Chapter

COMPARATIVE SUSTAINABILITY ASSESSMENT OF EXTENSIVE BEEF CATTLE FARMS IN A HIGH NATURE VALUE AGROFORESTRY SYSTEM

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ABSTRACT

This chapter analyzes the sustainability of beef cattle systems of the Spanish Rangelands known as “Dehesas”. These are traditional systems of the Iberian Peninsula where native herbaceous vegetation and evergreen species of Quercus provide the basis for extensive livestock farms. These systems are considered as outstanding High Nature Value (HNV) farming systems and the most extensive agroforestry systems in Europe according to CORINE Land Cover.

Beef farms in this area show low stocking rates and a small dependence on foodstuff purchases.However, certain changes have occurred in the last decadesdue to the Common Agricultural Policy

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(CAP). On the one hand, some farms have become more intensified, as a way to maximize the revenues from the CAP subsidies. On the other hand, many farms have turned to organic production, trying to take advantage both of new subsidies and of new market trends.

In this regard, the organic livestock farming model is gaining weight as an option for sustainable production since, according to various authors, these systems have advantages over conventional and intensive systems. In fact, organic production in the area has increased substantially in recent years due to several factors, such as the growing interest of the EU towards preserving sensitive ecosystems, the potential role of organic production in the development of rural areas and the growing consumers' demand for safer and higher quality foods produced under ethical and environmental standards.

In this study, we carried out a comparative assessment of the sustainability of different conventional and organic beef production systems located in dehesa rangelands. The systems analyzed were classified as follows. (i) non-organic farms (Conventional); (ii) organic farms that sold calves at weaning age as conventional ones (Organic 1); (iii) organic farms that fattened and sold their calves as organic (Organic 2). An adaptation of the MESMIS multicriteria framework was applied to calculate sustainability indices for each system. The results showed that the Organic 2 farms scored highest on most of the attributes of sustainability, as well as on the environmental and economic dimensions of sustainability. Thus, they were the most sustainable system (66.55%), followed by the Organic 1 (61.04%) and Conventional ones (56.89%). Despite Organic 2 was the most sustainable system, its implementation is complex due to both the high costs of organic inputs and the weak demand for organic beef.

The results also showed that all three types of systems need to improve in certain aspects that are crucial in the current and future context of the livestock sector. These aspects are: reducing the dependence on external feed, implementing more environmentally friendly farming practices, and farm diversification.

Keywords: Sustainability, organic farming, livestock systems, beef cattle, Mediterranean, dehesa

1. INTRODUCTION

Pasture-based livestock farms are suffering from both intensification and abandonment due to several socioeconomic factors, such as the reduction of their profitability and competitiveness (Ripoll-Bosch et al., 2013). As a consequence, the sustainability of such farms and agro-ecosystems where they are located is jeopardized. Moreover, most of these systems are located in high value environmental ecosystems, such as the Spanish dehesas. (Mediterranean agroforestry systems)

Dehesa is an agroforestry system typical of the southwestern quadrant of the Iberian Peninsula. It is characterizedby the presence of wooded pasture (the trees beingpredominantly species of oak), and by its main orientation to livestock extensive farming. Other uses on these systems alsoinclude crop farming (oats, barley and peas, mainly for re-useas animal feed), hunting and forestry (cork and firewood).

In the dehesa, the pastures, the trees, and the livestock complement each other and, when kept in equilibrium,conserve soil moisture, recharge the topsoil with nutrients,and prevent the invasion of scrub (Schnabel, 1997; Monteroet al., 1998). Indeed, the livestock plays a key role in the maintenance of the system as the use of appropriate cultural practices (such as a level ofgrazing suited to the system carrying forage production orforest regrowth) maintains the wooded layer, thus avoidingshrub invasion and increasing the system's efficiency (Coelho,1992).

These elements of grazingsystems can remain in equilibrium for long periods oftime, but imbalances can arise suddenly as the result of acritical change in one of the elements(Gaspar et al., 2009) affecting persistence of these systems.

In this context, it is thus necessary to design and implement livestock farming systems that take into account the abovementioned aspects with the objective of making them more sustainable. For this purpose, one necessary preliminary step is to unify the concept of sustainability in an agricultural context, as it can be different for different authors and stakeholders. According to Gómez-Limón and Sánchez-Fernández (2010), sustainable agricultural production is that which is economically viable (profitable), socially just (fair and equitable distribution of the wealth generated), and environmentally friendly (compatible with the maintenance of natural ecosystems). According to Rasul and Thapa (2004), it has to be low-input and regenerative, and has to make good use of a farm's internal resources through the incorporation of natural processes, knowledge, and improved production practices.

In this regard, the organic livestock farming model is gaining weight as an option for sustainable production since, according to various authors, these systems have advantages over conventional and intensive systems. Environmentally, it stands out that these systems apply practices that have less environmental impact on ecosystems and reduce their energy dependence to a greater extent than conventional (non-organic) systems (Tuomistoet al., 2012: Halberg 2012). Socioeconomically, this model can improve farm profitability by being able to demand a price premium (the difference in the price charged for the organic products with respect to the conventional ones).

However, the sustainability of production systems depends on many, often interrelated, factors which themselves vary from system to system and evolve over time (Ripoll-Bosch et al., 2012). One thus requires a holistic and dynamic framework that can cover the diversity of factors affecting sustainability, not just the legal framework defining organic production. This is especially important in areas which are fragile and with the complexity of a high number of trades-offs involving a wide range of stakeholders. The dehesa ecosystem is an example of such an area, since its management requires quite careful adjustment of the level of exploitation of the ecosystem. In fact, there is a fairly tight boundary between conservation and either over-exploitation or under-exploitation.

For these reasons, and given that there have as yet been no studies integrating participatory research and MESMIS techniques to compare the sustainability of organic and conventional beef cattle dehesa farms, the objective of the present work is to analyse the sustainability of these farms in a rural zone of southern Europe (Extremadura, SW Spain), in particular, those located in dehesas, using these methods.

