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Assessment of farm-level sustainability indicators for Moroccan sheep farming systems using an adapted IDEA approach analysis

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Abstract

Intensification of livestock farming during the last decades has raised many issues including ecological impacts and food security. In the Middle Atlas of Morocco, extensive sheep production systems are facing changes and constraints that may influence their sustainability. In this paper we present an adapted approach from IDEA (Indicateurs de la Durabilité des Exploitations Agricoles) method to evaluate the sustainability of sheep farming systems in the Eastern Middle Atlas, Morocco. For this purpose, 75 farms were selected from three production system in the area i.e. Agro-silvo-pastoral, Pastoral and Olive-grave based oasis systems. The assessment of sustainability of farms showed that agro-silvo-pastoral and pastoral ones presented higher score for sustainability compared to the olive-grave based oasis ones ($P<0.05$). Regarding the three sustainability dimensions, i.e. agro-ecologic, socio-territorial and economic, the comparison showed that farming system affects the agro-ecologic and socio-territorial scales ($P<0.05$) but not the economic one ($P >0.05$). Analyze of sustainability scores demonstrated that the sustainability of agro-silvo-pastoral farms is limited by the economic characters, while the agro-ecological aspects seem to be the weakness points of the olive-grave based oasis farms. Pastoral farms presented balanced scores for the three scales of sustainability. Consequently, improving these aspects could, on one hand, improves the global sustainability of the three sheep farming systems and, on the other hand, guaranties the continuity of this sector in the Moroccan Middle Atlas area.

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Introduction

Over the coming 35 years, agriculture will face an unprecedented collective pressures, including an increase of 30% in the global population, intensification of competition for increasing scarce land, water, energy resources, and moreover the growing threat of climate changes (FAO, 2014). By 2050, the World's population is projected to reach 9.3 billion (United Nations, 2013); therefore the agriculture food production needs to grow up by 100% in developing countries, and, worldwide, by 60% (FAO, 2014). Foresight UK (2011) reported that the present agricultural production trajectory could seriously compromise the long term global capacity to produce food to feed the growing world population. Hence, sustainability of agricultural production becomes a major priority for policymakers and international development agencies.

Over the last two last decades, the concept of sustainability development was the subject of debates over the precise meaning of the term sustainability. Rigby and Caceres (2001) mentioned that at least 386 definitions of sustainability were found in the literature. Even with these differences, the term of "agricultural sustainability" tends to designate a balanced relationship among environmental, socio-cultural, and economical aspects (Bauer and Mickan, 1997). Accordingly, for any a system to be sustainable, it should be technically feasible, environmentally sound and economically viable (Nardone *et al.*, 2004).

Livestock production is actively involved in this sustainable development challenges. A sustainable livestock farming system should improve, or at least maintain and protect the natural resources from running out, devaluing or generating outputs that reduce farming activities (Nardone *et al.*, 2004). Thus, livestock farmers are asked not only to enhance production to cover the increased global feed demand, but also to improve the animal welfare, biodiversity and environmental goods.

Small ruminant production is a very significant component of livestock production throughout the world and more especially in the Mediterranean region. It plays a fundamental role, other than economic, in areas such as ecological, environmental and cultural elements of the society. Goat and sheep farming systems of the Mediterranean area have traditionally been associated with marginal lands and pastoral systems, and are fundamental components of the Mediterranean human food chain (Boyazoglu and Flamant, 1990; Sanchez-Rodriguez *et al.*, 1996). In Morocco, sheep farming represents the cornerstone of economy and was for centuries extensive in nature, with sheep being farmed on pasture either on the plains or on the high and hilly areas. However, changes are occurring in these production systems because of availability of many types of pressures (Boughalmi *et al.*, 2015).

Within this context, the continuity of small family farms is a key point when assessing the sustainability of extensive systems. However, farm sustainability remains difficult to measure and, some argue, that precise measurement is impossible as it is site specific and dynamic in nature (Hennessy *et al.*, 2013). To evaluate and measure sustainability, the international community, at the World Summit on Sustainable Development, held in Johannesburg in 2002, has encouraged further work on identifying indicators for sustainability. This leads to a simplification of the complexity, a qualitative and a quantitative description of the studied systems, in order to communicate operational information necessary for official decision-makers (Desbois, 2007). Many sustainability measurement methods based on indicators were implemented, the most sound of which are: IDEA, abbreviation of the French appellation "Indicateurs de Durabilité des Exploitations Agricoles" Farm Sustainability Indicators; IDERICA; Indigo, abbreviation of the French reference "Indicateurs de Diagnostic Global à la parcelle"; the Dialect method; the Arbre method; etc. (Peschard *et al.*, 2004).

