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Typological analysis of the sustainability of dairy cattle farming in the Chelif valley (Algeria)

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Abstract. To identify production systems that could increase local milk production in a sustainable manner, a study was conducted on 135 dairy farms in the three main plains of the Chelif Valley, Algeria. These have been evaluated for environmental, social and economic sustainability based on the IDEA (Farm Sustainability Indicators) method.
The Principal Component Analysis identified 4 different types dairy production systems, namely Type 1: Medium-size dairy farms with cereal crop production; Type 2: Small-size dairy farms; Type 3: Medium-size dairy farms diversified crop production, and Type 4: Large-size dairy farms with diversified crop production.
Comparative analysis of ecological sustainability showed better results for medium-size dairy farms with cereal crop production (52.3 ± 10.17 / 100 points) and for large-size dairy farms with diversified crop production (51.6 ± 10.38 / 100 points), while the economic sustainability was better for medium-size dairy farms with diversified crop production (51.6 ± 19.20 / 100 points). On the other hand, social security was the weak point for all farm types.
On the regional level, it appeared that agri-environmental scores were better in Middle and Low Chelif valley while the best economic performances were recorded in High Chelif valley. On the regional level, it appears that the scores of agri-environmental scales are better in the middle and low Chelif while the economic performances are comparable between the three localities.

Key words: Algeria, dairy farming, IDEA, sustainability, typology.

INTRODUCTION

In the Chelif valley, located in the center of the country between the two major economic centers west of Algiers and east of Oran, three main plains are extended from the plain of Upper Chelif to the East, to that of Lower Chelif in the West, passing through the plain of Middle Chelif in the center. The entire river valley which covers an area of 44,630 km^2, does not lack assets. This area irrigated by the Chelif valley, it has most of the arable land where modern agriculture is developing and where there are important dairy production regions with a total of 123,017 heads of cows owned by 9,238 breeders and representing 7% of the national herd (MADR, 2013). Like other regions of the country, since the 1970s the valley has seen a series of dairy development plans that aimed to intensify production, to fight against underemployment and to develop rural areas (Adair, 1982; Bessaoud, 2006). However, the expected results have not been met.

The causes are linked to the absence of a global vision on the production systems and the lack of knowledge on the actual conditions of the farms due to lack of data on their structure and operation (Baouche, 2014). As of today, Algerian dairy farms face many uncertainties. The trend towards intensification of dairy operations is also increasingly questioned because of its impact on the environment and animal welfare (Fraser, 2006). The importance of a transition to more sustainable systems is, therefore, at the center of the current debate (Ozier-Lafontaine et al., 2011). Indeed, in the context of agriculture, sustainable development is a long-term, comprehensive, on-farm approach that maximizes the economic, environmental, and economic stability, equity, and health of the farm and family.

The major scientific task is therefore to identify how these dairy farms could evolve to respond to the above-mentioned challenges.

This article focuses on two essential points, namely the identification of the types of dairy cattle farms in the Chelif valley and the evaluation of the sustainability of these farms on the basis of the IDEA method (Vilain, 2003) which carries out a multidimensional diagnosis of the sustainability of the farm by the combination of three groups of indicators that measure agro-ecological, socio-territorial and economic sustainability. The IDEA method makes it possible to point out the strengths and weaknesses of a farm to show possible ways of improvement. The objectives of the agro-ecological scale refer to the agronomic principles of integrated agriculture. They must allow good economic efficiency for an ecological cost as low as possible. Those on the socio-territorial sustainability scale refer more to ethics and human development, which are essential features of sustainable farming systems. Finally, the objectives of the economic sustainability scale take into account the entrepreneurial function of the farm.

MATERIALS AND METHODS

The study was conducted between 2014 and 2015 on 135 dairy farms spread over the plains of the *Chelif valley*. It involved 64 farmers from *High Chelif* (*Wilaya of Ain Defla*), 50 from *Middle Chelif* (*Wilaya of Chlef*) and 21 from *Low Chelif* (*Wilaya of Relizane*). The choice of these farmers is based on their vocation (dairy cattle farming), the possession of the farming license and the adhesion to the milk collection network. A questionnaire was established as a survey guide with 190 questions relating to the operation of the dairy farm. It also made it possible to provide information on sustainability indicators using the IDEA method (Vilain, 2003), which includes three scales: agro-ecological, socio-territorial and economic. All scales have the same weight and range from 0 to 100 points.

1- The agro-ecological scale structured in three components of equal importance (capped at 33 and 34 points): domestic diversity (4 indicators), organization of space (7 indicators) and farming practices (7 indicators). The diversity component is introduced in the analysis to take into account the fact that an economical, autonomous and non-polluting agriculture relies on a high level of diversity of productions in order to take into account the complementarities and the natural regulation processes that work in the different types of cultivated ecosystems. Indicators associated with the organization of space component concern the organization of the plots, the management of non-productive environments and the valorization of spaces. The farming practices component analyzes the intensity of environmental pressure according to the farmer's

choices and technical itineraries (level of fertilization, intensity of phytosanitary treatments, consumption of fossil energy, etc.).

