- Nogueroles, C., & Sicilia, A. (2006). Descomposición y aprovechamiento de la materia orgánica [Decomposition and utilization of the organic matter]. In J. Labrador (Ed.), *Conocimientos, técnicas y productos para la agricultura y la ganadería ecológica Segunda edición* [Knowledge, techniques and products for organic agriculture and livestock raising] (2nd ed., pp. 49–61). Madrid: Sociedad Española de Agricultura Ecológica.
- Olivares, P. R., Gómez, C. M., & Meraz, A. M. (2005). Potential for conversion of conventional livestock farms to organic production systems in the state of Tabasco. *Revista Técnica Pecuaria en México*, 43, 361–370.
- Peacock, C., & Sherman, D. M. (2010). Sustainable goat production—some global perspectives. *Small Ruminant Research*, 89, 225–238.
- Phythian, C. J., Michalopoulou, E., Jones, P. H., Winter, A. C., Clarkson, M. J., Stubbings, L. A., ... Duncan, J. S. (2011). Validating indicators of sheep welfare through a consensus of expert opinion. *Animal*, 5, 943–952.
<http://dx.doi.org/10.1017/S1751731110002594>
- Pimentel, D., Hepperly, P., Hanson, J., Douds, D., & Seidel, R. (2005). Environmental, energetic, and economic comparisons of organic and conventional farming systems. *BioScience*, 55, 573–582.
[http://dx.doi.org/10.1641/0006-3568\(2005\)055\[0573:EEAECO\]2.0.CO;2](http://dx.doi.org/10.1641/0006-3568(2005)055[0573:EEAECO]2.0.CO;2)
- Pingali, P., & Raney, T. (2005). *From the green revolution to the gene revolution: How will the poor fare?* (ESA Working Paper No. 05-09). Rome: Food and Agriculture Organization of the United Nations.
- Rozzi, P., Miglior, F., & Hand, K. J. (2007). A total merit selection index for Ontario organic dairy farmers. *Journal of Dairy Science*, 90, 1584–1593.
[http://dx.doi.org/10.3168/jds.S0022-0302\(07\)71644-2](http://dx.doi.org/10.3168/jds.S0022-0302(07)71644-2)
- Scoones, I. (1998). *Sustainable rural livelihoods: A framework for analysis* (IDS Working Paper 72). Sussex: IDS, University of Sussex.
- Steinfeld, H. (2002). Increasing global demand for animal products. In *Responding to the increasing global demand for animal products* (pp. 1–2). BSAS-UADY, International Conference, Mérida, Yucatán, México.
- Stofferahn, C. W. (2009). Personal, farm and value orientations in conversion to organic farming. *Journal of Sustainable Agriculture*, 33, 862–884.
<http://dx.doi.org/10.1080/10440040903303595>
- Vaarst, M., Padel, S., Hovi, M., Younie, D., & Sundrum, A. (2005). Sustaining animal health and food safety in European organic livestock farming. *Livestock Production Science*, 94, 61–69.
<http://dx.doi.org/10.1016/j.livprodsci.2004.11.033>
- von Borell, E., & Sørensen, J. T. (2004). Organic livestock production in Europe: Aims, rules and trends with special emphasis on animal health and welfare. *Livestock Production Science*, 90, 3–9.
<http://dx.doi.org/10.1016/j.livprodsci.2004.07.003>



© 2017 The Author(s). This open access article is distributed under a Creative Commons Attribution (CC-BY) 4.0 license.

You are free to:

Share — copy and redistribute the material in any medium or format

Adapt — remix, transform, and build upon the material for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made.

You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

No additional restrictions

You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.



***Cogent Food & Agriculture* (ISSN: 2331-1932) is published by Cogent OA, part of Taylor & Francis Group.**

Publishing with Cogent OA ensures:

- Immediate, universal access to your article on publication
- High visibility and discoverability via the Cogent OA website as well as Taylor & Francis Online
- Download and citation statistics for your article
- Rapid online publication
- Input from, and dialog with, expert editors and editorial boards
- Retention of full copyright of your article
- Guaranteed legacy preservation of your article
- Discounts and waivers for authors in developing regions

Submit your manuscript to a Cogent OA journal at www.CogentOA.com