In this context, the present paper aims at assessing the sustainability of the current sheep production systems in the Moroccan Middle Atlas area as an example for using adapted approach from the French IDEA method (Vilain, 2003). This method, designed as a self-assessment framework for farmers, provides operational content for the assessment of agricultural sustainability.

Materials and methods

Farms survey

The present study involved 75 farms who were selected at random from three sheep production systems in the Eastern Middle Atlas of Morocco, which were the subject of some modifications over the few last years (Boughalmi *et al.* 2015). They consisted of 47 farms from the agro-silvo-pastoral system, 19 farms from the pastoral system and 9 farms from the olive-grave based production system. A survey questionnaire was developed to collect information regarding sustainability indicators. The survey guides included 122 questions inspired by the IDEA grid, and covered the following topics:

1. General information about the farm (location, labor force, flock size, animals' species and breed, land utilization), grazing management (kind and land of grazing) and the kind of production.
2. Livestock management (feeding strategies, production and reproduction performance and animal welfare).
3. Biodiversity aspects of the farm (plant and animal biodiversity).
4. Land management and agricultural practices (crop rotation, parcels distribution organic matter management and energetic independency).
5. Farmer's relationship with his entourage (technical assistance for livestock rearing, training days, landscape) and quality of life.
6. Economical aspects (feed purchase, veterinary and transport costs, sale of products, income, turnover rate)
7. Finally, open questions dealing with the problems that face small ruminants and concept of sustainable development in the Middle Atlas area, plus collecting opinions of the farmers on solutions.

Farm sustainability indicators method (IDEA)

The analysis of the sustainability on the three sheep production systems was adapted from the IDEA method, abbreviation of the French appellation "Indicateurs de Durabilité des Exploitations Agricoles" Farm Sustainability Indicators (Vilain, 2003).This method has the advantage of being adaptable to a time-limited investigation and it is designed as a self assessment tool to evaluate sustainability at farm level (Marchand *et al.,* 2014). It seeks to give practical content to the concept of sustainability by establishing an overall performance of the farm from scoring of indicators. This allows observation of differences in sustainability between production systems (Zahm *et al.*, 2008). Based on 41 sustainability indicators, covering the three scales of sustainability, the IDEA method allows quantification of various characteristics of agricultural systems by assigning a numerical score and aggregating the obtained information to get an overall performance (Yakhelf *et al.*, 2008). The aggregation was done using multidimensional IDEA grid that provides specific assessment grid for each scale (Vilain, 2003). Agro-ecological and socio-territorial sustainability scales are structured around 19 and 16 indicators respectively. They consist of three components of same weight, i.e. 33 or 34 points out of the total score 100 points (Table 1). The economic sustainability scale is structured by 6 indicators. It consists of four components with weights ranging between 20 and 35 points out of the total score of 100 points. The number of points assigned to each indicator ranges between 0 and a maximum value which is unique to each indicator. The addition of scores within each scale provides 3 totals assessment of sustainability for each scale (Vilain, 2003; Yakhelf *et al.*, 2008; Zahm *et al.*, 2008).

Setting up sustainability assessment grid for the Moroccan context

The IDEA approach was adapted to the local context and sustainability issues of the Moroccan sheep farming context. Changes were inspired from the Lebanon experience where Srour (2006) has made some changes in the same grid in order to adapt it to small ruminant farms. These changes concerned the choice of variables that constitute indicators, the indicators themselves, and their attributed scores. Two major types of changes were made to establish the sustainability assessment grid for the Moroccan sheep farming. The first one, concerned introduction or rejection of variables, and the second one involved the scoring set for each indicator without exceeding the total score of each component of sustainability. These differences between the original IDEA grid, as presented by Vilian (2003) and the present assessment grid are summarized in Tables 1, 2 and 3.

Table 1. Comparison between the original and the Moroccan adapted IDEA grid to assess the Agro-ecological sustainability scale.