2. Description of the Area of Study

The study area is the Autonomous Community of Extremadura in which dehesas are located (figure 1). This area is situated in the south-west quadrant of Spain, between lat 37º56’32’’- 40º29’15” and long 4º38’52’’- 7º32’35’’. It is one of the main zones of dehesa in Spain. Indeed, approximately 50% of its useful agricultural area is considered dehesa, for a total of 2.2 million ha. The climate is continental Mediterranean. It presents annual mean temperatures ranging between 16-17º C. Summers are dry and hot (the mean temperature in July is over 26ºC, and the maximum is usually over 40ºC). Annual rainfalls are irregular during the year and also among years. The mean rainfall varies between 300 mm and 800 mm (Hernández, 1998).

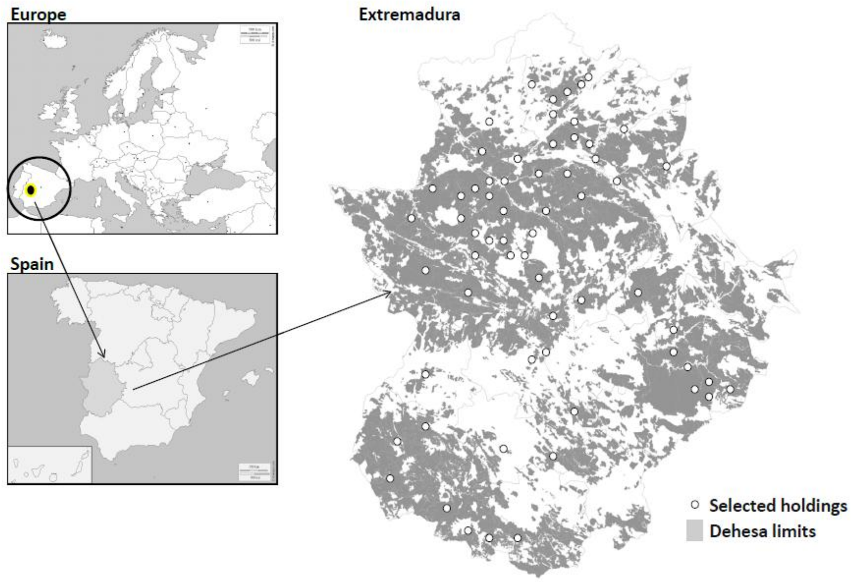

Figure 1. Extremadura region boundaries in Spain, dehesa limits in the region and location of selected farms for the study.

3. Overview of the Methodological Framework

The evaluation of the sustainability of the dehesa beef cattle farms in Extremadura Region was carried out in accordance with an adaptation of the MESMIS framework (Management System Evaluation Framework incorporating Sustainability Indicators) proposed by Masera et al. (1999). The adaptation we made for the present study allowed the characteristics of dehesa farms, the organic production model established by Council Regulation (EC) Nº 834/2007, the current challenges facing the livestock sector (increasing input prices and competitiveness) and the trends of the future CAP (quality products, and environmental and social services) to be integrated into the evaluation of the systems' sustainability. MESMIS is readily adaptable to whichever agro-ecosystems are under study. It permits sustainability indicators to be derived, measured, and monitored as part of a systemic, participatory, interdisciplinary, and flexible process of evaluation (López-Ridaura et al., 2002). The MESMIS framework has demonstrated its power to identify indicators for the evaluation of different agro-ecosystems and livestock systems in particular nearly 15 years (Astier et al., 2012; Ripoll-Bosch et al., 2012). However, the present work seems to be the first to apply it to comparing organic and conventional beef cattle farms.

The methodological framework of the research is presented in figure 2 and includes the following four steps: (i) selection of beef cattle systems, (ii) selection of sustainability indicators, (iii) data collection and database creation and (vi) sustainability assessment.

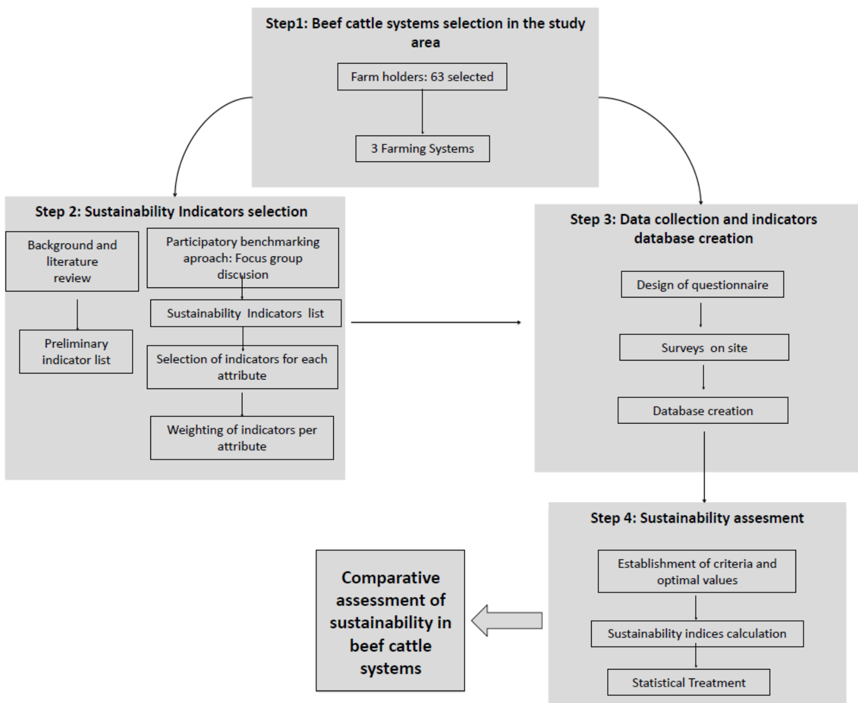

Figure 2. Methodological flowchart for studying the sustainability dehesa beef cattle systems.