2- The socio-territorial scale refers to ethics and human development, it characterizes the insertion of exploitation in its territory and in society. It assesses the quality of life of the farmer and the weight of the market or non-market services he provides to the territory and society. The three components of socio-territorial sustainability (product quality, employment and services, ethics and human development) have the same weight and are capped at 33 on a scale of up to 100. In practice, this scale combines and weight practices and quantifiable behaviours with more qualitative elements (such as the architectural quality of the buildings, the landscape quality of the surroundings). Some indicator values such as likely sustainability, work intensity, quality of life and feeling of isolation are self-declaring and estimated by the farmer.

3- The economic sustainability scale analyzes the economic results beyond the short term and the cyclical uncertainties. Structured in 4 components and 6 indicators, the analysis goes beyond taking economic performance into account in terms of short-term economic or financial profitability, but also analyzes the degree of economic independence, the transferability capacity of the farm and efficiency of its productive process. On a scale of up to 100, each of these four components is capped at between 20 and 25 units.

Each scale groups together several indicators, totaling 37. The score of a farm for each of the three sustainability scales is the cumulative number of points obtained for the various indicators of the scale considered. The higher the score the more the farm is sustainable for the scale considered. The choice of this method is motivated by the fact that it is relatively simple and easy to implement.

The data thus collected were the subject of a series of analyzes and statistical treatments. ANOVA was performed using the Statgraphics Centurion XVI version 16.1.1.18 software, multiple correspondence analysis (MCA) followed were performed to describe the types of farms present. Principal Component Analysis (PCA) was conducted to identify sustainability classes by components and sustainability scales. These analyzes were performed using the SPAD software version 6.5 (Coheris-SPAD, France).

RESULTS

Farm characteristics

The farms surveyed share a remarkable productive potential (Table 1). It consists of a land base of 4,134 ha (30.62 ± 44.64 ha per farm) for a total cattle population of 3,819 head of which 51.37% were dairy cows, with an average of 14.64 ± 12.82 dairy cow per farm.

Cereal cropping was practiced on all farms (N = 135) while arboriculture (N = 45) was more widespread in High and Medium Chelif. Vegetable crops (N = 40) were mainly farmed in Middle Chelif. Irrigation was practiced on 71.85% of the farms, whereby 47.41% used sprinkler irrigation and 10% drip irrigation, the latter mainly reserved for arboriculture and vegetable crops. The availability of labour on the farms was quite variable, averaging 6.13 ± 7.62 LbU (Labour Unit) /farm. This means that 1 LbU on average had to take care of 2.38 dairy cows and 5 ha of UAA (Useable

Agricultural Area). Cultivated fodder, which is the guarantor of economic milk production, occupied an area of 1,572.13 ha cultivated with by oats (N = 135), with a predominance in High and Middle Chelif. Clover (N = 60) and sorghum (N = 76) were homogeneously distributed between the three localities and alfalfa was of low importance (N = 10). A common practice to overcome shortage in cultivated fodder is the use of spontaneous fodder (N = 53), most often coupled with the distribution of excessive amounts of concentrated feed ranging from 4 to 10 kg cow per day (N = 135) but without real benefits from it in terms of milk production (on average 14 L cow per day). Pasture use was rare (N = 25) and mainly found on High Chelif farms (8%). The fodder autonomy in these farms (N = 135) is low since the recorded stocking rate is on average 11.29 ± 3.95 LU per ha of forage area.

Table 1. Mean values (and standard deviation) of major characteristics of four types of dairy farming systems in the Chelif valley

TYPE	1	2	3	4	TOTAL
N	69	11	31	24	135
Age of farmer (years)	46.5 a	43.7 a	48.4 a	43.4 a	46.2
	(15.51)	(13.61)	(15.09)	(12.12)	(14.67)
LbU (N)	4.0 b	3.0 b	9.1 a	9.8 a	6.1
	(2.04)	(1.68)	(11.94)	(9.80)	(7.63)
Cattle (N)	21.5 b	24.6 b	57.5 a	56.3 a	36.2
	(8.11)	(11.15)	(37.54)	(79.09)	(40.32)
Dairy cows (N)	8.3 c	11.4 bc	21.8 ab	24.9 a	14.6
	(3.85)	(6.07)	(12.32)	(32.81)	(16.77)
UAA (ha)	17.4 b	2.7 c	27.8 b	94.9 a	30.6
	(9.64)	(2.97)	(19.30)	(82.89)	(44.65)
FA (ha)	9.6 b	1.0 c	10.3 b	52.0 a	16.6
	(6.54)	(1.45)	(5.39)	(50.07)	(27.12)
LU/ha FA	2.6 c	9.1 a	5.3 b	1.0 c	11.3
	(2.42)	(10.72)	(6.47)	(0.90)	(39.47)

Values with common letters are not significantly different; LbU: Labour Unit; UAA: useful agricultural area; FA: forage area; LU: livestock unit.