Sustainability scales	Components	Indicators (Vilain 2003)	Maximum Notes of indicators	Bounds of components	Indicators (Boughalmi & Araba 2015)	Maximum Notes of indicators	Bounds of components
Agro-ecology	Diversity	A1. Diversity of annual or temporary crops	0 to 13	33 units	A1.Diversity of annual crops and pastoral species	0 to 11	40 units
		A2. Diversity of perennial crops	0 to 13		A2. Diversity of perennial crops and pastoral species	0 to 15	
		A3. Diversity of associated vegetation	0 to 5				
		A4. Animal diversity	0 to 13		A4.Animal diversity	0 to 5	
		A5. Enhancement and conservation of genetic heritage	0 to 6		A5. Enhancement and conservation of animal genetic heritage	0 to 9	
	Organization of space	A6. Cropping patterns	0 to 10	33 units	A6. Crop rotation	0 to 2	15 units
		A7. Dimension of fields	0 to 6		A7. Size of Plots	0 to 3	
		A8. Organic matter management	0 to 6		A8. Organic matter management	0 to 1	
		A9. Ecological buffer zones	0 to 12		A9. Ecological regulation on pasture by the presence of water point	0 to 1	
		A10. Measures to protect the natural heritage	0 to 4		A10. Action for the preservation of natural patrimony	0 to 4	
		A11. Stocking rate	0 to 5		A11. Loading (Animal loading intensity on pastures)	0 to 2	
		A12. Fodder area management	0 to 3		A12. Management of Fodder surfaces	0 to 2	
	Farming practices	A13. Fertilization	0 to10	34 units			
		A14. Effluent processing	0 to10				

Sustainability scales	Components	Indicators (Vilain 2003)	Maximum Notes of indicators	Bounds of components	Indicators (Boughalmi & Araba 2015)	Maximum Notes of indicators	Bounds of components
		A15. Pesticides and veterinary products	0 to10				
		A16. Animal well-being	0 to3		A16. Animal Welfare	0 to 30	
		A17. Soil resource protection	0 to5		A17. Protection of pasture-soil resources	0 to 7	
		A18. Water resource protection	0 to4		A18. Management of irrigation water resources	0 to 2	45 units
		A19. Energy dependence	0 to8				
		Grand total	100	100	Grand total	100	100

Table 2. Comparison between the original and the Moroccan adapted IDEA grid to assess the Socio-territorial sustainability scale.

Sustainability scales	components	Indicators (Vilain 2003)	Maximum Notes of indicators	Bounds of components	Indicators (Boughalmi & Araba 2015)	Maximum Notes of indicators	Bounds of components
Socio-Territorial	Quality of product and lands	B1. Quality of foodstuffs produced	0 to 12	33 units	B1. Quality approach	0 to 20	28 units
		B2. Enhancement of buildings and landscape heritage	0 to 7		B2 .Valorization of built heritage and landscape	0 to 3	
		B3. Processing of non-organic waste	0 to 6		B3. Management of non-organic waste	0 to 2	
		B4. Accessibility of space	0 to 4		B4. Accessibility of space (maintenance, roads, tracks...)	0 to 3	
	Employment and services	B5. Social involvement	0 to 9	33 units			33 units
		B6. Short trade	0 to 5		B6. Valorization of product by short supply chain	0 to 3	
		B7. Services, multi-activities	0 to 5		B7. Services and activities made for the territory	0 to 3	
		B8. Contribution to employment	0 to 11		B8. Livestock contribution to employment	0 to 10	
		B9. Collective work	0 to 9		B9. Collective work	0 to 7	
		B10. Probable farm	0 to 3		B10. Probable farm sustainability	0 to 10	

Sustainability scales	components	Indicators (Vilain 2003)	Maximum Notes of indicators	Bounds of components	Indicators (Boughalmi & Araba 2015)	Maximum Notes of indicators	Bounds of components
		sustainability					
	Ethics and human development	B11. Contribution to world food balance	0 to 10	34 units	B11. Product contribution to the global food balance	0 to 5	39 units
		B12. Training	0 to 7		B12. Training programs	0 to 6	
		B13. Labour intensity	0 to 7		B13. Labor intensity	0 to 6	
		B14. Quality of life	0 to 6		B14. Quality of life	0 to 6	
		B15. Isolation	0 to 3		B15. Isolation	0 to 5	
		B16. Reception, hygiene and safety	0 to 6		B16. Hygiene and safety of the workforce	0 to 5	
					B5. Social Involvement	0 to 6	
		Grand total	100	100	Grand total	100	100

Table 3. Comparison between the original and the Moroccan adapted IDEA grid to assess the Economic sustainability scale.

