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Assessment of extensive and oasis sheep farming systems sustainability in Morocco

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Abstract. Nowadays a strong social worldwide demand for sustainable livestock systems is observed. These systems must be environmentally friendly, economically viable for farmers, and socially acceptable. This paper presents an adapted approach from IDEA (*Indicateurs de la Durabilité des Exploitations Agricoles*) method to evaluate the sustainability of 75 sheep farms selected from three production systems in the Eastern Middle Atlas of Morocco, i.e. agro-silvo-pastoral, pastoral and oasis systems. Assessment of sustainability of these production systems showed higher scores for the agro-silvo-pastoral and pastoral farms compared to the oasis ones ($P<0.001$). Regarding the three sustainability pillars, i.e. agro-ecologic, socio-territorial and economic, the comparison showed that farming systems differ in the agro-ecologic and socio-territorial ones ($P<0.001$) but not in the economic pillar ($P>0.05$). The analysis of sustainability scores demonstrated that the sustainability of both agro-silvo-pastoral and pastoral farms is limited by the socio-territorial aspects, while the agro-ecological aspects seem to be the weak points of the oasis farms. Consequently, improving these aspects could on one hand, improve the global sustainability of the three sheep farming systems and on the other hand, guarantee the continuity of this sector in the Moroccan Eastern Middle Atlas area.

Keywords. Sustainability – Sheep farming systems – IDEA method – Middle Atlas – Morocco.

Evaluation de la durabilité des systèmes de production ovine au Maroc

Résumé. On assiste actuellement à une forte demande sociétale pour des systèmes d'élevage durables. Ces systèmes doivent être respectueux de l'environnement, économiquement viables pour les éleveurs, et socialement acceptables. Cet article présente une approche adaptée de la méthode IDEA (*Indicateurs de la Durabilité des Exploitations Agricoles*) pour évaluer la durabilité de 75 exploitations ovines sélectionnées de trois systèmes de production ovine dans le Moyen Atlas Oriental du Maroc, à savoir le système agro-sylvo-pastoral, pastoral et oasien. L'évaluation de la durabilité de ces systèmes de production a montré que les exploitations agro-sylvo-pastorales et pastorales ont présenté des scores élevés en comparaison avec ceux des exploitations oasiennes ($P<0,001$). Concernant les trois piliers de durabilité, à savoir agro-écologique, socio-territorial et économique, la comparaison a montré que les systèmes de production diffèrent pour les piliers agro-écologique et socio-territorial ($P<0,001$), mais pas pour le pilier économique ($P>0,05$). L'analyse des scores de la durabilité a montré que la durabilité des exploitations agro-sylvo-pastorales et pastorales est limitée par les aspects socio-territoriaux, alors que les ceux d'ordre agro-écologique semblent être les points faibles des exploitations oasiennes. Par conséquent, l'amélioration de ces aspects pourrait d'une part, améliorer la durabilité globale des trois systèmes de production ovine et d'autre part, garantir la continuité de ce secteur dans la région du Moyen Atlas Oriental du Maroc.

Mots-clés. Durabilité – Systèmes de production ovine – Méthode IDEA – Moyen Atlas – Maroc.

I – Introduction

Agricultural productivity and food security are facing many challenges such as human population growth, climate change, energy and water scarcity, and reemerging diseases. For example, by 2050, the world's population is projected to reach 9.3 billion (United Nations, 2013), therefore, agriculture food production needs to grow up at least by 60% to face this increase (FAO, 2014). Hence, the Rio+20 Conferences goals insisted on enhancing food security and nutrition, while encouraging

sustainable agriculture (FAO, 2014). Therefore, the sustainability of agricultural production, which may be designed as a balanced relationship among environmental, socio-cultural and economical aspects (Bauer and Mickan, 1997), is becoming a major priority for policy makers and international development institutions. Livestock production, specifically ruminant, is actively involved in these challenges. Nowadays, animal farming systems confront two grand challenges: on one hand, increasing production to cover the increased global feed demand; on the other hand, they should improve, or at least maintain, the natural resources without running out of, devaluing or generating outputs that reduce farming activities (Nardone *et al.*, 2004). However, farm sustainability remains difficult to measure (Hennessy *et al.*, 2013). Thus, the need to assess and evaluate this concept has led to develop assessment tools ranging between indicators approach (Zahm *et al.*, 2008; Thiollet-Scholtus and Bockstaller, 2015) and developed models (Paracchini *et al.*, 2015). In this context, the present paper aims to assess the sustainability of sheep production systems in Moroccan Middle Atlas using adapted approach from the French IDEA method “*Indicateurs de Durabilité d'une Exploitation Agricole*” (Vilain, 2003).

II – Material and methods

The study involved 75 farmers selected randomly from three sheep production systems in the Eastern Middle Atlas of Morocco, i.e. 47 farmers from the agro-silvo-pastoral system, 19 farmers from the pastoral system and 9 farmers from the oasis system. A survey questionnaire, including 122 question inspired from the IDEA grid, was developed to collect the needed information to assess the sustainability indicators. It covered the following topics: general information about the farm, livestock management, biodiversity aspects, land management and agricultural practices, farmer's relationship with his entourage and quality of life, economical aspects and finally, open questions dealing with the problems that face small ruminants and concept of sustainable development in the Middle Atlas area.