Typology of farms

The first two axes of the multiple correspondence analysis (MCA) explain more than 30% of the total variation of the sample; the approach allowed to identify 4 types of farms (Fig. 1).

Type 1: Medium-size dairy farms with cereal crop production

This Type represented of 51.11% of the farms and comprises medium-sized farms with a low level of diversification in plant production; 78.26% of these farms are evenly distributed between the High and Middle Chelif. The farm land of about 17 ha per farm, is mainly used for cereals (barley and durum wheat). There is very little market vegetable gardening and very little arboriculture. The fodder on these farms covers an area of 9 ha, mainly oats, used green and as hay for a 20-head cattle herd and an 8-head dairy cow herd per farm. In 56% of the cases sheep are also farmed. The stocking rate is average with 2.62 LU per ha forage area. The labour availability on these farms is partly family-based and averages about 4 LbU.

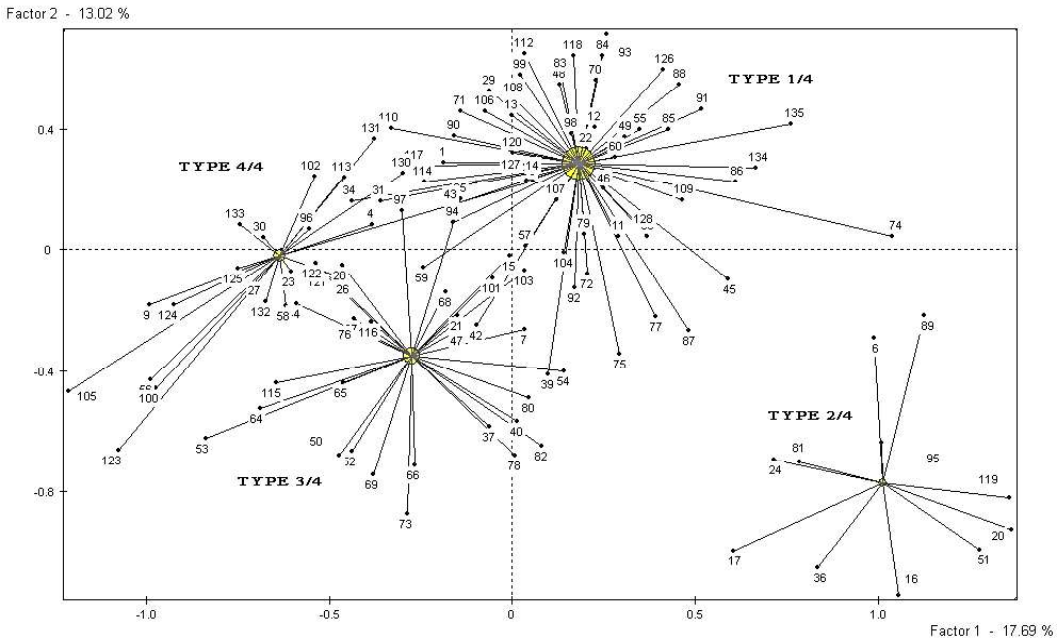

Figure 1. Representation on the first two axes of multiple correspondence analysis (MCA) deploying 190 variables that allowed identifying four distinct types of dairy farms.

Type 2: Small-size dairy farms

This type, which accounts for 8.14% of the farms with practically no land base, is spread over the entire study area with a slight concentration at High Chelif (63.63%). The number of dairy cows is small (11 cows per farm) and stocking rate is highest (9 LU per ha FA). In addition, all labour (3.54 LbU) mobilized on these farms belongs to the family.

Type 3: Medium-size dairy farms with diversified crop production

This Type includes 22.96% of the farms of which 45.16% are located in Middle Chelif. The farms are of medium size and focus on mixed crop-livestock farming. Average cattle population per farm is 57 heads with 22 dairy cows. The farm land of about 28 ha is cropped with fodder (10 ha), cereals, arboriculture and vegetables. The stocking rate is high (5 LU per ha FA), and the farms are moderately equipped with mechanical equipment and buildings. The frequent use of hired workers during labour peaks results in the presence of an important workforce (9 LbU).