Sustainability scales	components	Indicators (Vilain 2003)	Maximum Notes of indicators	Bounds of components	Indicators (Boughalmi & Araba 2015)	Maximum Notes of indicators	Bounds of components
Economic	Economic viability	C1. Available income per worker compared with the national legal minimum wage	0 to 20	30 units	C1. Economic viability	0 to 15	35 units
		C2. Economic specialization rate	0 to 10		C2. Economic specialization	0 to 20	
	Independence	C3. Financial autonomy	0 to 15	25 units	C3. Financial autonomy	0 to 15	25 units
		C4. Reliance on direct subsidies and indirect economic	0 to 10		C4. Reliance on direct subsidies and indirect economic	0 to 10	
	Transferability	C5. Total assets minus lands value by non-salaried worker unit	0 to 20	20 units	C5.Economical transferability	0 to 20	20 units
	Efficiency	C6. Operating expenses as a proportion of total production value	0 to 25	25 units	C6. Efficiency of the production process	0 to 20	20 units
		Grand total	100	100	Grand total	100	100

It shows that the agro-ecological sustainability scale assembles indicators from A1 to A19 explaining the main issues that livestock farming may cause to the environment. It favors livestock farming techniques that ensure a healthy environment to the future generations. Indicator A3 was combined with A2, while A13, A14, A15 and A19 were not included in the calculation due to lack of information. The socio-territorial sustainable scale includes indicators from B1 to B16 that aim to evaluate if the production system preserves the quality of life and working conditions for producer, and respond to consumer demands. In this scale, B5 indicator was removed from the "Quality of the products and land" component to the "Ethics and human development" component. At the economic scale level, no modifications have been done.

Statistical Analysis

Collected data were used to build a database on Excel file, which allowed the construction of sustainability calculation file. Comparison of farm sustainability results according to production system was performed with analysis of variance. It was performed by the GLM procedure (SAS, 1997). The effect of the production system as a fixed effect on all sustainability scales and components was analyzed according to the following model: $Yij = m + PSi + Eij$, where Yij is the variable analysed, m is the overall mean, PSi is the effect of production system (i = 1, 2, 3), and the error term was Eij. Farms were considered as experimental units. The Student-Newman Keul's procedure was used to separate least squares means when significant main effects were detected.

Results and discussion

Overall sustainability

The overall sustainability obtained scores revealed variability between farms. Least square means sustainability scores calculated for farms belonging to agro-sivlo-pastoral, pastoral and olive-grave based production systems are presented in Table 4. Scores indicating that extensive farms are globally more sustainable than those located in the olive- grave based oasis ($P< 0.05$). In these latter, overall sustainability is limited by the agro-ecological scale, whereas in the agro-silvo-pastoral farms the overall sustainability is mainly limited by the economic one. In the pastoral farms, the three scales of sustainability seem to be balanced. Nevertheless, all the surveyed farms presented insufficient agro-ecological, Socio-territorial and Economic sustainability scores (far from the 100 points set as a maximum).

Table 4. Effect of Agro-silvo-pastoral, Pastoral and Olive-grave based oasis sheep farming system on the global score of the three scales of sustainability in the Middle Atlas area.

Sustainability scale	Agro-silvo-pastoral system	Pastoral system	Olive-grave based oasis system	SEM	P
Agro-ecologic	56.57^a	47.84^b	21.66^c	1.09	0.0001
Socio-territorial	52.34^a	43.68^b	46.11^c	1.47	0.0001
Economic	38.61	45.00	49.44	5.98	0.13
Global sustainability	49.17^a	45.57^a	39.11^b	2.28	0.0002

SEM =standard error means.

P = probability.

^{a,b,c} Values within a row with different superscripts differ significantly at $P≤0.05$.

On the other hand, the effect of farming system on the scores of different scales of sustainability is also presented in Table 4. Results show that farming system did not affect the economic scale ($P > 0.05$) but affected significantly the agro-ecologic and socio-territorial ones ($P< 0.05$).