3.1. Beef Cattle Systems Selection in the Study Area (Step 1)

This study was carried out within the research project 'Study of the viability of different models of organic beef production: Influence on meat quality and economic analysis' (code INIA-RTA2009-00122-C03-03). As one of the objectives of the project was the comparison of conventional and organic beef cattle farms in Extremadura (SW Spain), similar number of conventional and organic farms were selected, in order to make such comparison possible. The farms analyzed in this study are all located in the dehesa ecosystem. In order to select the farms, preliminary lists were obtained from the certification body of organic production and from the main cooperatives of the region. Four selection criteria were taken into account to select the final holders included in the study:

- Beef cattle must be predominant over other livestock species.
- Farms' dimension must be over 25 adult cows, in order to avoid non-professional farms.
- Selected farms should be representative of the different types of dehesa: woodland density, orography, soil conditions and pastures production. This requisite has been used in several studies addressing livestock production systems (Milán et al., 2006; Gaspar et al., 2007; Gaspar et al., 2008; Gaspar et al., 2009a; Gaspar et al. 2009b).
- All organic farms must have overcome the conversion period to the organic production system[1].

Finally, 63 farms were selected (30 conventional farms and 33 organic farms), which is in line with other studies analyzing livestock production systems (Serrano et al., 2004; Gaspar et al., 2007; Gaspar et al., 2009a; Gaspar et al. 2009b). As some of the organic farms selected are behaving almost conventional farms (they are certified as organic but their products are sold in the conventional market to avoid the constraints of organic markets), three beef cattle systems were identified:

- System 1 ('Conventional'): It includes the conventional farms n= 30.
- System 2 ('Organic 1'): comprised 22 farms that were certified as organic, whose purpose was the production and sale of non-organic calves at the age of weaning (4.5-6 months of age and 160-220 kg live weight) to be fattened on other farms (under the conventional system). Although the farms in this system are certified as organic, their output

[1] According to the Council Regulation 834/2007, this process last 3 years for beef cattle. During such period, farms comply with more than the 80% of the legal requirements needed to be organic.

is sold as conventional, since there is no demand for organic weaned calves.

- System 3 ('Organic 2'): This system includes 11 certified organic farms, that complete the fattening of all their calves in accordance with the organic model, and sell all of them as organic ones.

3.2. Sustainability Indicators Selection (Step 2)

3.2.1. Background and Literature Review

Firstly, a preliminary list ofsustainability indicators were designed on the basis of the scientific literature (Nahed et al., 2006; Gaspar et al., 2007; Gaspar et al., 2008; Gaspar et al., 2009a; Gaspar et al., 2009b; Blanco-Penedo et al., 2012; Gómez-Limón and Sánchez-Fernández, 2010; Lebacq et al., 2013; Ripoll-Bosch et al., 2012; Ripoll-Bosch et al., 2013), on EAA (2001, Regulation EC No 138/2004 and subsequent amendments), and on the Council Regulation (EC) No. 834/2007.

3.2.2. Participatory Benchmarking Approach: Focus Group Discussion

Secondly, a participatory research strategy based on a focus group was applied. The focus group comprised 4 farm managers, 3 technicians (veterinarians and agronomists), and 5 academic experts. It allowed integrating local and scientific knowledge, taking into account stakeholders interests and values, following a collaborative procedure among researchers, advisers, and farmers.

In a first meeting the focus group selected the factors considered important for the sustainability of beef cattle farms, of dehesaagroecosystem, and of the rural populations. The previous list of indicators was then presented to the participants who evaluated the appropriateness, relevance and measurability of the indicators selected, according to the recommendations of Lebacq et al. (2013) and Dale et al. (2013). Finally, a definitive list of indicators was set on the basis of three criteria: (i) they were currently used in similar sustainability studies; (ii) they were coherent with the environmental social, economic, and rural orientation of the study; and (iii) they addressed present and future problems of the sustainability of rangeland beef cattle production systems, together with dehesa and organic production.

In order to increase the practical applicability of the indicators selected, they were grouped into ‘attributes’ selected from the scientific literature. Once indicators were grouped within attributes, relative weights were assigned to each indicator. Thus, the sum of the relative weights of each indicator of the same attribute will be equal to 100%.

In the following paragraphs, we shall describe the attributes on whose basis the sustainability was evaluated.

Adaptability and Flexibility: This is the system's capacity to find new levels of equilibrium, i.e., to continue being productive or profitable when faced with long-term changes in the environment (e.g., new economic or biophysical conditions). This attribute also includes the capacity to actively seek new levels or strategies of production when facing critical points to their adaptability.

*Self-reliance***:** This is the system's capacity to regulate and control its interactions with the exterior.

Equity: This is the system's capacity to distribute wealth, costs, and resources fairly, both within and between generations. It also relates to the quality of life. Its indicators are measures related to workforce, as well as access to services and information, and the degree of social interaction.

Stability and Resilience: This refers to the system's capacity to return to equilibrium or productivity levels similar to the initial level after serious disturbance, and to maintain the profits provided by the system at a non-declining level over time, under normal or average conditions.

Productivity: This is the agro-ecosystem's capacity to provide the required level of goods and services. It represents the value of the attribute in a given time period. It is a key indicator of the economic dimension of sustainability.

The selected indicators, their units, the attribute in which they were groupedand their weightsare presented in Table 1.

3.3. Data Collection and Indicators Database Creation (Step 3)

On the basis of the indicators selected, a questionnaire was designed. The questionnaire included items corresponding to both qualitative and quantitative aspects that were necessary in order to calculate de indicators included in the list. Information was collected by direct surveys to the farm manager and by personal observation directly on the farm. Afterwards a database was created with the purpose of perform the analyses.