Type 4: Large-size dairy farms with diversified crop production

This Type includes 17.78% of the farms and is spread over the three localities with a slight concentration in Low Chelif (45.83%). The large-size farms are characterized by a large land area (95 ha) devoted to cereals, arboriculture and market gardening, all irrigated, and a significant presence of fallow. The livestock unit is dominated by dairy cattle with 25 dairy cows on average. The forage area occupies an important place in the crop rotation, with an average of 52 ha per farm. The stocking rate recorded in this group is lowest with 1.1 LU per ha FA. The mixed management system mowing / grazing, a practice that avoids the depletion of certain plots. These farms are generally well equipped with agricultural equipment and buildings and the employment of hired labour is important (10 LbU on average).

Sustainability of farms: overall and regional characteristics

The agro-ecological scale had the highest score, i.e. 49.6 ± 10.86 out of 100 points with individual values ranging from 20 to 76 points (Table 2). It was followed by the economic scale with a score of 45.3 ± 20.56 points (ranging from 3 to 84 points) and finally by the socio-territorial scale with a mean score of 37.0 ± 6.26 points (ranging from 19 to 51 points) (Table 2). Overall sustainability estimated by the average of the lower scale for each farm was relatively low, i.e. 31.2 ± 7.83 points (ranging from 3 to 47 points). For 48.89% of the farms, minimum point values were attributed to the socio-territorial scale, whereas minimum values were attributed to the economic and agro-environmental scales for respectively 40.0% and 11.11% of the farms. The sum of the three sustainability scales yielded a score of 132.9 ± 23.86 out of 300 points (ranging from 73 to 178 points). The overall sustainability scores were similar between the three locations. However, the scores of the agri-environmental scales were better in Middle and Low Chelif while the best scores of the economic scale were recorded in High Chelif.

Table 2. Mean values (and standard deviation) of sustainability scales scores attributed to farm types and sustainability classes

Category	N	AGRO	SOCIO	ECO	SUM	SUS
CLASS 1	38	55.9 a	36.4 b	63.5 a	155.9 a	36.4 a
		(7.82)	(5.28)	(9.69)	(12.44)	(5.28)
CLASS 2	27	38.6 b	42.5 a	66.0 a	147.2 b	37.0 a
		(7.10)	(4.66)	(11.20)	(13.74)	(5.54)
CLASS 3	18	39.9 b	29.7 c	26.8 b	96.2 d	23.3 c
		(10.35)	(6.53)	(7.07)	(11.28)	(4.92)
CLASS 4	52	54.2 a	37.3 b	27.8 b	119.3 c	27.1 b
		(7.51)	(4.73)	(7.17)	(9.05)	(6.05)
TOTAL	135	49.6	37.1	45.4	132.1	30.5
		(10.86)	(6.26)	(20.56)	(23.86)	(7.88)
TYPE 1	69	52.3 a	36.7 b	44.5 ab	133.5 a	30.8bc
		(10.17)	(6.19)	(21.13)	(22.92)	(7.94)
TYPE 2	11	36.6 c	36.4 b	33.5 b	106.5 b	25.7 c
		(11.79)	(7.32)	(16.34)	(22.39)	(6.53)
TYPE 3	31	46.8 b	37.8 b	51.6 a	136.3 a	34.6 a
		(8.62)	(6.53)	(19.20)	(23.12)	(7.35)
TYPE 4	24	51.6 ab	37.8 a	45.2 ab	138.9 a	31.5ab
		(10.38)	(5.84)	(20.59)	(22.38)	(7.29)
High Chelif	56	46.3 b	37.6 a	48.5 a	138.9 a	31.6 a
		(11.48)	(7.47)	(21.69)	(27.21)	(8.17)
Middle Chelif	48	51.7 a	36.7 a	43.9 a	137.5 a	30.9 a
		(10.42)	(5.37)	(20.78)	(22.53)	(8.54)
Low Chelif	31	52.5 a	36.8 a	42.0 a	136.6 a	31.0 a
		(8.88)	(5.17)	(17.77)	(19.30)	(6.07)

Values with common letters are not significantly different; N: Number; AGRO: agro-ecological; SOCIO: socio-territorial; ECO: economic; each yielding a maximum of 100 points; SUM: sum of score points (maximum 300) SUS: Overall sustainability (calculated by the average of the lower scale for each farm).

Classification of farms according to sustainability scores

The principal component analysis identified four axes, the first two of which accounted for 81.34% of the variability. The hierarchical classification helped to identify four sustainability classes (Fig. 2).