Furthermore, an overall analyze of correlations' coefficients between sustainability farm scales indicates a statistically significant non-correlation between agro-ecological and economic sustainability in the case of studied farms (P>0.05). This result is not consistent with that stated by Zahm *et al.* (2008). According to these authors, there is often a form of inverse relation between agro-ecological sustainability and economic sustainability. On the other hand, a positive correlation (r=0.38; P=0.001) was detected between agro-ecological and socio-territorial scales. However, the study of this relationship for each production system, shows that there was not a signification correlation between the three scales (P>0.05).

These results indicate the possibility of improvement, at the same time, of farms' agro-ecological and economic sustainability, and the possibility to move simultaneously toward more sustainable production systems.

Agro-ecological sustainability scale

The agro-ecological scale consists of three components, i.e. diversity, organization of space and farming practices. This scale analyses the propensity of the technical system to make efficient use of the environment at the lowest possible ecological cost (Zahm *et al.*, 2006). Results presented in Table 5 show differences among the three sheep farming systems in the agro-ecological components' scores.

In relation to the diversity component, registered weaknesses in the olive-grave based farms are mainly related to the low values of vegetal and animal diversity indicators. The limited experience of these farmers in agriculture activity, the low number of animal species in their flocks, and the mixed genetic composition of their sheep flocks, resulting from an unorganized cross-breed program, may explain this weakness (Boughalmi *et al.* 2015). In the opposed case, the highest scores of "diversity" component registered in the agro-silvo-pastoral and pastoral farms (Fig. 4) are attributed to the consideration of some pastoral species in addition to the cultivated crops species to evaluate the vegetal diversity, the important number of animal species in the farm (at least four) and the rearing of local breeds (Timahdite and Beni Guil) in their cradle area.

About the organization of space component, the following observations can be done:

- First, crop rotation is almost absent in the three production systems. Rain-fed cereals and vegetables are the dominating crops in the pastoral and agro-silvo-pastoral systems respectively; while in olive-grave based oasis farms, olive trees dominating the cultivated surfaces;

- Second, the territorial organisation of the cultivated areas is characterized by heterogeneity in size and spatial arrangement of fields. The size and location of plots indicator was negatively considered. Le Roux *et al.* (2008) explained that distribution of fields often leads to excessive movements (labour forces and equipment) and can become a major problem for agricultural activities (dates, or the doses of a treatment, etc...).

- Third, the organic matter management indicator is highly considered by the great majority of farmers. In all studied farms, manure produced on site is locally used to fertilize agricultural surfaces and is not sold outside the production area.

- Fourth, strong weaknesses are registered in the olive-grave based farms in relation to the use and the organization of the pastoral space (Fig. 4), since in the olive-grave based farms lambs are produced under an intensive production system. At the same time, a poor organization of the pastoral space was observed in both agro-silvo-pastoral and pastoral production systems. The lack of water points on pastures, the absence of chart that engages farmers to respect and protect the natural patrimony, the high intensity of animal loading on pastures and the strong dependence to the purchased livestock concentrate feed could explain this organization.

The component farming practices have also registered weaknesses in the case of olive-grave based farms which concern mainly: animal welfare aspects, pasture's soil protection practice and the management of irrigation water resources. These issues must be better considered by the concerned farmers. Thus, integration of grazing activity in the existing sheep farming system of the olive-grave based farms may enhance the animal welfare condition and the replacement of the traditional system of irrigation by a drip one could preserve water resources.

In the case of extensive farms, agro-silvo-pastoral farms presented higher scores for the considered component than the pastoral ones ($P<0.05$). Differences are related to the availability of feed over pasture and the health status of the flock since pastoral flocks do not benefice from particular health supervision, and farmers do not respect the vaccination calendar.

Socio-territorial scale

The socio-territorial scale consists of three components i.e. quality of the products and the land, employment and services, and ethics and human development. It characterizes the farms' integration within its landscape and society (zahm *et al.*, 2008).

In relation to the component "quality of the products and land", weaknesses are registered particularly in the valorization of product quality and in the processing of non-organic wastes. Indeed, the low scores of processing of non-organic wastes indicator are due to lack of treatment or recycling of plastic (bags, bottle …) and veterinary products (vials, syringes …) which are disposed directly in nature. For the valorization of product quality, low scores are related, on one hand, to the absence of system of lamb meat qualification, and on the other, to the absence of traceability, especially for lambs raised in pastoral and olive-grave based oasis farms, because of long commercial chain. However, relating meat quality to its production system has improved the extensive farms' scores compared to the olive-grave based oasis ones (Fig. 4) since lamb meat from extensive system presented better organic quality than that from sheepfolds (Priolo *et al.* 2001).