Table 1.Selected attributes and indicators: definitions, units, and weights

Attributes and indicators	**Units***	**Criteria****	**Weight**
Adaptability and Flexibility			
Number of agricultural activities/products	Qualitative scale	Max.	20.03
Wooded UAA per total UAA	%	Max. P90	19.72

Attributes and indicators	**Units***	**Criteria****	**Weight**
Dependence on livestock revenue	%	Min. P10	19.00
Farmer's age	Years	Rec.	15.03
Level of studies	Qualitative scale	Max.	12.70
Off farm income/total income	%	Max.	7.98
Cows per bull	Cows	Q1	5.53
Self-reliance			
Owned UAA per total UAA	%	Max.	18.30
Dependence on subsidies	Subsidies per total income. %	Min.	18.10
External dependence on animal feed	€/ha	Q1	17.30
Family AWU/Total AWU per 100 ha UAA	AWU100 ha^{-1}	Q3	13.30
Cultivated UAA per total UAA	%	Q3	10.90
Quality of tracks	Qualitative scale	Max.	8.90
Veterinary and medicine expenses	€ha^{-1}	Q1	7.10
Other intermediate consumption	€ha^{-1}	Q1	6.10
Equity			
Workforce stability	AWU100ha^{-1}	Q3	24.60
Total AWU per 100 ha UAA	AWU100 ha^{-1}	Q3	17.90
Number of external workers	AWU100 ha^{-1}	Q3	14.70
Satisfaction level	Qualitative scale	Max.	13.40
Distance to social services	Km.	Q1	11.02
Cattlemen associations membership	Qualitative scale	Max.	10.18
Farmer's gender	Dichotomous	Yes.	4.30
Distance to the slaughterhouse	Km.	Q2	3.90
Stability and resilience			
Total stocking rate	LUha^{-1}	Rec.	21.50
Farm continuity/future plans	Qualitative scale	Max.	19.30
Soil and crop management	Qualitative scale	Max.	12.67
Use of pesticides and/or mineral fertilizers	Dichotomous	No	11.23
Degree of integration	Dichotomous	Yes	10.30
Use of preventive antiparasitics and/or antibiotics	Dichotomous	No	8.10
Dung management	Qualitative scale	Max.	7.90
Carbon sequestration	C tonsha^{-1}	Q3	4.90
Percentage of autochthonous ruminants	%	Q3	4.10
Productivity			
Livestock productivity	Total sales/total LU. €LU^{-1}	Q3	15.24
Labour productivity	Total sales/ AWU. €AWU^{-1}	Q3	15.07
Profitability rate	%	Q3	12.90
Land productivity	€ha^{-1}	Q3	12.89
Cow productivity	Calves	Rec.	12.30
Net value added	€ha^{-1}	Q3	11.20
Sales of livestock	€ha^{-1}	Q3	9.00
Other sales	€ha^{-1}	Q3	6.90
Mortality rate	%	Min.	4.50

* Dichotomous: yes/no; UAA: Utilized Agricultural Area; AWU: Annual work Units; LU: Livestock Units;

** Max.: maximum value; Min.: minimum value; Q3: third quartile; Q2: second quartile; Q1: first quartile; P90: 90th percentile.

3.4. Sustainability Assessment (Step 4)

3.4.1. Establishment of Criteria for Optimal Values

Once the data were collected the optimal or reference values were established. These are desirable values for each indicator attainable under the circumstances on an ideal system (Nahed et al., 2006). The establishment of the optimal values is one of the most critical points in the assessment of the farms' sustainability (Masera et al., 1999), since the results, conclusions and measures implemented at the farm level will depend on such values. For establishing the optimal values, different principles (criteria) must be followed. Thus, optimal values can be selected by taking into account the maximum value of the sample, certain quartile, percentile or a value recommended in the scientific literature.

The optimal values were set in a new meeting of the focus group. The participants were given a table of all the indicators and their basic statistical descriptors (maximum, minimum, mean, and percentiles). They were also provided with information regarding the values used in other research papers(Nahed et al., 2006; Gaspar et al., 2009a; Gaspar et al., 2009b; Ripoll-Bosch et al., 2012)

The attendeeswere asked to choose one of the values given as optimal for each indicator, and only in extreme cases to give another value. The results were summarized and presented to the focus group again, to try to reach greater consensus. The criteria used for each indicator is also presented in table 1.The optimal values are shown in tables 2 and 3 in order to present them along with the results of the sustainability indicators.

3.4.2. Sustainability Indices Calculation

The values of the indicators were transformed into sustainability indices. These indices are expressed as percentages, ranging from 1 to 100. Thus, the selected farms obtained scores that allowed a better understanding of their relative sustainability, since the closer they are to 100, the better the system in terms of sustainability. Such conversion was made on the basis of the AMOEBA procedure (Ten Brink et al., 1991), by using the optimal value of each indicator as follows:

- For the indicators whose optimal values were chosen to be the maximum, the index was calculated by means of the equation (1):

Sustainability index = (indicator value / optimal value) × 100 (1)

- For the indicators whose optimal values were to be the minimum, the index was calculated by means of the equation (2):

Sustainability index = (optimal value / indicator value) × 100 (2)

For the indicators whose values were lesser than the optimal value and whose optimal values were chosen to be some percentile, the mean, or a recommended value, formula 1 was applied. On the contrary, formula 2 was used when the value of the indicator was greater than the optimal value.

3.4.3. Statistical Treatment of Results

To detect differences between farms' systems sustainability indices (scores), a single factor one-way analysis of variance (ANOVA) was applied. These analyses were carried out with the 2011 Statistical Package for Social Systems, version 20.0.

4. RESULTS

The results for the sustainability indicators for the three farm systems are presented in tables 2-4. Table 2 shows the mean values and standard deviation of the quantitative indicators. Tables 3 shows the results for the qualitative indicators. Table 4 presents the calculated sustainability indices (scores).