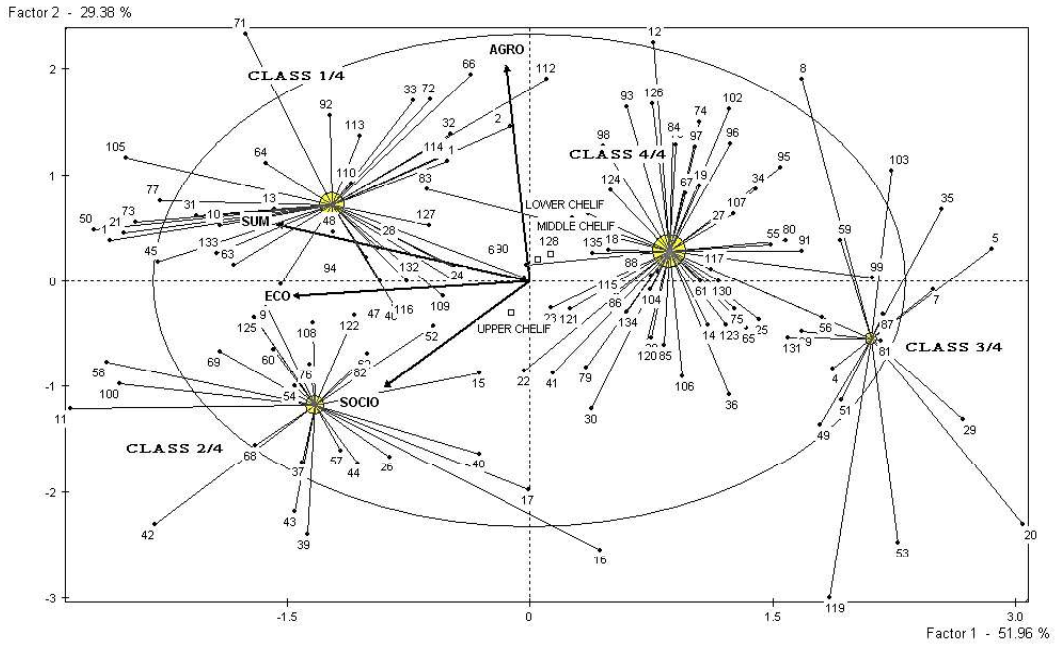

Figure 2. Distribution of dairy farms (numbers) across four sustainability classes as displayed by the first two axes of the hierarchical classification (principal component analysis).

Class 1: High sustainability limited by socio-territorial scale

This class comprised 28.15% of the surveyed farms; these were distributed between the High, Middle and Low Chelif with respectively 44.7%, 31.6%, and 23.7%. These farms yielded the highest sustainability score (155.9 ± 12.44 / 300 points) and were characterized by good agro-environmental (58.0 ± 7.38 / 100 points) and economic performance (63.5 ± 9.69 / 100 points) but poor performance on the socio-territorial scale (36.5 ± 5.28 / 100 points).

Class 2: Average sustainability limited by agro-ecological scale

This class consisted of 20% of the farms of which 55.56% were concentrated in High Chelif. It displayed the best scores for the economic and socio-territorial scales with respectively 66.1 ± 11.20 and 42.5 ± 4.66 / 100 points. However, it displayed average sustainability (147.2 ± 13.74 / 300 points) because it was limited by the score of the agro-ecological scale (38.4 ± 7.10 / 100 points).

Class 3: Low overall sustainability

This class comprised 13.33% of the farms of which 61.11% were located in High Chelif. It grouped the farms with the lowest sustainability score (96.22 ± 11.28 / 300 points) with 39. 9 ± 10.35, 29.7 ± 6.53 and 26.7 ± 7.07 points / 100, respectively, for the agro-ecological, the socio-territorial and the economic scale.

Class 4: Moderate sustainability limited by economic scale

This class was represented by 38.52% of the farms that were distributed between the High, Middle and Low Chelif with respectively 25.0%, 46.2%, and 28.9%. Similar to class 1, they displayed good agro-ecological performance (54.2 ± 7.51 / 100 points) but on the other hand low scores on the socio-territorial scale (37.3 ± 4.73 / 100 points) and the economic scale (27.8 ± 7.17 / 100 points).

Distribution of farm types across sustainability classes

Type 1: Medium-size dairy farms with cereal crop production

Of Type 1 farms, 79.7% were divided between class 1 (high sustainability limited by socio-territorial scale; 31.88%) and class 4 (moderate sustainability limited by economic scale; 47.82%). This Type obtained the highest score on the agro-ecological scale with 52.8 ± 10.17 / 100 points because of the diversity component which recorded a score of 20.0 ± 5.78 / 33 points. This is explained by the high animal diversity and the annual crop component. The organization of space (16.97 ± 4.41 / 34 points) and the farming practices (15.3 ± 6.30 / 33 points) contributed moderately through the complex rotations encountered, the small dimensions of the fields cultivated as well as the restricted use of pesticides. The low score of the social scale (36.7 ± 6.19 / 100 points) resulted from the low scores recorded by the quality and employment components with respectively 8.9 ± 2.35 and 7.8 ± 3.82 points of a total of 33. The ethics component score was good (20.8 ± 3.25 / 34 points) due to the lack of use of imported food and the average quality of life, estimated by the farmers of this Type and this, despite a slight feeling of isolation. The average score obtained for the economic scale (44.5 ± 21.13 / 100 points) was mainly due to a considerable financial autonomy and a certain independence vis-à-vis public aid (Table 3).