To adapt the IDEA approach to the local agricultural context and specifically to livestock farming instead of agriculture, changes were made in the original IDEA grid as presented by Vilain (2003). These changes concerned the choice of variables that constitute indicators, the indicators themselves and their attributed scores. Thus, in the adapted grid, the agro-ecological sustainability pillar assembles 19 indicators evaluating the relationship of livestock farming with the environment. Some indicators were combined, while others were not included in the calculation due to lack of information. The socio-territorial sustainable pillar includes 16 indicators that aim to evaluate the influence of the production system on the farmers' life quality and its response to the consumers' demands. In this pillar, B5 indicator was removed from the “Quality of the products and land” component to the “Ethics and human development” component. At the economic pillar level, no modifications have been done.

Comparison of farm sustainability results according to production system was performed by the GLM procedure (SAS, 1997). The effect of the production system as a fixed effect on all sustainability pillars and components was analyzed according to the following model: $Y_{ij} = m + PS_i + E_{ij}$, where Y_{ij} is the variable analyzed; m is the overall mean, PS_i is the effect of production system ($i = 1, 2, 3$). The error term was E_{ij} . 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.

III – Results and discussion

Globally, the three farming systems presented low sustainability scores for the agro-ecological, socio-territorial and economical pillars. Table 1 shows differences in sustainability pillars scores and their components between production systems. Comparison regarding these three pillars shows that farming system did not affect the economic pillar ($P = 0.34$) but affected significantly the agro-ecologic and socio-territorial ones ($P = 0.0001$).

Table 1. Assessment of the Agro-ecological, Socio-territorial and Economic sustainability pillars and their components for the agro-silvo-pastoral, Pastoral and Oasis production systems

Pillars of sustainability	Pillars' components	Maximum score (units)	Agro-silvo-pastoral system	Pastoral system	Oasis system	SEM	P
Agro-ecological	Diversity	40	18.48 ^a	17.00 ^b	7.55 ^c	0.59	***
	Organization of space	15	7.7 ^a	8.36 ^a	3.22 ^b	0.34	***
	Farming practices	45	26.65 ^a	22.10 ^b	11.00 ^c	0.64	***
	<i>Total score of the agro-ecological pillar</i>	<i>100</i>	<i>52.85^a</i>	<i>47.47^b</i>	<i>19.88^c</i>	<i>0.77</i>	<i>***</i>
Socio-territorial	Quality of the product and land	28	12.48 ^a	12.57 ^a	9.55 ^b	0.37	***
	Employment and Services	33	13.27	14.10	16.00	0.81	NS
	Ethics and Human development	39	12.34 ^a	5.57 ^b	13.44 ^a	0.63	***
	<i>Total score of the socio-territorial pillar</i>	<i>100</i>	<i>38.10^a</i>	<i>32.26^b</i>	<i>39.00^a</i>	<i>1.16</i>	<i>***</i>
Economic	Economic viability	35	10.00	11.11	15.00	2.16	NS
	Independence	25	18.15	18.33	23.33	1.96	NS
	Transferability	20	15.00 ^a	18.88 ^b	7.50 ^c	0.96	***
	Efficiency	20	14.47 ^a	16.66 ^a	10.00 ^b	1.63	*
	<i>Total score of the economic pillar</i>	<i>100</i>	<i>57.63</i>	<i>65.00</i>	<i>55.83</i>	<i>4.45</i>	<i>NS</i>
Overall sustainability scores		100	49.78 ^a	48.29 ^a	38.94 ^b	1.55	***

*P ≤ 0.05; **P ≤ 0.01; ***P ≤ 0.001.

Farms belonging to the two extensive farming systems i.e. agro-silvo-pastoral and pastoral presented better overall sustainability score than the oasis farms (P<0.001). This can be related in part to their highest agro-ecological sustainability performance (P<0.05). Results presented in the spider diagram (Fig. 1) and in Table 1 showed that the oasis farms had the lowest scores along all components of the agro-ecological pillar compared with the two extensive farming systems. In these farms the "Diversity" component score is reinforced by the important animal diversity, reflected in the rearing of more than two species in the same flock, as well as the rearing of local breeds in their cradle area (Timahdite and Beni Guil); and by a good vegetation diversity including some pastoral species in addition to the cultivated crop species. Contrary, at oasis farms the presence of olives' trees associated mostly with two cultivated species at maximum and the raise of one to two animal species, explain the decline of agro and animal biodiversity. In these farms, the presence of sheep population from an unorganized crossing breed program shows the weak valorisation of the animal genetic patrimony. On the other hand, the valorization of pastoral space, which increased the animal welfare scores, the presence of rain-fed crops and the use of drip irrigation system increased the "Farming practices" component score of the agro-silvo-pastoral and pastoral farms compared to the oasis ones. Furthermore, the consideration of the organization of rangelands space, and of cultivated space, may explain the differences between the extensive and the oasis farms concerning the "Organization of space" component.