Table 2. Mean values and standard deviation of the quantitative sustainability indicators for the three farm systems

Attributes and indicators	Conventional	Organic 1	Organic 2	Optimal	Sample (±S.D.)
Adaptability and Flexibility					
Wooded UAA /total UAA	45.56	46.00	75.80	98.00	50.98 (±42.40)
Dependence on livestock revenue	60.50	53.14	51.27	37.95	56.32 (±17.98)
Farmer's age	45.94	46.59	50.73	30.00	47.00 (±9.98)
Off farm income/total income	17.92	8.41	29.55	100.00	16.63 (±28.44)
Cows per bull	30.59	30.67	28.29	20.88	30.22 (±13.40)
Self-reliance					
Owned UAA per total UAA	64.43	54.45	55.27	100.00	59.35 (±44.40)
Dependence on subsidies	11.13	12.73	12.27	0.00	11.89 (±21.73)
External dependence on animal feedstuff	109.69	17.55	96.63	6.71	75.24 (±112.18)

Attributes and indicators	Conventional	Organic 1	Organic 2	Optimal	Sample (±S.D.)
Family AWU/Total AWU per 100 ha UAA	83.91	79.90	48.80	100.00	76.38 (±31.70)
Cultivated UAA per total UAA	11.13	12.73	12.27	13.38	11.89 (±21.73)
Veterinary and medicine expenses	17.87	4.51	4.84	1.41	10.93 (±21.16)
Other intermediate consumption[a]	145.43	117.64	122.57	61.13	131.73 (±162.27)
Equity					
Workforce stability[b]	0.16	0.77	0.55	0.19	0.20 (±0.37)
Total AWU per 100 ha UAA	1.12	0.85	0.67	1.05	0.95 (±1.04)
Attributes and indicators	Conventional	Organic 1	Organic 2	Optimal	Sample (±S.D.)
Number of external workers	0.39	0.25	1.23	0.95	0.49 (±0.74)
Distance to social services[c]	22.27	33.39	41.08	13.60	29.44 (±23.78)
Distance to the slaughterhouse	19.20	68.30	95.36	35.40	49.65 (±44.26)
Stability and resilience					
Total stocking rate	0.73	0.50	0.44	0.33	0.60 (±0.64)
Carbon sequestration[d]	0.05	0.05	0.08	0.07	0.05 (±0.03)
Percentage of autochthonous ruminants	23.73	34.28	66.63	86.02	34.90 (±42.67)
Productivity					
Livestock productivity	429.32	350.43	556.81	620.92	424.03(±224.24)
Labour productivity	37,253	21,958	37,805	54,673	32,008 (±20,798)
Profitability rate[e]	4.43	4.20	4.35	5.76	4.34 (±2.69)
Land productivity[f]	642.40	470.25	586.65	576.67	572.55 (±410.82)
Cow productivity	0.81	0.70	0.65	1.00	0.75 (±0.21)
Net value added[g]	383.00	333.40	375.22	423.07	364.32 (±245.07)
Sales of livestock	292.96	152.84	215.92	244.28	230.58 (±223.23)
Other sales	1.49	11.34	9.75	0.09	6.37 (±23.05)
Mortality rate	3.12	4.34	10.21	0.00	4.79 (±9.49)

S.D.: Standard deviation. [a] It is the sum of workforce salaries + amortization costs + land leasing costs. [b] Workforce stability: [((Fixed AWUs)/ (Fixed AWUs + Temporary AWUs)]) × 100. [c] Distance to the nearest municipality with at least 10,000 inhabitants. [d] The methodology followed by Murillo et al. (2009) was used. Tons of carbon stored = estimated farm's total forest biomass per ha × carbon stored by photosynthesis. Estimated farm's total forest biomass was based calculated by integrating the characteristics of the farms' woody area (species, density and size) and the data provided by the 3rd National Forest Inventory (MAGRAMA, 2007). Carbon stored by photosynthesis = 0.5. Estimated farm's total forest biomass / ha = (estimation abovementioned / UAA) ×* BEF ×* WD. BEF: biomass expansion factor = 1.69. WD: wood density of Olm oaks and Quercus sp.= 0.5. It is the coefficient use to convert the biomass to dry matter.[e] Ratio between net surplus and the average capital assets, estimated from the value of total fixed capital and the value of capital. [f] Gross output/ha UAA. All the products of the agricultural activities. All agricultural output is recorded except that produced by units that produce solely for their own consumption.[g] Measures the value created by all the agricultural output after the consumption of fixed capital. That output is valued at basic prices and intermediate consumption is valued at purchaser prices. Is calculated as follows: (Gross output – Intermediate consumption – Amortization) + (those subsidies not related to livestock farming).

Table 3. Qualitative sustainability indicators for the three farm systems: categories of each indicator and percentage of farms

	Attributes and indicators	Conventional	Organic 1	Organic 2	Optimal
Adaptability and Flexibility	Number of agricultural activities/products				
	1: One activity	86.7	59.1	54.5	
	2: Two activities	23.1	53.8	23.1	
	3: Three activities	0	9.1	0	5
	4: Four activities	3.2	0	9.1	
	5: Five activities	0	0	9.1	
	Level of studies				
	1: No studies or basic education	30	40.9	27.3	
	2: Secondary and/or vocational education and training	30	36.4	36.4	3
	3: University degree	40	22.7	36.4	
Self-rel.	Quality of tracks				
	1: Good	63.3	72.7	72.7	
	2: Need improvement	26.7	27.3	27.3	1
	3: Bad quality	10	0	0	
Equity	Satisfaction level				
	1: Unsatisfied	46.7	40.9	45.5	
	2: Intermediate level of satisfaction	46.7	50	54.5	3
	3: Satisfied	6.7	9.1	0	
	Cattlemen association membership				
	1: Belong to 0 associations	6	8.11	0	
	2: Belong to 1 association	20	20	0	3
	3: Belong to 2 or more associations	74	64.86	100	
	Farmer's gender[a]				
	1: Female	3.3	18.2	9.1	1
	2: Male	96.7	81.8	90.9	
Stability and resilience	Farm continuity/future plans				
	1: Abandon	6.7	4.5	0	
	2: Herd reduction or change of species	3.3	0	9.1	
	3: Conversion to the conventional system and vice versa	60	81.8	72.7	3 and 4
	4: Increase the herd size	30	13.6	18.2	
	Soil and crop management[b]				
	0: None measure/ is carried out	16.7	13.6	0	
	1: One measure is implemented	16.7	31.8	36.4	
	2: Two measures	46.7	27.3	45.5	5
	3: Three measures	16.7	18.2	0	
	4: Four measures	0	9.1	9.1	
	5: Five measures	3.3	0	9.1	
	Use of pesticides and/or mineral fertilizers				
	0: No	63.3	100	100	0
	1: Yes	10	0	0	
	Degree of integration				
	0: No integration of various livestock species, crops and trees	93.3	86.4	63.3	1

Attributes and indicators	Conventional	Organic 1	Organic 2	Optimal
1: Integrate these elements	6.7	13.6	36.4	
Use of preventive antiparasitics and/or antibiotics				
0: They do not use them	3.3	100	100	0
1: Yes, they use them	96.7	0	0	
Dung management				
1: No dung due to extensiveness	30	36.4	0	
2: Spreading of immature dung	56.7	45.5	45.5	4
3: Dung heaping (immature)	13.3	4.5	45.5	
4: Compost	0	13.6	9.1	

[a]From the sustainable rural development points of view, the participation of women in the management and ownership of farms, play a double role. On the one hand, it is more equitable, since there is no exclusion of women from the rural world. On the other hand, the fixation of women in rural areas can be related to the establishment of families and more population in such areas.