Table 3. Mean points (and standard deviation) achieved by four different types of dairy farms for major sustainability components

TYPE	1	2	3	4	MEAN
Diversity	20.0 b	14.8 c	22.5 ab	23.2 a	20.7
	(5.78)	(5.60)	(5.41)	(6.84)	(6.23)
Organisation of space	16.9 a	8.7 c	13.2 b	13.2 b	14.8
	(4.41)	(7.96)	(4.50)	(3.74)	(5.30)
Farming practices	15.3 a	16.3 ab	11.2 b	15.2 a	18.70
	(6.30)	(7.07)	(3.57)	(4.84)	(6.47)
Quality of products	8.1 b	8.8 ab	9.7 a	9.2 ab	8.8
	(2.35)	(2.27)	(2.70)	(2.21)	(2.49)
Employment and services	7.8 a	8.9 a	6.3 a	6.4 a	7.31
	(3.82)	(4.16)	(3.84)	(3.63)	(3.87)
Ethics and human development	20.8 ab	18.6 b	21.7 a	22.1 a	21.0
	(3.25)	(4.39)	(4.04)	(2.89)	(3.56)
Economic viability	10.8 b	5.4 b	15.5 a	10.5 b	11.4
	(9.17)	(7.22)	(9.73)	(9.64)	(9.53)
Independence	21.6 a	22.6 a	22.9 a	22.9 a	22.2
	(5.98)	(53.73)	(4.23)	(5.43)	(5.49)
Transferability	2.9 ab	1.1 ab	0.3 b	1.9 ab	1.9
	(5.45)	(3.62)	(1.44)	(4.66)	(4.63)
Efficiency	9.2 ab	4.4 b	12.9 a	9.8 ab	9.8
	(9.67)	(7.51)	(10.35)	(10.84)	(10.03)

Values with common letters are not significantly different.

Type 2: Small-size dairy farms

Of this farm type, 45.45% reached the lowest scoring grade on the three sustainability scales (class 3; low overall sustainability). The rest was distributed homogeneously across the other sustainability classes. The low animal and crop diversity, the absence of annual crops, the simplified rotation, the high stocking rate and the energy dependency strongly penalized the biodiversity component (14.3 ± 5.6 / 33 points) and the organization of space (8.7 ± 7.96 / 34 points) resulting in a low score on the agro-environmental scale (36.6 ± 11.79 / 100 points). Farmers' negative feelings about quality of life and isolation affected the socio-territorial scale (36.4 ± 11.79 / 100 points). Furthermore, low income per family worker, Higher economic specialization and low efficiency of production system due to high use of inputs yielded low economic scores (33.6 ± 16.34 / 100 points).

Type 3: Medium-size dairy farms with diversified crop production

Of this farm Type 51.6% are equitably divided between class 1 and class 4, while 38.70% belong to class 2 (class with medium sustainability limited by the agro-ecological scale). These farms recorded average scores for the agro-environmental scale (46.8 ± 8.62 / 100 points), due to good animal and plant diversity, but reached low scores for the organization of space (13.2 ± 4.5 / 34 points) due to high stocking rates and lack of pasture. If these farms tend towards zero pesticides, irrigation and the use of fertilizers as well as the absence of effluent treatment devices are negative aspects of farming practices (11.2 ± 3.57 / 33 points). They have a good ethical score (21.7 ± 4.04 / 33 points) since they positively value their quality of life and do not feel isolation. Yet, the low contribution to employment on these farms and the lack of multiple activities and / or collective work generated low scores on the socio-territorial scale (37.8 ± 6.53 / 100 points). However, they recorded the highest economic score (51.6 ± 19.20 / 100 points) due to high viability, which is mainly explained by high income per family worker, financial autonomy (government aid is less than 20% in these farms) and good economic efficiency because of the good proportion of inputs thus privileging their own resources, which guarantees their long-term sustainability.

Type 4: Large-size dairy farms with diversified crop production

Farms of this Type 4 to 41.66% belong to sustainability class 4, with 51.6 ± 10.38 / 100 points for agro-ecological sustainability due to the good score of the diversity component (23.2 ± 6.84 / 33 points) despite the absence of local breeds in these farms. Although grazing is poorly practiced on these farms, the complex rotations encountered, the presence of intercropping, the partition of plots of modest size and the relative forage autonomy illustrated by the low stocking rate favor the space organization component of these farms (13.21 ± 3.74 / 34 points). The score of the agricultural practices component (15.21 ± 4.89 / 33 points) is directly related to the respect of animal welfare and the restricted use of pesticides and fertilizers. However, the practice of irrigation and the lack of soil protection and effluent treatment devices are negative aspects. The score obtained by the ethics component (22.08 ± 2.89 / 33 points) is linked to the good quality of life of the farmers and the moderate work load. In addition, their relative financial autonomy and their independence from government aid explains their respectable economic performance (45.21 ± 20.59 / 100 points).