Another aspect taken into account in analyzing this component is the architectural quality of buildings and the landscape quality of surroundings. Indicators concerning the use of industrial buildings on pastures and the facility of accessibility to the pastoral space evaluate these aspects. Scores decreased and tended to zero when these indicators are not in favor of the natural space. In agro-silvo-pastoral system, some farmers tended to change the architecture of builds on pasture from traditional one, which is based on traditional materials (rocks or argil), to that built with industrial materials. This tendency is the origin of transformations of rural areas to unmarked area (Vilain, 2008). However, in the pastoral system the use of the traditional tents on pastures had increased their scores. On the other hand, for both extensive systems, the access to or from pastures to village depends of the topography of the area. Traditional roads exist in some areas, and in some else clear road leading to some farmers on pastures do not exist. Only local community knows the direction using natural indicators. In the olive-grave based oasis case, the recent emergence of this system explains the modern architecture and the acceptable infrastructure which surely facilitates farmers' movement, but unfortunately decreased their scores in relation the architectural quality of buildings and the landscape quality of surroundings' indicators.

The employment and services component has registered also many weaknesses in all surveyed farms (Fig. 4). These weaknesses are mainly related to:

i) Short trade indicator, because of domination of intermediaries in the lamb meat supply chain in the area; so, instead of establishing a sale-contract, farmers might try to be organized into a cooperative or farmers group to commercialize their products directly and to control the production chain;

ii) The indicator of services and multi-activities, which refers mainly to the agro-tourism and the involvement into scientific research; this indicator has registered nil scores,

iii) The collective work indicator, because nowadays individualism, unfortunately, characterizes the sheep farmers' society in the Middle Atlas. So, an improvement concerning these aspects is required, and finally,

iv) The short-term sustainability of farms which auto-estimates its existence for the next ten years.

Concerning "ethics and human development" component, indicators evaluate farmers and shepherds' life quality, farmers' social involvement and their responsibility to the global food balance. This last aspect refers to the notion of citizenship and global solidarity. In its complexity, it considers the excessive use of imported products, such as maize fodder, strengthens the dependence of production to the world market products (Briquel *et al.*, 2011). This mainly relates to olive-grave based oasis farms, since sheep farming is mainly based on concentrate feed and fodders, and in lower case of extensive farms, since concentrate feed are used as supplement on pastures. For the social involvement indicators, low scores are a consequence of the limited involvement of farmers in social activities such as training courses, participation in social events, and accessibility to information.

On the other hand, the auto-estimation of the quality of life of farmers showed that most of them in the three production systems, work intensively from 2 to 4 months by year, have a mediocre quality of life, and are geographically and socially isolated, particularly the pastoral farmers. Concerning shepherds, the auto-estimation of life's quality showed that livestock workers in the pastoral farms have inappropriate work condition, compared to agro-silvo-pastoral and olive-grave based oasis farms where workers have acceptable conditions.

Economic sustainability scale

The economic sustainability scale consists of four components i.e. viability, dependence, transferability, and efficiency. This scale analyses based not only on economic profitability but also on the relation of farmers with their economic environment and the sustainability of their activity (Zahm *et al.*, 2006).

Despite the structural differences between the studied farms, economic scores' means comparing farms of the three studied production systems show no significant differences between the three groups (Table 5). In relation to the first component, indicators evaluate the economic viability and the economic specialization rate. The first indicator is measured by calculation of the importance of livestock contribution in farmers' income compared to the Moroccan GMIW (The guaranteed minimum inter-occupational wage). Results show that in the two extensive systems, farmers presented incomes levels lower than the GMIW, while olive-grave based oasis farmers presented high economic viability (Table 5, Fig. 1).

Table 5. Influence of Agro-silvo-pastoral, Pastoral and Olive-grave based oasis production system on the components of the Agro-ecological, Socio-territorial and Economic sustainability scales.