[b] Number of measures/agricultural management practices implemented to reduce soil erosion and to improve soil quality. These include: cover crops, mulching, intercropping, crop rotation, plot rotation, fallow, and use of compost.

In the following paragraphs, we shall describe the main findings of the farm systems. Table 4 shows the calculated sustainability indices (scores) of each farm system and of the sample.

Adaptability and Flexibility

As can be seen in table 4, significant differences were found among thefarm systems ($p<0.01$). These differences were mainly due to the number of agricultural activities/products and the wooded UAA per total UAA, as both indicators are interlinked. More wooded area allows a higher degree of diversification of the holding (measured as the number of agricultural activities/products).The degree of business diversification and the wooded area are key elements for the dehesa farms. In this sense, the Organic 2 systems showed the greatest degree of diversification (54.55%), and of wooded area (77.34%). As a result, the set of indicators studied showed the Organic 2 farms to be more adaptable and flexible than the Conventional and Organic 1 farms.

Self-Reliance

Organic 2 farms showed the lowest percentage of family AWU / total AWU per 100 ha UAA, and the worst scores (48.80%). This may be because their specialization and their higher degree of diversification force the farm-holder to hire outside labour, thus reducing the farm's self-reliance. Additionally, reducing outlays on feed is especially important since it usually represents the greatest cost of production. This is especially important in organic farms, since the prices of organically grown feedstuffs are much higher than conventional ones. In this sense, the Organic 1 farms scored best (68.27%) in terms of their relative lack of dependence on external feed. This is because they did not fatten their calves, but they sold them on at weaning, so that they hardly consumed any concentrate. On these farms, only the breeding cows and bulls required externally supplied feed at times when the available food resources generated by the farm (pasture, hay, and crops produced on the farm itself) do not cover the animals' nutritional needs. The Conventional farms scored next best (33.46%). This is because not all the farms in this farm system fattened their calves and the conventional feedstuff price is lower. Organic 2 farms had the worst scores because they all fattened their calves organically. In summary, with respect to the self-reliance attribute the Organic 1 system showed to be the best positioned, followed by Organic 2, and Conventional the worst positioned (70.14%, 61.05% and 57.99%, respectively).

In the case of the Organic 1 farms, the differences were strongly influenced by their not being full-cycle production systems, meaning that they had reduced feed purchase and labour costs.

Table 4. Mean values, standard deviation and significance of the sustainability indices (scores) for the three farm systems

Attributes and indicators	Convent.	Organic 1	Organic 2	Sample (±S.D.)	P-value
Adaptability and Flexibility	54.14 [a]	56.42[a,b]	65.34 [b]	56.89 (±12.44)	*
Number of agricultural act./products	38.89 [a]	50.00[a,b]	54.55 [b]	45.50 (±21.00)	*
Wooded UAA per total UAA	46.48	46.92	77.34	52.02 (±43.27)	NS
Dependence on livestock revenue	66.39	78.45	76.15	72.31 (±18.91)	NS
Farmer's age	68.38	65.95	61.64	66.35 (±13.96)	NS
Level of studies	70.00	60.61	69.70	66.67 (±27.44)	NS
Off farm income/total income	17.92	8.41	29.55	16.63 (±28.44)	NS
Cows per bull	71.75	71.62	76.24	72.49 (±20.15)	NS
Self-reliance	61.05 [a]	70.14 [b]	57.99 [a]	63.69 (±13.01)	*
Owned UAA per total UAA	64.45	54.42	55.35	59.36 (±44.42)	NS
Dependence on subsidies	88.84	87.38	87.95	88.17 (±21.71)	NS
External dependence on animal feedstuff	33.46 [a]	68.27 [b]	26.06 [a]	44.33 (±44.64)	**
Family AWU/Total AWU per 100 ha UAA	83.91 [a]	79.90 [a]	48.80 [b]	76.38 (±31.70)	**
Cultivated UAA per total UAA	27.92	49.37	50.96	39.43 (±43.82)	NS
Quality of tracks	76.67	86.36	86.36	81.75 (±28.82)	NS
Veterinary and medicine expenses	30.80 [a]	65.98 [b]	63.09 [b]	48.72 (±37.52)	**
Other intermediate consumption	68.39	68.45	52.91	65.71 (±28.25)	NS