DISCUSSION

A mixed farming system: Agriculture-livestock farming

Dairy cattle husbandry in the Chelif valley is practiced in a mixed crop-livestock system in farms of very variable size (30.6 ± 44.64 ha), but generally larger the average national estimated farm size of 8.3 ha (General Census of Agriculture, 2001). Most of the agricultural area is allocated to cereals, mainly barley and wheat, which often rotate with market gardening or fallow. Although Cereals practiced as rainfed system in spite of the irrigation capacities, according to Hartani et al. (2007) Cereals contributes to food security for humans and provides an essential feed for livestock. Despite the livestock number is important and as reported by Suttie (2004), the share of fodder crops, mainly oats, used as green feed and as hay in the rotation, is constrained by the competition with food crops. This great disparity in the distribution of land and the low diversification of the fodder area was also observed by Ghozlane et al. (2006) on dairy cattle farms in the Tizi-Ouzou region where the fodder area was only cultivated with vetch-oats and to a lesser extent with alfalfa. Irrigation is usually reserved for perennial crops described as heritage to be passed on to future generations (Djebbara, 2004) and to market gardening described as a high-value crop (Si-Tayeb, 2015). Fodder is often cultivated rainfed, while pastures, which are still the oldest and most natural way of using grassland and annual forages (Huyghe & Delaby, 2013), are of small size despite very low implementation cost (Le Gall et al., 2001). The farmers overcome fodder shortage by a large amount of concentrate in the ration of animals without really taking into account their needs. This practice was also observed by Srairi (2009) for dairy cattle farms in Morocco. Finally, the amount of labour used depends on the size of the farm; it is mostly family-based in small farms and, according to Bourenane et al. (1991), is geared at minimized spending and to cushion the unemployment shock amongst family members of working age. Unemployment is more pronounced in rural areas where agriculture provides the bulk of employment for the population.

Diversity of farms defined by regional potential

The Dairy Basin in the Chelif valley hosts completely differentiated dairy farms, which, like farms in other regions of the country, produce according to the ecological and climatic conditions (Benniou & Aubry, 2009; Boukkedid, 2014). Indeed, the results of the typology showed four types of dairy cattle farms marked by a regional diversity: the High Chelif plain is dominated by cereal farms of average size (39.13% of the Type 1) and farms of small size with reduced livestock numbers (63.63% of Type 2). According to Belhadia (2016), this region is characterized by a cereal-fallow association. The same author also indicated that cereal crops annually occupy more than 45% of the Useable Agricultural Area (UAA). Medium-size cereal farms are also widespread in Middle Chelif (39.13% of Type 1), but more important are medium-size farms with diversified crop production (45.16% of Type 3). Crop diversification in this region was also reported by El Mahi (2005). The Low Chelif is characterized by large farms with medium livestock numbers and diversified crop production (45.83% of Type 4). As reported by Douaoui et al. (2008), it appears that agriculture in Low Chelif mainly comprises orchards of citrus and olive trees, irrigated vegetable crops (melon, watermelon, artichoke, onion) and rainfed cereal crops.

Contribution of the agriculture-livestock farming association to the sustainability of farms

Sustainability in the Chellif Valley is in favor of large farms that practice mixed cropping: although the overall sustainability scores are comparable between the different types encountered (with the exception of indoor farms of Type A2), the overall sustainability is better in large diversified farms, (Type A3 and A4). Livestock-Mixed farming is a virtuous production system, both environmentally and economically (Veysset 2014, Sneeseens 2014).

Ecological sustainability is the strong point of these farms as it reaches 49.6% of the theoretical maximum. However, this value remains lower than those obtained in other regions of the country, particularly in the semi-arid region of Setif, evaluated at 67% by Yakhlef et al. (2008) and in the Mitidja Plain valued at 71.5 and 73% respectively by Bekhouche (2004) and Benatellah (2007). In addition, the comparative analysis of ecological sustainability shows better results for Type 1 and Type 4 farms, but limits the sustainability of 31.88% of Type 3 farms because of the large size of plots which promotes erosion phenomena (Villain et al., 2000), and the excessive use of fertilizers.