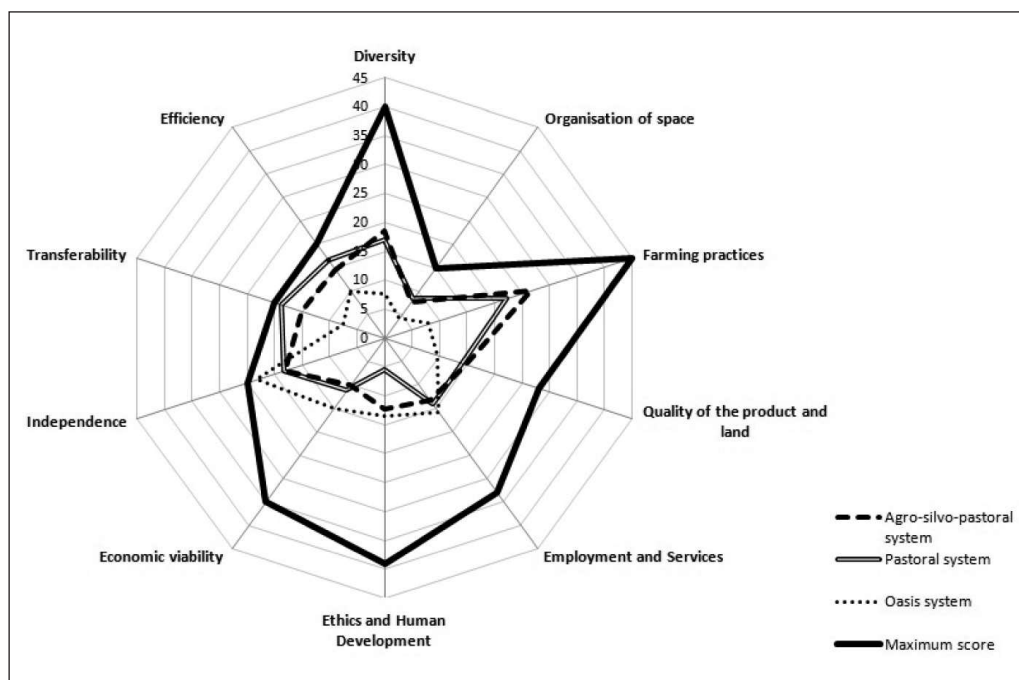


Fig. 1. Score distribution of agro- ecological, socio-territorial and economic sustainability pillars' components for the agro-silvo-pastoral, pastoral and oasis sheep farming systems in the Oriental Middle Atlas area.

Regarding the socio-territorial pillar, no difference was found between the agro-silvo-pastoral and the oasis systems ($P > 0.05$). Both of them perform better than the pastoral one ($P < 0.05$). The socio-territorial sustainability of the pastoral farms was lowered by the "Ethics and Human development" component score (Table 1). This component evaluates the farmer satisfaction vis-à-vis the conditions of exercise of its activity, the participation in training, or its responsibility vis-à-vis the global food balance. The pastoral system was characterized also by a poor quality of life, a geographical and social isolation and of improper condition of work in comparison with agro-silvo-pastoral and oasis ones. On the other hand, the three systems perform similarly along the "Employment and services" component ($P = 0.089$), but differently for the two other ones. Agro-silvo-pastoral system performs the same ($P > 0.05$) as pastoral system concerning the "Quality of the product and land" component, and the same as oasis system regarding "Ethics and Human development". Since lamb meat from extensive system presented better organic quality than that from sheepfolds in oasis systems, relating meat quality to the production system in this study may explain in part the important score of extensive farms compared to the oasis one regarding the "Quality of the product and land" component.

Concerning economic sustainability components, pastoral system scored higher for the economic transferability followed by the agro-silvo-pastoral then oasis system ($P = 0.0001$). As this component corresponds to the financial capital, evaluated by the flock size, transferred by inheritance, this favors the extensive farms compared to the oasis ones, because of the important financial capital associated with the bigger flocks for this type of farms. Moreover, the pastoral and the agro-silvo-pastoral system presented better economic efficiency than the oasis system ($P = 0.05$) which reflects the independence of the studied farms and the good management of their own resources.

IV – Conclusion

This study claims the importance of the evaluation of livestock farms sustainability in the rural area, especially the sheep ones. Results derived from the assessment of the three pillars of sustainability show differences between the agro-silvo-pastoral, pastoral and oasis systems. These differences reflect variability in farmer's practices and behaviours. They could be improved through trainings in sustainable animal agriculture, and the development of a guidance document intended to assist professionals in the small ruminant sector to improve the environmental sustainability of farms. This work may be used in this purpose to identify the more pertinent indicators for sustainability improvement adapted to the Moroccan and south Mediterranean conditions.

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