Attributes and indicators	Convent.	Organic 1	Organic 2	Sample (±S.D.)	P-value
Equity	57.90	55.18	63.44	55.53 (±14.72)	NS
Workforce stability	10.00 [a]	4.55 [a]	45.45 [b]	14.29 (±35.27)	**
Total AWU per 100 ha UAA	77.98 [a]	60.48 [b]	62.88 [b]	62.44 (±29.44)	*
Number of external workers	23.99 [a]	22.34 [a]	49.78 [b]	27.91 (±36.35)	*
Satisfaction level	52.87	55.59	51.00	53.49 (±20.18)	NS
Distance to social services	77.73 [a]	66.61 [b]	58.92 [b]	70.56 (±23.78)	*
Cattlemen associations membership	85.00	79.55	100.00	85.71 (±27.57)	NS
Farmer's gender	51.67	59.09	54.55	54.76 (±14.80)	NS
Distance to the slaughterhouse	96.77 [a]	61.30 [b]	44.93 [b]	75.33 (±29.13)	***
Stability and resilience	43.46 [a]	61.85 [b]	69.31 [b]	54.39 (±16.49)	***
Total stocking rate	61.47	69.71	69.46	65.74 (±22.71)	NS
Farm continuity/future plans	85.67	87.27	88.18	86.67 (±21.33)	NS
Soil and crop management	35.33	35.45	41.82	36.51 (±23.43)	NS
Use of pesticides and/or mineral fertilizers	55.00 [a]	100.00 [b]	100.00 [b]	78.57 (±39.87)	***
Degree of integration	6.67 [a]	13.64 [a,b]	36.36 [b]	14.29 (±35.27)	*
Use of preventive antiparasitics and/or antibiotics	3.33 [a]	100.00 [b]	100.00 [b]	53.97 (±50.24)	***
Dung management	28.33	36.36	54.55	35.71 (±40.59)	NS
Carbon sequestration	63.74 [a]	65.30 [a]	97.31 [b]	70.15 (±41.70)	*
Percentage of autochthonous ruminants	25.48 [a]	36.16 [a,b]	70.50 [b]	37.07 (±44.38)	*
Productivity	67.93 [ab]	61.62 [a]	76.69 [b]	67.26 (±16.84)	*
Livestock productivity	74.40 [ab]	64.60 [a]	89.93 [b]	73.69 (±24.97)	*
Labour productivity	67.46 [a]	46.42 [b]	74.26 [a]	61.30 (±31.25)	*
Profitability rate	62.65	65.39	72.56	65.34 (±31.13)	NS
Land productivity	75.39 [ab]	71.31 [a]	93.24 [b]	77.08 (±23.11)	*
Cow productivity	80.92	70.44	65.12	74.50 (±21.03)	NS
Net value added	70.46	67.45	83.46	71.68 (±25.96)	NS
Sales of livestock	68.83 [ab]	56.25 [a]	86.23 [b]	67.48 (±29.22)	*
Other sales	3.33	22.73	18.18	12.70 (±33.56)	NS
Mortality rate	96.88	95.66	89.79	95.21 (±9.49)	NS
Overall sustainability	56.89 [a]	61.04 [b]	66.55 [c]	60.03 (±6.87)	***

[a, b, c] Values within a row with different superscripts differ significantly at P<0.05. Pvalue; NS: P>0.05; *=P<0.05; **=P<0.01; ***=P<0.001.

Equity

In relation to the attribute of equity, the first three indicators are related to labor, since it is considered that the more workers employed in the farms (preferably non family worker), the more equitablethe systems are. Conventional farms are those that employ more people, although organic farms (both systems) hiremore external workers, making therefore a higher contribution to the distribution of the profits obtained from the farms.

Regarding the access to social services (health, leisure, etc.), the distance between the farm and the nearest municipality with at least 10,000 inhabitants was been used as an estimator. Social services are available only in large municipalities in the area. Thus, the longer the distance between the farms and the municipalities, the more time is needed to access the public services, thus reducing the farmers' quality of life. In this sense, Conventional farms scored the highest (77.73%). Similarly, differences ($p<0.001$) between the distance to the slaughterhouse between Conventional and Organic farms were found. Conventional farms were located closer to these facilities, due to the fact that there are few organically certified slaughterhouses in the region (only 2).

Overall, no farms system presented significantly better scores for the Equity attribute.

Stability and Resilience

As can be observed in table 4, remarkable differences ($p<0.001$) were found among Conventional and Organic farms. As the majority of indices grouped in this attribute are related to the agro-ecosystem management, these differences highlight that Organic farms contribute to environmental stability to a greater extent than conventional farms do. Specifically, significant differences ($P<0.001$) were found among Conventional and Organic farms (Organic 1 and Organic 2) for the use of pesticides and/or mineral fertilizers (55.00% vs. 100.00%), and for the use of preventive antiparasitics and/or antibiotics (3.33% and 100.00%). This result is due to the fact that the EU legislation in force on organic production (Council Regulation EC Nº 834/2007 and subsequent amendments) prohibits the use of these products.

However, for the degree of integration (measured as the integration of different livestock species, crops, and trees), the differences were found among the Organic 2 system and the rest of systems ($p<0.05$). The higher degree of integration can be explained by the fact that Organic 2 farms are mainly located in the centre and South of Extremadura, were soils are of higher quality, and the density of trees and their size is also higher. This allows integrating crops and other livestock species (such as the Iberian pigs) more easily.

Productivity

Regarding the indicators with more weight on the attribute of productivity, (livestock and labour productivity) Organic 2 farms obtained the highest scores because they fattened all their livestock (so that there was greater retention of value added) and because of the higher price at which organic calves are sold (25% above the price of the fattened calves of the Conventional system.) Accordingly the Organic 1 system positioned last (61.62%) comes from the fact that they do not fatten their calves as they mainly try to maximize subsidies.

Considering the overall sustainability of the systems analysed, the Organic 2 farms are the most sustainable, followed by Organic 1, and Conventional.

5. DISCUSSION

The degree of business diversification is a key element in rangeland farms in general, and in dehesa farms in particular (Gaspar et al. 2009b), because their profitability is low and their economic stability is strongly dependent on the farm's feeding resources. In this sense, farms with a greater variety of outputs (livestock, olives, firewood, cork, etc.)such as Organic 2 farms have a greater capacity to adapt to changes such as the collapse of prices in the beef cattle sector. This degree of diversification is reinforced by the higher percentage of wooded area that this farm system showed.

The availability of wooded area is a key element for dehesa farms. Economically, it allows them to increase their feed resources and their diversification potential, increasing the economic performance and reducing the economic risk. Environmentally, the presence of wooded areas reduces erosion, leaching, and groundwater pollution, increases biodiversity, and improves nutrient recycling (Smith et al. 2011). In this sense, it would be advisable for dehesa farms to increase their wooded areas and, in some cases, the density of trees, as this would redound in environmental and economic benefits.