The economic sustainability that reaches 45.38% of the theoretical maximum is lower than that recorded by Ghozlane et al. (2010) in a similar study in the region of Tizi Ouzou (Algeria), 54.7%. Although this sustainability is the strong point of Type 3 farms, it remains the weak point for 47.82% of Type 1 farms and 46.66% of Type 4 farms because of a low efficiency of the production system. This weakness of the economic scale is noted by M'hamedi et al. (2009) in a similar study conducted in Tunisia on 30 dairy farms. In this regard, they suggest that technical innovations to stabilize yields must be adapted to the low financial capacities of producers.

On the other hand, social sustainability is the weak point for all identified groups; it reaches only 37% of the theoretical maximum. This weakness of the social ladder is also observed by Benatalah et al. (2013) for the dairy cattle farms of the Mitidja and Bir plain (2015) for farms in the semi-arid region of Sétif (North-East of the country). The socio-territorial sustainability scale does not depend on production systems but depends more on the lifestyle of the farmer (M'hamedi et al., 2009).

At the regional level, it appears that the scores of the agri-environmental scales are better in the middle and low Cheliff respectively 51.7 ± 10.42 and 52.5 ± 8.88 on 100 points, while the economic and social performances are comparable between the three localities.

CONCLUSIONS

Taking into account the diversity of agricultural situations is a fundamental condition for the success of interventions in rural areas. Livestock is an essential component of the production systems in the Chelif valley, despite its limited income potential compared to cash crop cultivation. The crop-livestock association is essential for the sustainability of these farms. Indeed, very good results for overall sustainability were observed in more than 28% of the surveyed farms. Ecological sustainability is the strong point of Type 1 and Type 4 farms, reaching 49% of the theoretical maximum across the whole sample. Economic sustainability, which reached 45% of the theoretical

maximum, was best on Type 3 farms. Social sustainability, on the other hand, was the weak point for all farms, reaching only 37% of the theoretical maximum.

Aggregating component scores allows multiple combinations to achieve a better sustainability outcome. The simple active involvement with associations and the collective work are likely to improve the scores for 32% of type1 farms whose sustainability is limited by the social scale. The valorization of the products of these farms by short chain would encourage the putting in relation of proximity farmers and consumers on the one hand and would improve the sustainability for 48% of these farms which is limited by the economic scale (in the same way as 42% of Type 4 farms). The low economic scale is often due to a low efficiency of the production system.

In fact, a better valuation of the farm's own resources would contribute to improving their perenniality and thus ensuring their sustainability. Limiting the size of the plots and encouraging the establishment of mixed cropping would be a lever of action capable of improving the scores for 39% of Type 3 farms whose sustainability is limited by the agroecological scale. Similarly, the significant introduction of legumes into rotations allows better use of complementarities among cultivated species will also participate.The lowest scores of the three sustainability scales are recorded mainly in 45.45% of Type 2 farms, which are practically family farms (mainly indoor farms), they remain very dependent on the inputs market and their sustainbility is questioned.

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Annexes:

Scale A --- agro-ecological				
Components	18 indicators		Maximum scores	
Domestic diversity	A1	Diversity of annual crops	14	Total capped at 33
	A2	Diversity of perennial crops	14	
	A3	Animal diversity	14	
	A4	Enhancement of genetic resources	6	
Space organization	A5	Cropping pattern	8	Total capped at 33
	A6	Plot size	6	
	A7	Organic matter management	5	
	A8	Ecological Buffer area	12	
	A9	Contribution to environmental issues	4	
	A10	Enhancement of space	5	
	A11	Forage area management	3	
Farming practices	A12	Nitrogen balance	8	Total capped at 34
	A13	Effluents processing	3	
	A14	Pesticides	13	
	A15	Veterinairy treatments	3	
	A16	Soil resource protection	5	
	A17	Water resources management	4	
	A18	Energy dependence	10	
Scale B --- Socio-territorial				
Components		18 indicators	Maximum scores	
Quality of products and territory	B1	Quality approach	10	Total capped at 33
	B2	Enhancement of buildings and landscape heritage	8	
	B3	Processing of non-organic waste	5	
	B4	Accessibility of space	5	
	B5	Social involvement	6	
Employment and services	B6	Short trade	7	Total capped at 33
	B7	Autonomy	10	
	B8	Services, multiactivities	5	
	B9	Contribution to employment	6	
	B10	Collective work	5	
	B11	Probable sustainability	3	
Ethics and human developmen	B12	Contribution to world food balance	10	Total capped at 334
	B13	Animal welfare	3	
	B14	Training	6	
	B15	Labor intensity	7	
	B16	Quality of life	6	
	B17	Isolotaion	3	
	B18	Reception, hygiene, and safety	4	
Scale C --- Économic				
Components		6 indicators	Maximum scores	
Economic Viability	C1	Economic Viability	20	30
	C2	Economic specialization rate	10	
Independence	C3	Financial autonomy	15	25
	C4	Sensitivity to aids	10	
Transferability	C5	Capital transferability	20	20
Efficiency	C6	Efficiency of production process	25	25