Scales of sustainability	Components	Agro-silvo-pastoral system	Pastoral system	Olive-grave based oasis system	SEM	P
Agro-ecological	Diversity	18.5^a	17.0^b	7.5^c	0.69	0.0001
	Organization of space	7.6^a	8.0^a	5.1	0.59	0.0001
	Farming practices	30.5^a	22.8^b	9.0^c	0.82	0.0001

Socio-territorial	Quality of the product and land	25.9[a]	24.1[b]	16.1[c]	0.66	0.0001
	Employment and Services	13.3	14.1	16.0	0.87	0.08
	Ethics and Human development	13.2[a]	5.4[b]	14.0[a]	0.84	0.0001
Economic	Economic viability	4.8[a]	5.2[a]	12.2[b]	2.3	0.01
	Independence	13.3	13.7	17.7	1.9	0.67
	Transferability	14.7[a]	18.9[b]	7.2[c]	0.8	0.0001
	Efficiency	11.9	7.1	12.2	3.05	0.14

SEM =standard error means

P = probability

[a,b,c] Values within a row with different superscripts differ significantly at P≤0.05.

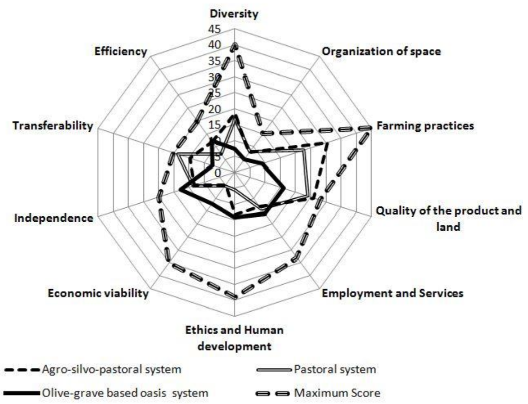

Fig. 1. Score distribution of agro- ecological, socio-territorial and economic sustainability scales' components for the agro-silvo-pastoral, pastoral and olive-grave based oasis sheep farming systems in the Middle Atlas area.

The second indicator is based on the assumption that diversification in economic activity is economically more sustainable than specialization. Indeed, for a farm, the more diverse it is, the less sensitive it becomes in facing economic constraints. So, higher scores are assigned to farms who present more diversification. Results show low scores in relation to this indicator in the case of the majority of extensive farms where sheep breeding contributes 75 to 100 % to the farmers' income. Nevertheless, inverse relations were registered in the case of olive-grave based oasis farms due to the limited contribution of the livestock in the farmers' income (<50%). Subsequently, it may be improved only with associated agricultural activities that are not demanding in water such as associated rainfed perennial crops with rainfed cereals.

The "independence" component provides information on financial autonomy and sensitivity to subsidies and allowances. For these two indicators, no differences were observed between the surveyed farms (Fig. 1, Table 5). Indeed, for sheep farming subsidies are often related to the government's aids in livestock concentrate feed, i.e. barely, during drought periods.

The economic transferability component concerns the continuity of agricultural farms and its dependency on its associates. Consequently, the capital must be distributed for more than one associate to ensure farm continuity. This indicator corresponds to the ratio between the financial capital and the number of associated men. Scores corresponding to this indicator are higher in extensive farms than in olive-grave based oasis farms (Fig. 4). This is due to the fact that the financial capitals in extensive farms are more important than in oasis farms.

Finally, the efficiency component measures the efficiency of input use. Results show similar scores are almost registered in all farms of the three systems. This reflects the independence of the studied farms and the good management of their own resources.

Conclusion

Finding from this study emphasizes the importance and need for evaluating livestock farms sustainability in the rural area, especially the sheep ones. It highlights the existent of socio-territorial and agro-ecological issues in the studied farms. Results derived from the measurement of the three scales of sustainability show differences between the agro-silvo-pastoral, pastoral and olive-grave based oasis systems. These differences reflect variability in farmer's practices and behaviors. They could be all improved by better integration in the society as well as recommended strategic programs.

Based on the outlined results, decision makers may design their strategies taking into consideration registered weaknesses. Thus, oriented and corrected measurement may be designed through incentive policies. They have to be adapted in accordance with farms' specificities.

Despite the fruitful results of the adapted IDEA approach to assess sustainability at sheep farm level, it seems necessary, as perspective, to improve the future grid used to assess the sustainability at farm level. This improvement is realized first, by involving farmers to validate the grid aiming to reflect better the real field situation; secondly, some indicators should be actualized, notably socio-territorial ones, due to the continuous evolution of farmers' society. Finally, there is a need for development of more simple pertinent indicators that allow the evaluation of sustainability of livestock sector in the Moroccan and maybe the Mediterranean conditions.

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