With regard to the self-reliance it is interesting to note that with the high prices of feedstuff and the projected constraints that pasture-based livestock systems of Mediterranean basin can suffer due to climate changes (Nardone et al. 2010, Segnalini et al. 2013), self-reliance becomes a key aspect for dehesa systems, which must improve their performance with respect to it. In this sense, Organic 1 farms had the highest scores due to their reduced use of concentrates, since they base their production system on farms' natural resources. Despite this appearing to be advantageous, it may undermine other sustainability attributes as they did not fatten their calves and therefore their productivity decreases. This could be an important weakness as there is no market for weaned calves and, as a consequence, farmers depend upon intermediaries (traders and feedlots) for selling their calves.

On the contrary, Organic 2 farms are more dependent on external resources, which can lead to a high reduction of their sustainability if an increase of concentrates' prices occurs. However, although consumers' demand for organic beef still remains low, Organic 2 are predictably less vulnerable, due to the fact that they have established contracts with retailers, which reduce the importance of such low self-reliance and their level of risk. With respect to the dependence on subsidies, none of the three production systems seems to be less dependent on them than the others. However, organic ruminants systems located in other areas have been found to be highly dependent on subsidies (Hrabalová and Zander 2006, Argyropoulos et al. 2013). This divergence on the results can be explained by the fact that, as Lobley et al. (2009) and Lobley et al. (2013) pointed out, the differences among organic and conventional farms are mainly due to their structure and management, more than to the fact of being organic or not.

From the equity point of view, no major differences were found among systems. However, the indices related to the workforce showed interesting differences that have already been addressed. According to Morison et al. (2005), organic farms showed less mean jobs per area (calculated as "Total AWU per 100 ha UAA in our study). However, comparisons among different studies must be interpreted carefully, since job creation varies greatly with enterprise type, farm size and regions (Morison et al. 2005, Lobley et al. 2009).

Regarding the distance to the slaughterhouse, the differences found are worthy of a deeper analysis. As it has been mentioned above, organic farms are further from the slaughterhouses, which is due to the low number of organically certified slaughtering premises. In the case that demand for organic beef would increase, the development of the organic beef sector would be difficult since this scarce development of the organic industry. Additionally, this greater distance makes it difficult to implement activities of elaboration and direct sales of their products to consumers, which would allow the producer to charge a price premium, which is, according to (Tzouramani et al. 2011), indispensable for organic production because of the higher costs involved.

With regard to the stability and resilience of the farms, it has been observed that organic farms showed a reduced use in synthetic inputs (pesticides, mineral fertilizers, and preventive antiparasitics and antibiotics). It had been observed previously in beef cattle farms in Spain (Blanco-Penedo et al. 2012) and , according to Anderson et al. (2012) and Sanderson et al. (2013), has positive environmental and economic effects. Moreover, Organic 2 farms had a greater degree of integration of different livestock species, crops, and wooded areas. This integration allows the farms to make better use of their food resources, to conserve their natural resources and landscape diversity, and strengthen their ecosystem services, while providing themselves with their own agricultural inputs, and reducing their external dependence and vulnerability. Additionally, it is interesting to study the higher scores for carbon sequestration of the farms analyzed, since enhancing carbon sequestration is the main approach that rangelands and agroforestry systems can adopt to address climate change. In fact, rangelands have a great potential for storing carbon (Schuman et al. 2002). In such systems, improved land management practices and the presence of trees contribute to carbon sequestration, thereby improving soil quality (Nair et al. 2009) and mitigating climate change.

Moreover, their use of native species better adapted to local conditions, means that livestock productivity is less affected by extreme weather conditions(such as the high summer temperatures. This aspect is important due to the climate changes that Spain is predicted to undergo (Segnalini et al. 2013). For all these reasons, the Organic 2 system is thus expected to be more stable.

In addition, it is important to say that environmentally friendly production systems may not lead to long-term economic and social sustainability of a farm (Darnhofer et al. 2010). However, organic and resource-conserving agriculture may help smallholders (as those of dehesa) to navigate changing environmental and market conditions (Bennett and Franzel 2013). Moreover, the interaction between the social, ecological and economic dimensions are of great importance in the resilience thinking (Darnhofer et al. 2010).

Finally, and with respect to the Productivity, Organic 2 farms again obtained the highest scores. The results shed light on this issue, since few comparisons have been made regarding productivity and profitability between organic and conventional beef cattle farms. Those carried out not always compare to two systems under the same conditions (two extensive systems: organic vs. Conventional). Thus, the main differences found in other studies come from the structure and management of the farms, rather than whether the farms are organic or conventional. Nevertheless, some conclusions can be made from those results. It seems that organic cattle farms tend to be less productive and/or less profitable than conventional farms due to several reasons: longer productive period, overhead costs specially the feedstuffs, and lower revenues (Blanco-Penedo et al. 2012, Gillespie and Nehring 2013). In the present study, no differences were found between the organic farms that sold organic products (Organic 2 farms) and the Conventional ones.

6. Conclusion

This indicator-based comparative evaluation of the sustainability of organic and conventional beef cattle farms has allowed us to establish levels of sustainability in technical, environmental, social, and economic terms for these types of production systems in a high-value Mediterranean agro-ecosystem. Regarding sustainability attributes considered in the study, Organic 2 farms had the best scores on the Adaptability and Flexibility, Stability, and Productivity attributes. Organic 1 farms had the best scores on the Self-reliance attribute, due mainly to not fattening their calves.

In terms of overall sustainability, farms belonging to the Organic 2 system were found to be the most sustainable. These farms are in an advantageous position for their present and future sustainability in view of the orientations of the new Common Agricultural Policy (environmentally friendly production systems), as well as the trend in consumer demand for products that are more natural, healthy, and environmentally sustainable. In summary the organic, complete cycle, beef cattle production systems is a more sustainable option than the other two under these indicators. Nonetheless, implementing these systems is complex due to the high costs involved in the production of organic calves and to the weak demand for them.

In general, all three types of farm need to improve in certain common aspects that are crucial in the current and future context of the livestock sector. These aspects are: reducing the dependence on external feed, implementing more environmentally friendly farming practices and farm diversification. The result will be both to lessen the farm's vulnerability and to increase its production of environmental and social services. Indeed, it is in these latter where the dehesa beef cattle farms can stand out and benefit from the market and from agricultural policies.

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